**Physical Oceanographic Measurements and Underway Environmental Observations**

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**Abstract**

Oceanographic data were collected at fixed stations around the South Shetland Islands during two legs of the 2010/11 AMLR Survey. A total of 97 CTD/carousel casts were completed on Leg I and 69 CTD deployments were done simultaneously with the Tucker Trawl on Leg II. Results indicated that:

- Antarctic Circumpolar Current (ACC) water remained mainly offshore, and was found primarily in the western part of the South Shetland Islands;
- Waters were mixed between Elephant Island and the Shackleton Fracture Zone, giving way to the colder, saltier waters of the Bransfield Strait south of Elephant Island and around Joinville Island;
- A number of instrument problems with dated equipment suggest the need for replacement of these instruments; and
- The new Tucker Trawl system provided the ability to better quantify biological and physical relationships at smaller space scales.

## Introduction

Oceanographic variability has been shown to influence the Antarctic Peninsula ecosystem at a variety of temporal and spatial scales. These influences include impacting primary productivity in the region, the strength of currents, and the amount of snow and ice impacting the success of land-breeding birds and mammals. The objectives of this study were to:

1. Collect and process physical oceanographic data in order to identify hydrographic characteristics and map oceanographic frontal zones;
2. Collect and process underway environmental data in order to describe sea surface conditions during the surveys; and
3. Investigate the use of the Sea-Bird SBE19plus CTD mounted on the new Tucker Trawl system.

Together these data may be used to describe the physical conditions associated with various biological observations, as well as provide a detailed record of the ship's movements and the environmental conditions encountered.

## Methods

*CTD/Carousel Stations*

A total of 97 CTD/carousel casts were completed on Leg I, using a Sea-Bird SBE 911plus CTD system together with a SBE 32 carousel carrying 11 ten-liter General Oceanics sample bottles. A Sea-Bird SBE 43 Dissolved Oxygen (DO) sensor, WetLabs C-Star red transmissometer, three Biospherical PAR sensors, and a Teledyne Benthos bottom detection altimeter were also interfaced to the CTD. All the above equipment was new, except for two of the PAR sensors, which were installed alongside a new PAR sensor on the carousel frame, for historical cross calibration purposes. A new Biospherical masthead 4pi PAR sensor was installed as a surface PAR reference, and cabled directly into a new SBE 11plus CTD deck unit to be recorded simultaneously with the CTD profile data.

The CTD, carousel, and auxiliary sensors were set up as per Table 1.1 and operated from the portside winch, which was fitted with a calibrated winch monitoring system (cable load, wire out, and wire speed). Deck sheets were generated for every station and CTD data were logged and bottles triggered using Sea-Bird Seasave Win32 Version 5.30a software. CTD "mark" files (reflecting data from the cast at bottle triggering depths), were also collected. Data were processed using SBE Data Processing Version 5.30a software, averaged over 1 m bins, and saved separately as up and down traces during post processing. Downcast data were reformatted using a SAS script and then imported into Ocean Data View (ODV) format for further "in-field" checking and presentation.

The CTD and its auxiliary sensors were calibrated by the manufacturers prior to the cruise and all calibration certificates have been stored in a central filing system, along with the calibration sheets from previous AMLR cruises.

The new Chelsea Instruments Aquatracka submersible

Table 1.1. SCS and CTD sensor installation summary (Legs I and II).

| **SCS Sensor Installation Summary** | | | | |
|---|---|---|---|---|
| SENSOR | MANUFACTURER | MODEL | SERIAL NO. | CALIBRATED |
| Leg I | | | | |
| Weather Station | Ocean Environmental Systems | WeatherPak WP2000 | 797 | 7-Jul-10 |
| PAR sensor (2pi) | Licor | Quantum LI-190SZ | Q40069 | 17-Aug-09 |
| Pyranometer | Licor | LI-200 | PY66797 | 25-Aug-09 |
| PAR sensor (4pi) | Biospherical Instruments | QSR-2100 | 10281 | 23-Jun-10 |
| Thermosalinograph | Sea-Bird Electronics | SBE-21 | 2971 | 2-Jul-10 |
| Remote TSG probe | Sea-Bird Electronics | SBE-03-01/S | 1310 | 2-Jul-10 |
| GPS navigator | Ship's GPS | | Ship supply | |
| Gyro compass | Furuno Marine | | Ship supply | |
| Leg II | | | | |
| Weather Station | Ocean Environmental Systems | WeatherPak WP2000 | 798 | 7-Jul-10 |
| PAR sensor (2pi) | Licor | Quantum LI-190 | Q28168 | 20-Jul-10 |
| Pyranometer | Licor | LI-200 | PY67458 | 25-Aug-09 |
| PAR sensor (4pi) | Biospherical Instruments | QSR-2100 | 10281 | 23-Jun-10 |
| Thermosalinograph | Sea-Bird Electronics | SBE-21 | 2971 | 2-Jul-10 |
| Remote TSG probe | Sea-Bird Electronics | SBE-03-01/S | 1310 | 2-Jul-10 |
| GPS navigator | Ship's GPS | | Ship supply | |
| Gyro compass | Furuno Marine | | Ship supply | |

| **CTD Sensor Installation Summary** | | | | | |
|---|---|---|---|---|---|
| DESCRIPTION | MANUFACTURER | MODEL | SERIAL NO. | CHANNEL | CALIBRATED |
| Leg I | | | | | |
| Deck Unit | Sea-Bird Electronics | SBE 11plus V2 | 11P-60321-0844 | | 7-Aug-10 |
| Underwater Unit | Sea-Bird Electronics | SBE 9plus | 09P60321-0995 | | 7-Aug-10 |
| Temperature Sensor | Sea-Bird Electronics | SBE 3plus | 5339 | Freq 1 | 7-Aug-10 |
| Conductivity Sensor | Sea-Bird Electronics | SBE 4C | 3769 | Freq 2 | 3-Aug-10 |
| Pressure Sensor | DigiQuartz with TC | Internal | 995 | Freq 3 | 5-Aug-10 |
| Circulation Pump | Sea-Bird Electronics | SBE 5T | 90543 | | Aug-10 |
| SBE Carousel | Sea-Bird Electronics | SBE 32 | 3260321-0800 | | Aug-10 |
| DO Sensor | Sea-Bird Electronics | SBE 43 | 1916 | Voltage 0 | 31-Jul-10 |
| PAR (new 2011) | Biospherical | QCP-2300 | 70320 | Voltage 2 | 18-Oct-11 |
| PAR (new 2005?) | Biospherical | QCP-2300 | 4744 | Voltage 3 | 23-Jun-10 |
| PAR (old) | Biospherical | QCP-200L | 4264 | Voltage 4 | 23-Jun-10 |
| Altimeter | Teledyne Benthos | PSA-916 | 50481 | Voltage 5 | 2010 |
| Transmissometer | Wetlabs | C-Star Red | CST-1332DR | Voltage 6 | 19-Aug-10 |
| Masthead PAR sensor 4pi | Biospherical | QSR-2200 | 70386 | Into SBE 11p | 2010 |
| Leg II | | | | | |
| Underwater Unit | Sea-Bird Electronics | SBE 19plus V2 | 19p53746-6645 | | 2010 |
| Circulation Pump | Sea-Bird Electronics | SBE 5T | 55722 | | 2010 |
| DO Sensor | Sea-Bird Electronics | SBE 43 | 431917 | Voltage 0 | 2010 |

fluorometer failed on first power-up and was not used until spare parts were obtained before Leg II. The CTD, auxiliary sensors, and carousel equipment functioned reliably with the usual amount of pre-emptive servicing of underwater connectors required. The enclosing of the R/V Moana Wave transom greatly improved the safety of working on the aft-deck and reduced the amount of deployment damage to the equipment. With the deck being dry, maintaining and servicing the CTD system during the cruise was easier. The CTD system was stowed on the aft deck and secured to the ship's steelwork with ratchet straps during transits and between stations. A set of carousel water sampling bottles was broken when the CTD slammed the ship, but all these bottles were able to be repaired and put back into use.

Water samples were collected at 11 discrete depths on all casts for phytoplankton analysis during Leg I. CTD scan rates were set at 24 scans/second during both down and up casts. Sample bottles were only triggered during the up casts. Profiles were limited to a depth of 750 m or 5 m above the sea bottom when shallower than 750 m. A Teledyne Benthos altimeter was used to stop the CTD descent 5 to 15 m from the seabed on the shallow casts, depending on sea-state. Standard bottle sampling depths were 750 m, 200 m, 100 m, 75 m, 50 m, 40 m, 30 m, 20 m, 15 m, 10 m, and 5 m.

Salinity calibration checking was not done due to problems with the Guildline Portasal salinometer. Comparisons of dissolved oxygen levels in the carousel water samples with the levels measured during the casts (via the DO sensor) were not attempted during the survey.

*CTD/Tucker Trawl Stations*

During Leg II, a new Sea-Bird SBE 19plus V2 portable CTD system with a pumped SBE 43 DO sensor (see Table 1.1) was mounted on the Tucker Trawl and interfaced into the Tucker Trawl's electronics. CTD data were presented in real-time and logged by the Tucker Trawl software. A total of 69 Tucker Trawl stations were sampled during Leg II. The CTD performed well; only routine connector maintenance and battery changes were necessary. The SBE 19plus V2 CTD and SBE 43 DO sensor were calibrated by the manufacturers prior to the cruise and all calibration certificates have been stored in a central filing system, along with the calibration sheets from previous AMLR cruises. After an initial learning period, the Tucker Trawl electronics and software worked well. The deployment and retrieval procedures set in place by the deck operators resulted in the protection of the delicate electronics and no major damage resulted in any of the 69 trawl stations, even in bad weather. The only damage of note was to the oil-filled pressure casing cover of the net triggering motor. The cover was knocked against the ship on deployment and force jammed into the casing. Repairs were possible by heating the casing to release the jammed lid, rinsing the motor and refilling with oil. One of the flowmeters on the Tucker Trawl was replaced with a spare unit when it stopped functioning. Because the Tucker Trawl electronics, sensors, and CTD are complex and exposed to possible damage, a protective cage and spare parts should be considered for future cruises. Problems were experienced with both sea cables. The CTD (Leg I) and IKMT were deployed from the starboard side winch (Rochester .322" coax cable) and the Tucker Trawl on the port side winch (Rochester .450" coax cable).

Both cables displayed the tendency of having excess "spring" in them and wanting to coil back on themselves, unravel, and eventually kink. The .322" cable started unraveling and eventually kinked on three occasions during Leg I and twice on Leg II. This necessitated that the cable be cut back and the mechanical dead end and electrical underwater termination be redone each time. This also occurred on the .450" cable on the 13th tow using the Tucker Trawl (500 m deep tow). As soon as the tension was released from the cable on retrieval, it sprung back on itself and coiled and kinked on the winch drum. Various causes of these malfunctions were explored:

1. Exceeding working load of cables;
2. CTD or nets spinning underwater;
3. Dead ends not gripping both layers of armor;
4. Kinking due to pinching damage in A-frame moving parts;
5. Kinking due to hooking on ship protrusions when A-frame moving;
6. Cable not being layered smoothly on winch drum;
7. Exceeding minimum specified bending radius of cable (9"); and
8. Chaffing on blocks.

No definite solution has been found, but it is noted that both the hanging blocks on the aft A-frame are less than the minimum cable bending radius of 9".

*Underway Environmental Observations*

Environmental and vessel position data were collected, logged, and displayed for a total of 59 days (30 days and 29 days during Legs I and II, respectively) via the Scientific Computer System (SCS) software package, which was run on a Windows XP based Dell PC with an internal 8-port RS232 expander card.

Environmental data were collected via a Coastal Environmental Company Weatherpak system, a Licor quantum PAR sensor, and a Biospherical 4PI QSR-2100 PAR sensor installed on the R/V *Moana Wave's* bridge-top mast. A Sea-Bird SBE-21 thermosalinograph (TSG) and debubbler system were installed in the zooplankton laboratory and fed into the SCS, with a remote Sea-Bird SBE-3 sea surface temperature probe in the suction line of the TSG pump, close to the hull intake. This system performed well, except during severe sea conditions when cavitation would require the pump to re-prime. The relative wind data were converted to true speed and true direction by the internally-derived functions of the SCS logging software. Vessel position data were recorded through the ship's GPS and gyro-compass, which were also fed into the SCS system.

All the above instruments were calibrated by the manufacturers prior to the cruise and all calibration certificates have been stored in a central filing system, along with the calibration sheets from previous AMLR cruises. See Table 1.1 for SCS installation summary.

The R/V *Moana Wave* does not have a deep echo sounder that can be used to record bottom soundings to the SCS or provide an indication of depth before deploying the CTD and nets. In shallow waters, soundings were obtained from the EK60 system; in deeper water, soundings obtained during the 2009 survey were used.

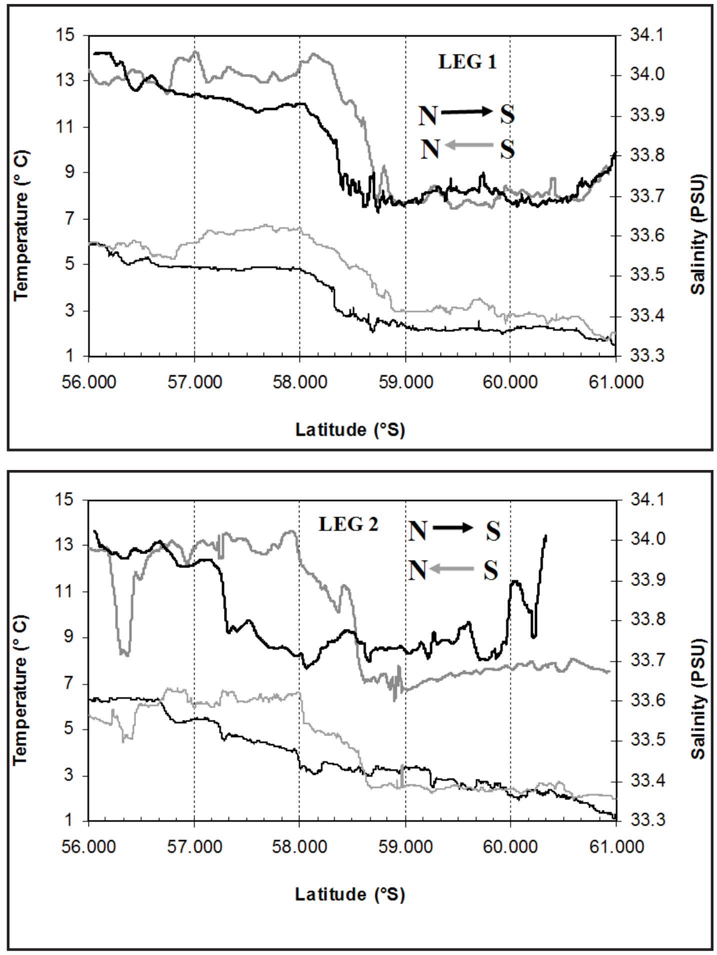



Figure 1.1. The position of the polar fronts as determined for AMLR 2011 Legs I (top) and II (bottom), from measurements of sea surface temperature and salinity for the south and north transits to and from the South Shetland Islands survey area.

## Results

During Leg I, 97 CTD stations were successfully sampled across the survey grid. The position of the Antarctic Polar Front, identified by pronounced sea surface temperature and salinity change, was located from the logged SCS data during the four transits from and to Punta Arenas and the South Shetland Islands (See Figure 1.1). This frontal zone is normally situated between 57-58° S.

During both the south- and north-bound transits of Leg I, the Antarctic Polar Front was well defined with sharp salinity changes between 58° S and 58° 40' S, with accompanying sea surface temperature (SST) dropping from approximately 5°C to 2.5°C on the south-bound and increasing from 3.5°C to 6.5°C on the north-bound transit. Leg II saw less well-defined fronts, with the beginning of the front encountered around 57° 20' S on the southward transit and 58° 40' S to 58° S on the northward transit.

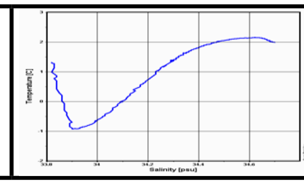
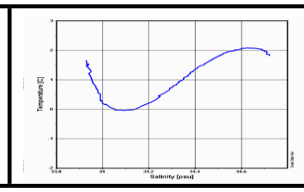
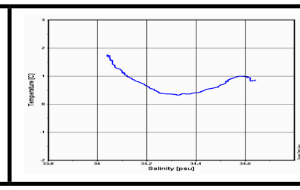
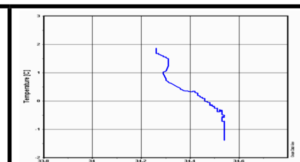
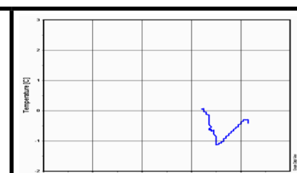
A comparison of the Sea-Bird SBE-21 thermosalinograph (TSG) system with CTD data showed that the TSG salinity readings were on average 0.005 ppt (n = 96) lower than the CTD, while the TSG sea temperature readings were on average 0.057°C (n = 96) higher than the CTD's 5 m temperature data.

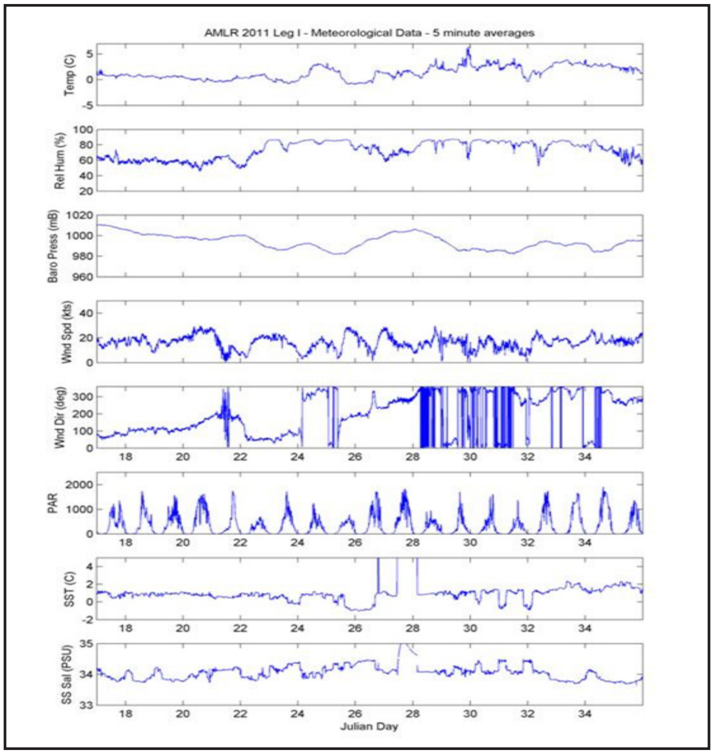
Environmental data were recorded for the duration of the surveys and for the transits between Punta Arenas and the survey area. Processed data were averaged and filtered over 1-minute and 5-minute intervals for Legs I and II (Figures 1.2 and 1.3, respectively).

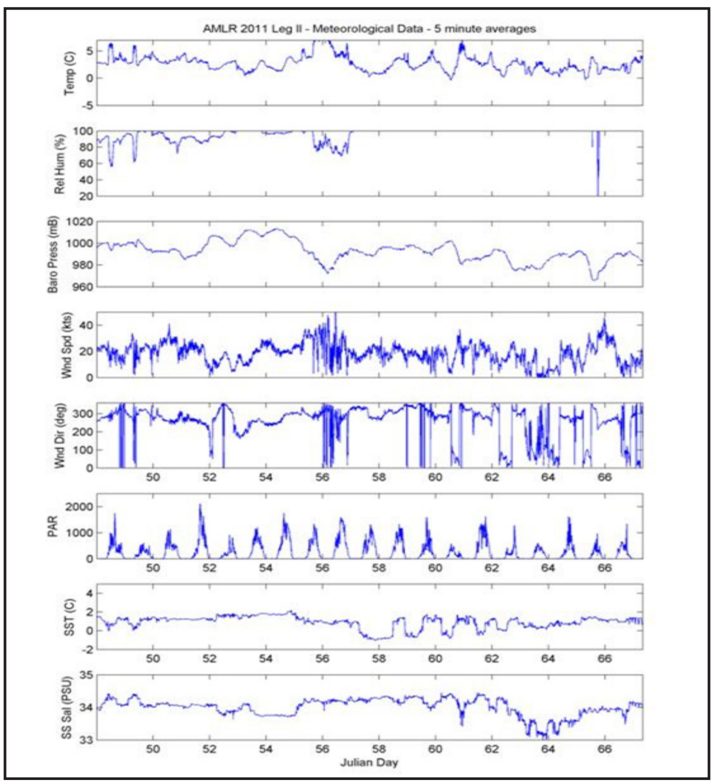
## Discussion

All data were processed and a first attempt at water zone classification was undertaken to group stations with similar temperature and salinity profiles into five water zones as defined in Table 1.2 and presented in Figure 1.4. The tentative water zone classifications are sometimes prone to ambiguity, particularly in the coastal regions

Table 1.2. Water Zone definitions applied for AMLR 2011.

| | **T/S Relationship** | | | |
|---|---|---|---|---|
| | **Left** | **Middle** | **Right** | **Typical TS Curve (from 2002)** |
| **Water Zone I (ACW)** | **Pronounced V shape with V at ≤0°C** | | | |
| Warm, low salinity water, with a strong subsurface temperature minimum, Winter Water, approx. -1°C, 34.0ppt salinity) and a temperature maximum at the core of the CDW near 500m. | 2 to >3°C at 33.7 to 34.1ppt | ≤0°C at 33.3 to 34.0 ppt | 1 to 2°C at 34.4 to 34.7ppt (generally >34.6ppt) |  |
| **Water Zone II (Transition)** | **Broader U-shape** | | | |
| Water with a temperature minimum near 0°C, isopycnal mixing below the temperature minimum and CDW evident at some locations. | 1.5 to >2°C at 33.7 to 34.2ppt | -0.5 to 1°C at 34.0 to 34.5ppt (generally >0°C) | 0.8 to 2°C at 34.6 to 34.7ppt |  |
| **Water Zone III (Transition)** | **Backwards broad J-shape** | | | |
| Water with little evidence of a temperature minimum, mixing with Type 2 transition water, no CDW and temperature at depth generally >0°C | 1 to >2°C at 33.7 to 34.0ppt | -0.5 to 0.5°C at 34.3 to 34.4ppt (note narrow salinity range) | ≤ 1°C at 34.7ppt |  |
| **Water Zone IV (Bransfield Strait)** | **Elongated S-shape** | | | |
| Water with deep temperature near -1°C, salinity 34.5ppt, cooler surface temperatures. | 1.5 to >2°C at 33.7 to 34.2ppt | -0.5 to 0.5 °C at 34.3 to 34.45ppt (T/S curve may terminate here) | <0°C at 34.5ppt (salinity < 34.6ppt) |  |
| **Water Zone V (Weddell Sea)** | **Small fish-hook shape** | | | |
| Water with little vertical structure and cold surface temperatures near or < 0°C. | 1°C (+/- some) at 34.1 to 34.4ppt | -0.5 to 0.5°C at 34.5ppt | <0°C at 34.6ppt |  |




Figures 1.2 and 1.3. Meteorological data (5-minute averages) recorded between 11 January and 10 February 2012 (Leg I, top) and between 13 February and 15 March 2012 (Leg II, bottom) of the AMLR 2010/11 Survey. PAR is photosynthetically available radiation.

around King George and Livingston Islands and south and southeast of Elephant Island. Classifications of Zone IV (Bransfield Strait) and Zone V (Weddell Sea) waters in these areas could change if other oceanographic data, such as density, are considered. For the purpose of this report, in which only tentative conclusions are reported, only the criteria contained in Table 1.2 were used. This was done to ensure consistency with past cruises and only serves as a "first attempt field classification." Stations that were too shallow, or where the water showed excessive mixing, were not classified for this report and are unlabelled on Table 1.2.

During Leg I, the most clearly defined Zone I (ACC) water was found on the two northern stations of Line 11 of the West Area, with the majority of the deep stations off the shelf break, north of the islands, tending towards Zone II (Transition) water and Zone III (Transition) water.

Zone IV (Bransfield Strait) water was found to the east and southeast of Elephant Island and in the South Area. Slight influences of Zone IV were also found north of the islands in the West Area, at the inshore stations 17-11, 16-10, and 14-10. Influences of Zone V (Weddell Sea) water were found east of Elephant Island, as well as in the Joinville Island Area and southern stations of the South Area.

For comparative purposes, vertical temperature profiles have been plotted for the same two station lines (EI03 and EI07) as last year. Figure 1.5 shows lines EI03 and EI07 for AMLR 2011 Leg I.

## Protocol Deviations

There were no deviations from the standard protocol during the 2010/11 AMLR Survey.

## Disposition of Data

Data are available from Christian Reiss, Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, CA, 92037; phone/fax (858) 546-5603/(858) 546-7003; email: Christian.Reiss@noaa.gov.

## Acknowledgments

The co-operation and assistance of the R/V *Moana Wave's* staff was excellent. All requests for assistance were dealt with effectively and in a professional manner.

## References

Schlitzer, R. 2001. Ocean Data View <http://www.awi.bremerhaven.de/GEO/ODV>.

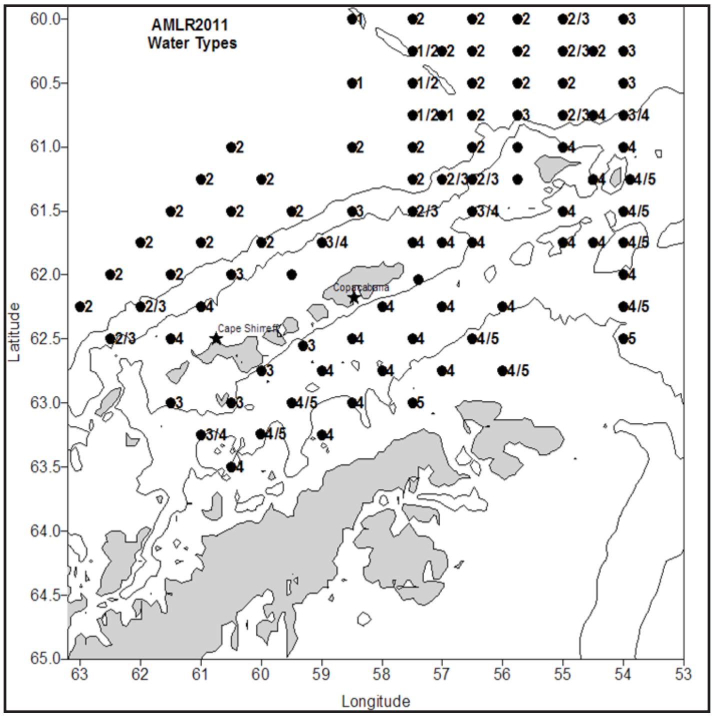



Figure 1.4. Leg I Water Zone classification for AMLR 2011, as defined in Table 1.2.

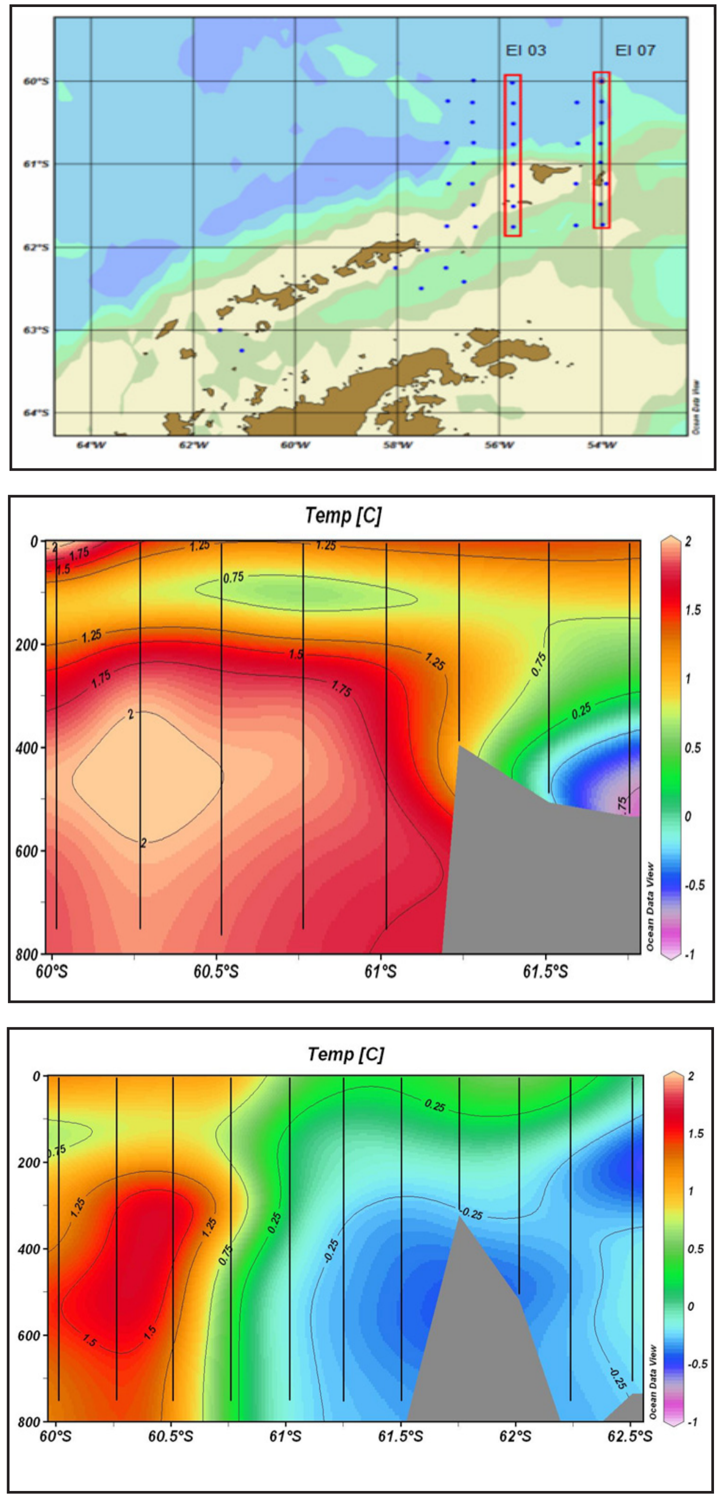



Figure 1.5. Vertical temperature profiles derived from CTD data recorded on two transects, EI 03 (middle) and EI 07 (bottom), during Leg I of AMLR 2011 South Shetland Island survey.

**NOAA Technical Memorandum NMFS**
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**FEBRUARY 2014**

# AMLR 2010-2011 FIELD SEASON REPORT

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NOAA-TM-NMFS-SWFSC-524

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