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Hydrographic data from the GEF Patagonia cruises

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Abstract

The hydrographic data reported here were collected within the framework of the Coastal Contamination, Prevention and Marine Management project (GEF Patagonia), which was part of the scientific agenda of the United Nations Development Program (UNDP). The project goal was to strengthen efforts to improve sustainable management of marine biodiversity and reduce pollution of the Patagonia marine environment. The observational component of the project included three multi-disciplinary oceanographic cruises designed to improve the knowledge base of the marine environment and to determine the seasonal variability of physical, biological and chemical properties of highly productive regions in the southwest South Atlantic continental shelf. The cruises were carried out on board R/V *Ara Puerto Deseado*, in October 2005 and March and September 2006. In each cruise, hydrographic stations were occupied along cross-shelf sections spanning the shelf from near-shore to the western boundary currents between 38° and 55° S. This paper reports the quasi-continuous vertical profiles (CTD) and underway surface temperature and salinity data collected during the GEF Patagonia cruises. These data sets are available at the National Oceanographic Data Center, NOAA. US, doi:10.7289/V5RN35S0.

1 Introduction

The Argentine continental shelf is one of the largest shelf areas in the World Ocean and comprises the Patagonian Shelf Large Marine Ecosystem (PLME, Heileman, 2009). The Atlantic Patagonia continental shelf extends from 55° S at the tip of Tierra del Fuego to approximately 39° S. The shelf is a shallow submerged plateau very wide in the south (∼ 850 km) and narrows toward the north. The offshore edge is marked by a sharp change in bottom slope located at 115–240 m depth (Parker et al., 1997). This region is one of the most productive in the Southern Hemisphere and supports a wide variety of marine life (Falabella et al., 2009). In-situ estimates of primary production in

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austral spring range between ~ 200 mg C m^{-2} d^{-1} and > 3000 mg C m^{-2} d^{-1} near frontal regions (Lutz et al., 2010). The high biological productivity of the PLME sustains an intense fishing activity, mostly by Argentine fleets but also by other international fleets (Heileman, 2009). In addition, this large primary production leads to the absorption of large quantities of carbon dioxide from the atmosphere (Bianchi et al., 2005) accounting for about 1 % of the global ocean's net annual CO_2 uptake, almost 4 times the mean rate of CO_2 uptake of the global ocean (Bianchi et al., 2009).

The high production is mostly associated with various shelf and shelf-break fronts generated by strong winds, large-amplitude tides, large buoyant discharges and the proximity of the nutrient-rich Malvinas Current (e.g. Acha et al., 2004; Saraceno et al., 2005; Palma et al., 2008; Matano and Palma, 2008; Matano et al., 2010). To determine the seasonal variability of physical, chemical and biological properties and improve the knowledge base of the Patagonia marine environment and its biodiversity, three oceanographic cruises were carried out on board R/V *Ara Puerto Deseado* as part of the GEF Patagonia project (Fig. 1). The cruises were carried out in October 2005 (GEFPAT-1) and March (GEFPAT-2) and September 2006 (GEFPAT-3). Each survey consisted in the occupation of 7–9 cross-shelf sections from near-shore to the upper slope of the western Argentine Basin close to the 2000 m isobath. The cruise design provided quasi-synoptic observations of the near-shore tidal fronts, the mid-shelf region, the shelf-break front and the western edge of the Malvinas Current (e.g. Romero et al., 2006). We report a brief description of procedures of acquisition and processing of vertical CTD profiles and underway surface temperature and salinity data.

2 Hydrographic stations

2.1 CTD profiles

At each station a vertical quasi-continuous conductivity–temperature–depth (CTD) profile was collected with a Sea-Bird Electronics model 911plus, equipped with fluorescence and turbidity sensors in GEFPAT-1, oxygen sensor in GEFPAT-2 and oxygen, fluorescence and turbidity sensors in GEFPAT-3. Additional redundant temperature and conductivity sensors were used in some stations during GEFPAT-3. Table 1 summarizes the CTD sensors used in each cruise. Most vertical profiles reached to within ∼5 m off the bottom within the continental shelf and 10 m off the bottom at stations deeper than 200 m, except under adverse weather conditions or when the distance of the package from the bottom was uncertain, such as over regions of steep bottom slope. The CTD was mounted with a rosette sampler and the package was deployed on a conducting cable, which allowed for real-time data acquisition and display on board. A General Oceanics (model GO 1015) 12 bottles water-sampler was employed in GEFPAT-1 whereas a SeaBird Carousel (model SBE32) 24 bottles water-sampler was employed in GEFPAT-2 and GEFPAT-3. Both models held 5 L Niskin bottles. Duplicate CTD cats were carried out in GEFPAT-1 to collect water samples for ancillary biological programs. Duplicate casts were identified by station file names with suffix b. Down-cast profile data were reported because during downcast the CTD sensors sample the water column with minimal interference from the underwater package. However, in some stations which presented noisy data during the down-cast, up-cast data were reported. Down-cast (up-cast) file names were prefixed by d (u). Station date and times are reported in UTC.

2.2 CTD data processing

CTD data were post-processed according to common standards, using Seabird Data Processing software routines (Seasoft-Win32, http://www.seabird.com/software/sswin.htm, SBE, 2005). The nominal calibrations were used for data acquisition. Final conductivity calibration was determined empirically by comparison with the salinities of discrete water samples taken during each up-cast. Conductivity and dissolved oxygen sensors were calibrated as described in the following sections. Fluorescence and turbidity data were reported based on factory calibrations only.

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Data were subsequently averaged at 1 dbar pressure intervals. The data for each cast were inspected and any remaining density spikes removed by linear interpolation of the original temperature and conductivity data and all derived parameters recalculated at that level.

2.3 CTD sensor calibration

2.3.1 Conductivity

On board calibration of the conductivity sensor was performed empirically by comparing its nominally calibrated output against the calculated conductivity values obtained from water sample salinities using the pressure and temperature of the CTD at the time of bottle closure. An estimate of bias (Offset) and slope corrections to the nominal factory calibration were determined using a linear least squares fit. For each cruise bottle conductivities were fitted to CTD conductivities and conductivity differences greater than 2 standard deviations from the fits were rejected.

Vertical profiles of salinity differences between CTD and bottle salinity were plotted to identify suspect water samples caused by leaky Niskin bottles or drawn from regions of relatively large vertical salinity gradients. Also, potential temperature–salinity (θ–S) diagrams of historical hydrographic data collected in the same region were overlaid to check for consistency. All suspect bottle data were discarded and not used in the CTD calibration process described above.

CTD observations of GEFPAT-2 were collected during a late austral summer, when shelf waters present a strong vertical stratification associated with vertical temperature gradients of the order of 1 °C m^{-1}. Across these intense temperature gradients, spurious CTD salinity spikes were frequently observed. Salinity spikes were removed based on the comparison with bottle salinities obtained at selected stations where water samples across the thermocline were obtained at $\sim$ 1 m resolution. In stations without high resolution bottle sampling, both, down- and up-casts and water sample salinities were combined to reconstruct salinity profiles. The reconstructed data were inspected to

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check for density inversions, which were removed by linear interpolation and all derived parameters recalculated at the interpolated level. Station file names of reconstructed profiles were identified with the station file name suffixed by re.

To illustrate the quality of the conductivity calibration Fig. 2 displays the salinity residuals after calibration. Table 2 summarizes the comparisons between CTD and water sample salinity after CTD data were calibrated for each cruise as previously described.

2.3.2 Dissolved oxygen

Calibration of the oxygen sensor was performed using a statistical method estimating calibration coefficients for calculating dissolved oxygen in milliliters per liter ($mL\,L^{-1}$) from SBE 43 output voltage. The technique requires dissolved oxygen concentrations reported in $mL\,L^{-1}$ determined from a range of Winkler titrated water samples and SBE 43 oxygen voltage outputs measured at the times the water samples were collected (SBE, 2002). Though the sensor manufacturer recommends advancing the oxygen voltage data relative to the CTD pressure (SBE, 2005), we carried out several test and concluded this alignment led to a larger dissolved oxygen mismatch between CTD and water samples across the thermocline. Thus, no alignment corrections were applied.

The oxygen from water samples was compared with historical data collected in the region to check for consistency and to identify suspicious data. The standard deviation of the residuals was approximately 1 $\mu mol\,kg^{-1}$. Figure 3 presents the differences between SBE 43 dissolved oxygen after calibration and Winkler titration dissolved oxygen.

2.4 Water sample analysis

Water samples at selected levels were taken from 5 L Niskin bottles for the determination of salinity and dissolved oxygen. Salinity and dissolved oxygen were determined on board. Salinity samples were collected in 200 mL glass flasks and salinity was determined with a Guildline Autosal 8400B salinometer. The Autosal standardization was

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carried out with Ocean Scientific International ltd. (OSIL) standard seawater (SSW) batches P131 (1996) and P141 (2002, GEFPAT-1), P141 (2002) and P146 (2005, GEFPAT-2) and P146 (2005, GEFPAT-3), according to the procedure described in the salinometer technical manual (Guildline, 2004). Salinity values were calculated and reported in Practical Salinity Units (PSS78, UNESCO, 1981).

The double conductivity ratio of SSW during GEFPAT-3, showed a positive trend with time determined from the difference between the beginning and the completion of each run of samples. In order to determine whether the observed drift was due to alteration of the SSW or due to instrument drift, at the beginning and at the end of one run the instrument was standardized with a new vial of SSW. This test revealed an estimated Autosal drift of double conductivity ratio of 0.00013 over a period of 5 h, which is approximately equivalent to a rate of change in salinity of 0.00048 h^{-1}. In addition this test indicates a SSW alteration of 0.0001 of double conductivity ratio, equivalent to a salinity change of 0.002 during the 5 h period. These estimates can be considered upper error limits as other salinity sample runs took about the same or shorter time. To account for the salinometer drift for each run a linear trend correction was estimated by a least squares fit and salinity from seawater samples corrected by removing the spurious trend.

Dissolved oxygen was determined with a modified Winkler method (Carpenter, 1965) using an amperometric endpoint detection technique. In the three GEF Patagonia cruises the dissolved oxygen concentrations were determined with a Mettler DL 21 automatic titration system. Samples were collected in ~ 125 mL volume-calibrated borosilicate glass flasks and whole bottle titration was carried out in the analysis. Standardizations were performed with commercial potassium iodate solutions (0.01N) provided by OSIL and also prepared ashore. The thiosulfate solution was standardized at a temperature within ±1 °C of the temperature at which the oxygen samples were analyzed. Duplicate thiosulfate standardizations were run requiring endpoints to be within (±0.3 %) of each other.

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3 Underway measurements

Throughout the three cruises underway near-surface (∼ 3 m) quasi-continuous surface temperature and salinity data were collected using two Sea-Bird Electronics Seacat 21 Thermosalinographs (SN 2310 in GEFPAT-1 and SN 3265 in GEFPAT-2 and GEFPAT-3). The data were recorded every 30 s and occasionally every 60 s along some tracks of GEFPAT-2. Bottle salinity samples were taken periodically from the thermosalinograph water intake to calibrate the thermosalinograph conductivity sensor. These water sample salinities were determined on board following the same procedures described above.

Pump malfunctioning, continental discharges near shore and intense phytoplankton blooms tend to clog the thermosalinograph filter and alter the flow rate. Flow rate disturbances can result in large temperature and conductivity fluctuations. At different stages of the Patagonia GEF cruises the thermosalinograph data presented indications of these types of problems which required flow rate readjustment and filter replacement. To smooth the noise in the thermosalinograph data caused by flow rate disturbances, temperature and conductivity were filtered using a cosine filter with an 11-point window length. Filtering was carried out employing the Window Filter routine available in the Seabird Data Processing software (SBE, 2005).

3.1 Sensors calibration

Thermosalinograph temperature and conductivity were compared with temperature and corrected CTD conductivity extracted from the 3 dbar level during down and up casts for each station. Similar to the CTD calibration procedure, a bias (Offset) and slope corrections to the nominal calibration were determined from a linear least squares fit to the CTD vs. thermosalinograph of each variable. Values greater than 2 standard deviations from the fits were rejected. In addition, the corrected thermosalinograph salinities were compared with the salinity from bottle samples to provide an independent verification of the above described calibration. Differences between

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the corrected thermosalinograph salinities and the bottle salinities for each cruise are shown in Fig. 4. Table 3 presents the thermosalinograph–bottle salinity comparisons after temperature and conductivity sensors were calibrated.

4 Data access

The hydrographic data sets from GEF Patagonia cruises are reported in standard Seabird format. Data from individual stations are presented in separate ASCII character files consisting of 1 dbar data records in physical units listed together with detailed metadata. For each cruise thermosalinograph data are reported in various ASCII files in the original sampling frequency with records in physical units. The data are available at the National Oceanographic Data Center, NOAA. US; doi:10.7289/V5RN35S0.

Data coverage and parameters measured

Repository-Reference: doi:10.7289/V5RN35S0, CTD continuous profiles and Thermosalinograph data, available at: doi:10.7289/V5RN35S0.

Coverage: 38–55° S; 70–54° W.

Location Name: Western South Atlantic, Patagonia Continental Shelf.

Date/Time Start: 8 October 2005.

Date/Time End: 25 September 2006.

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Table 1. Summary of CTD sensors used in GEF Patagonia cruises.

Cruise Date	Station Number	Sensor	Model	Serial Number
GEFPAT-1		Pressure	Digiquartz w/TC	57472
8–28 Oct 2005	1	Temperature	SBE 3plus	031689
	1	Conductivity	SBE 4C	041381
	2–68, 70–81[a]	Temperature	SBE 3plus	031691
	2–68, 70–81	Conductivity	SBE 4C	041382
	1–68, 70–81	Fluorescence	Seatech WET Labs FLF	2125
	1–68, 70–81	Turbidity	Seatech LS6000 WET Labs LBSS	495
GEFPAT-2		Pressure	Digiquartz w/TC	95796
10 Mar–1 Apr 2006	1–83	Temperature	SBE 3plus	032951
	1–83	Conductivity	SBE 4C	042657
	1–14, 38–83[b]	Oxygen	SBE 43	0869
GEFPAT-3		Pressure	Digiquartz w/TC	95796
5–25 Sep 2006	1–56	Temperature 1	SBE 3plus	032951
	1–56	Conductivity 1	SBE 4C	042657
	24–56	Temperature 2	SBE 3plus	031689
	24–56	Conductivity 2	SBE 4C	041381
	1–56	Oxygen	SBE 43	0869
	1–56	Fluorescence	Seapoint SCF	2816
	1–56	Turbidity	Seatech LS6000 WET Labs LBSS	495

[a] Station 69 no CTD profile.
[b] Stations 15–37 no oxygen sensor.

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Table 2. Calibrated CTD vs. water sample salinity comparison for each cruise calculated for the whole water column ($0 < p < p_{max}$) and below 200 dbar ($200 < p < p_{max}$). Number of samples (N) is indicated for each set.

Cruise	Station	$0 < p < p_{max}$		N	$200 < p < p_{max}$		N
		Mean	Std. Dev.		Mean	Std. Dev.	
GEFPAT-1	1–81	0.0000	0.0015	377	0.0005	0.0012	58
GEFPAT-2	1–83	0.0000	0.0027	323	−0.0004	0.0034	44
GEFPAT-3	1–56	−0.0001	0.0013	265	0.0001	0.0012	52
GEFPAT-3[a]	24–56	0.0001	0.0020	138	0.0024	0.0015	26

[a] secondary sensors.

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Table 3. Calibrated thermosalinograph vs. water sample salinity comparison for GEF Patagonia cruises. Number of samples (*N*) is indicated for each cruise.

Cruise	Mean	Std. Dev.	*N*
GEFPAT-1	−0.006	0.024	61
GEFPAT-2	−0.006	0.019	97
GEFPAT-3	−0.007	0.020	45

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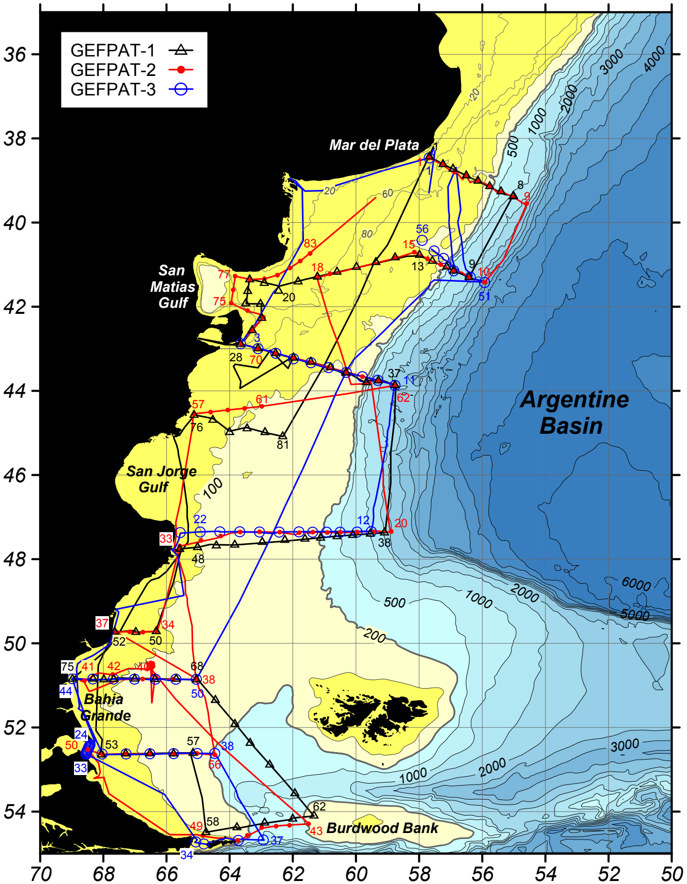

Fig. 1. Location of hydrographic stations occupied during the GEF Patagonia cruises (symbols) and cruise tracks along which surface observations were collected (lines). Selected station numbers for each cruise are shown with same colors. The background shading and contours indicate bottom topography in meters.

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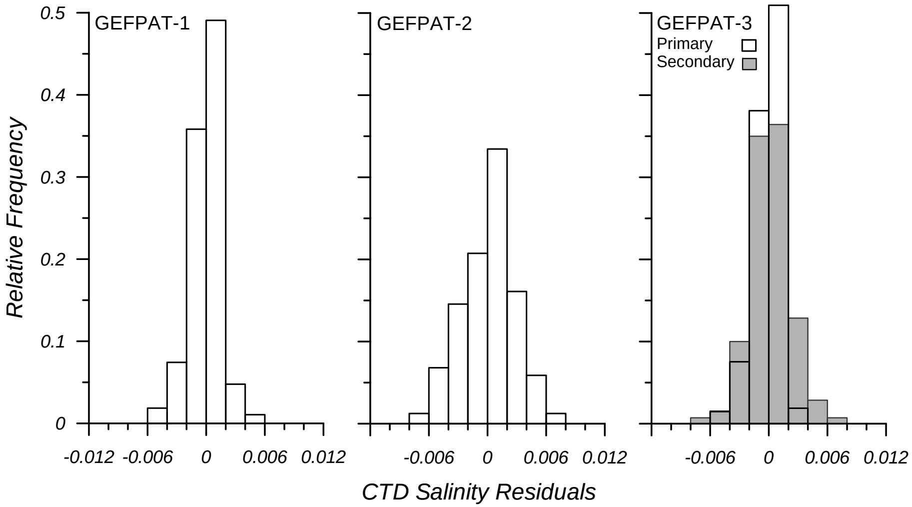

Fig. 2. Relative frequency distribution of salinity residuals after CTD calibration for GEF Patagonia Cruises.

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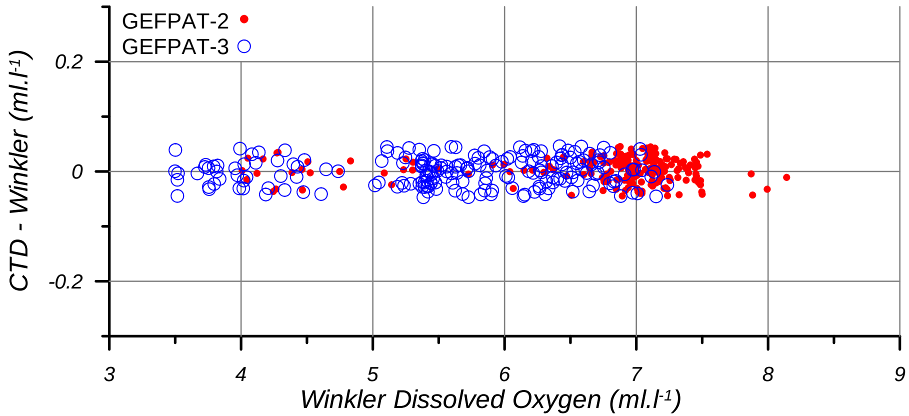

Fig. 3. Distribution of dissolved oxygen residuals in $mL\,L^{-1}$, after SBE43 sensor calibration for GEF Patagonia Cruises.

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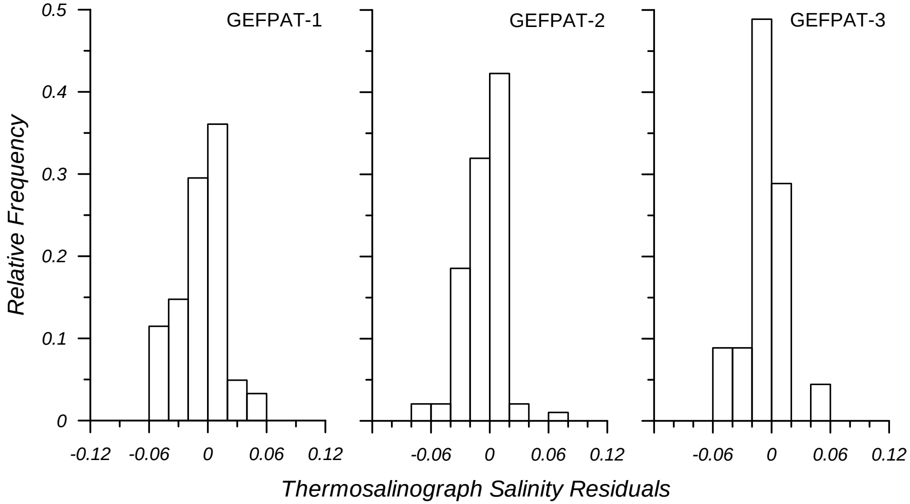

Fig. 4. Relative frequency distribution of salinity residuals after Thermosalinograph calibration for GEF Patagonia Cruises.

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