Regional Cruise

Intensive Observational Period 2008
R/V Melville, cruise 2007-088
9 January – 1 February 2008
Arnold L. Gordon, Chief Scientist

I Introduction:

The general objective of RIOP08 is to obtain a regional view of the stratification and circulation of the Philippine seas [Figure 1; the ship track is included].

The more specific objectives of the Regional IOP 2008 cruise are:

- to reoccupy select stations of the exploratory cruise of June 2007 for comparison of the winter monsoon to the summer monsoon conditions;
- to further explore PhilEx related findings of joint cruise and to investigate changes as the winter monsoon matures from time of the joint cruise to our regional cruise;
- to acquire a detailed view of the conditions in the area of the Mindoro and Panay Straits [in support of the Craig Lee process cruise in February];
- to 'check out' features in the circulation and stratification suggested by model output and satellite derived data products;
- to further investigate overflow into Sulu and Mindanao Seas, as well as overflow into the 'interior seas' of Philippine waters;
- to investigate ocean response to the sharp wind-curl patterns associated with wind/island effect.

Blue Skies of RIOP08

The participants of RIOP08 are listed in Section IV.

The PhilEx program involves four planned oceanographic cruises in the Philippines (Figure A). The first phase, named the EXPLORATORY CRUISE (PhilEx01) was from 6 June to 3 July 2007. The second phase, named JOINT CRUISE (PhilEx02) was conducted from 29 December 2007 to 4 January 2008. The third phase, named REGIONAL IOP CRUISE (PhilEx03) aimed to obtain a regional view of the stratification and circulation of the Philippine Seas was conducted from 9 January to 1 February 2008 and divided into 2-leg shifts. The first leg of PhilEx03 was from 9-22 January 2008 involved the investigation of the internal Philippine seas. The second leg of PhilEx03 was from 22 January to 1 February 2008 involved oceanographic studies of the Sulu Sea and the straits near Mindoro.

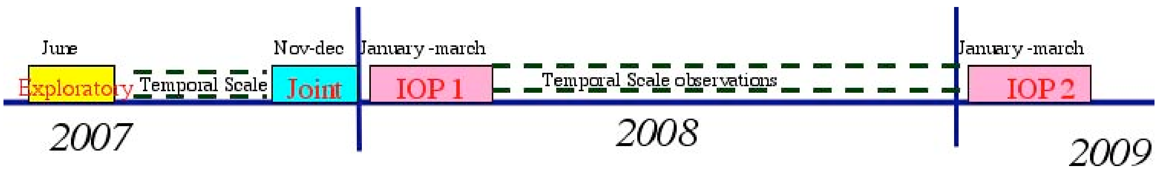

Figure A. PhilEx overview

SUMMARY of ACTIVITIES (please see the appendices of this final report for more details on each sampling activity)

[1] CTD/LADCP/optics: Lowering of the CTD [Temperature, salinity, oxygen profiles], and LADCP [shear profiles], were made to collect profiles of ocean characteristics. CTD/LADCP stations (52 in all).

[2] The observations consist of CTD-O_2/LADCP stations and underway data gathered by hull ADCP, 150 and 75 KHz, providing current roughly 300 and 700 m, respectively, and underway-surface data of meteorological/SSS/SST/Chlorophyll.

[3] Water Sampling: A 7-bottle rosette with a capacity of 10 liters each was lowered with all the CTD cast (52). 2-4 of these bottles were used for water chemical analysis (dissolved oxygen (DO), and salinity).

[4] Plankton Sampling: for plankton [at the deep chlorophyll maximum (DCM), above DCM and below DCM].

[5] Live plankton Observations: Between CTD stations surface water was collected and observed for live microzooplankton behavior.

[6] Winds: Wind data was logged every 5-30 minutes for the entire duration of the cruise.

The data collected on the cruise is attached as a DVD.

Acknowledgements- The 153 CTD/LADCP stations and several underway surveys made for an intense 23 day cruise. The team of researchers and support staff and ship officers and crew displayed remarkable level of teamwork; it was a fun cruise. Everyone aboard is a true professional. The Philippine researchers lead by Cesar Villanoy [Leg 1] and Laura David [Leg 2] are to be especially commended. Their cheerful attitude and sense of responsibility are truly admirable. The official Observers of the Philippine government pitched right into the work, becoming integral members of the team. The US researchers displayed a positive sense of sharing information and expertise. Julie Pullen, a modeler, is commended for her appreciation of observational oceanography, a very good sign. Frank Delahoyde, the Scripps computer support person, provided his usual solid support, particularly in tracking down quality issues in the CTD salinity sensors used on the Joint and Regional cruises. The Scripps Res tech, Drew Cole, is excellent, always there when needed, and always so cheerful. The many graduate students on the research staff, whiling learning how to become observational oceanographer, were essential to the cruise success. My thanks to Captain Wes Hill and the Mates and entire Melville crew for safe passage through all of the hazards of archipelago waters, with its many small fishing boats and nets; and to the Engineers who kept the ship cool and comfortable in the tropical clime.

II Data Collection:

During RIOP08 we obtained 153 CTD-Oxy-fluorometer/LADCP stations [Figures 2] as well as underway data along the track [Figure 1]. As with leg 1 we repeated several stations of the exploratory cruise to contrast the winter and summer monsoon ocean stratification and circulation. We also repeated stations obtained during the joint cruise to investigate the evolution of the ocean response to the developing winter monsoon.

The CTD-Ox provides information about the ocean stratification, a consequence of a variety of ocean and atmosphere spatial variable processes, spanning a range of temporal scales, thus providing an integrated look at the resultant stratification. The Hull and Lowered ADCP provides more of an instantaneous look at the shear within the water column. The comparison of these data to the CTD often provide insight to how the ocean works. The underway system provides a suite of parameters of the sea surface along the ship track, revealing the impact of sea-air fluxes as well as the swirls of the surface layer eddy fields.

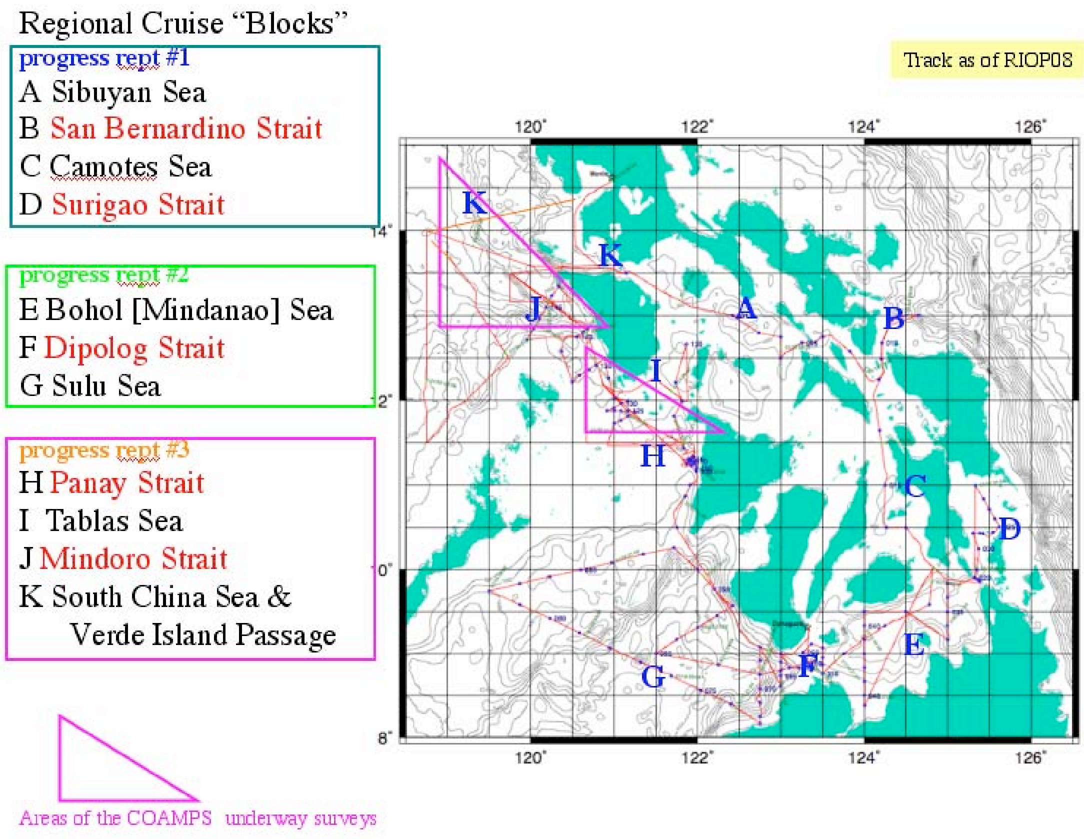

Figure 1 Research Blocks and ship track of ***RIOP08****.*

Water samples were taken for calibration of the CTD salinity. A pressure depend offset in the salinity sensor was found that affected the Joint and the Regional cruises. CTD data of the highest quality is always needed to unravel the complex, spatial and temporal depended process characteristic of archipelago regions, particularly in the investigation of the ventilation of the deep isolated basins of the Philippine waters. The CTD oxygen sensor also requires close calibration. The onboard oxygen titration as well as processing CTD cast water samples for chlorophyll [with attention to the impressive chlorophyll maximum found at the top of the pycnocline on most stations] were carried out by UPD/MSI/PH, see report of Laura David appended to this progress report.

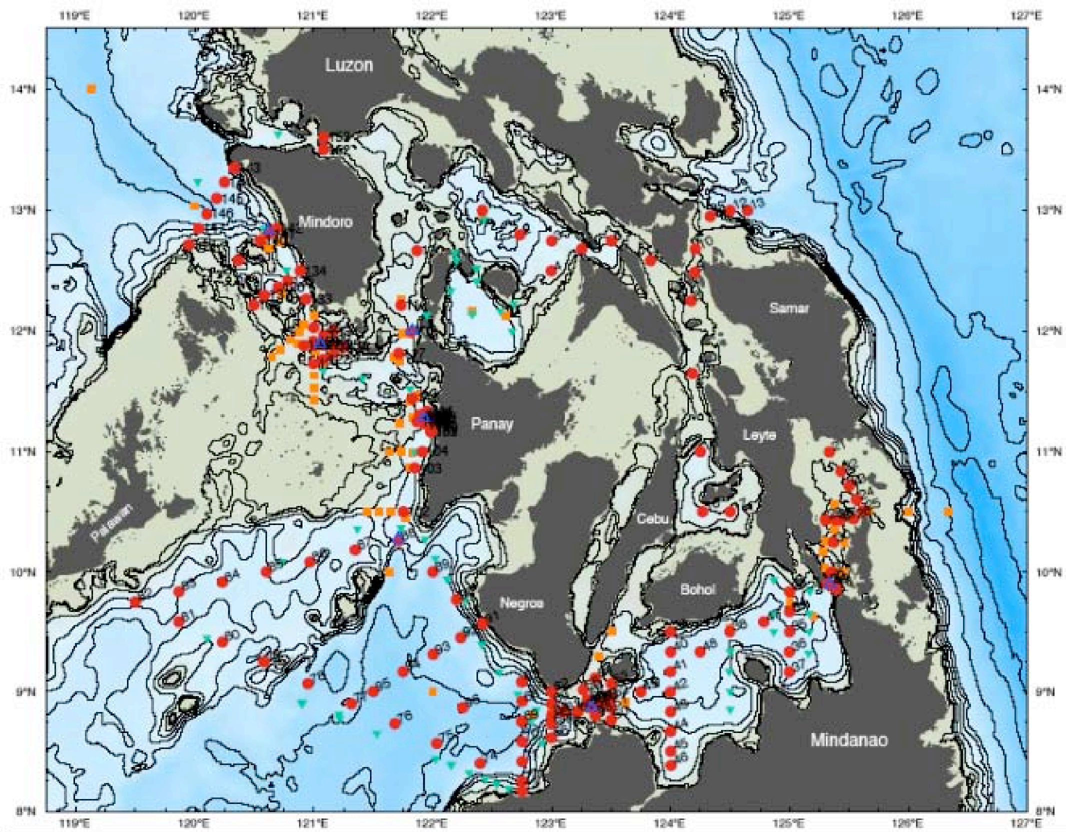

Figure 2 Regional 2008 IOP CTD/LADCP stations [red dots]. The smaller orange squares are stations obtained during the Exploratory Cruise June/July 2007. The green triangles are the stations of the Joint Cruise Nov/Dec 2007. The blue open triangles mark the positions of the ADCP and MP moorings.

Besides the standard station and underway data collection we preformed 4 underway surveys [Figure 1] for evaluation of the 3 km resolution Coupled Ocean/Atmosphere Mesoscale Prediction System, COAMPS model ocean and atmosphere predictions, see the appended report by Julie Pullen. The underway hull ADCP, the sea surface and the meteorological observations will be used for comparison to the model simulations of the winter monsoon conditions. The wind field, affected by the configuration of the mountainous islands of the Philippines, induce an ocean response [spin-up/spin-down] to this highly textured and variable forcing field. Specific attention is on the energetic wake eddies that form to the west of the tip of Mindoro and Panay

Islands, and to the extension of the Mindoro effect into the South China Sea.

As the underway anemometer was not working due to corroded electrical connection, the science watch read the ship anemometer dials every 15 minutes. These were then digitized and converted to the real wind upon correction of the ship speed/heading information. Replacement connectors are expected to arrive in Manila before the start of the IOP process cruise of Craig Lee.

Closely spaced grids of CTD/LADCP, with supporting multibeam topographic data and the suite of underwater surface and hull ADCP data were carried out over the ADCP moorings in the Panay Strait [11° 16.74'N; 121° 55.464'E; 106-116; 149-151 sequence] and Mindoro Strait [11° 53.648'N, 121° 03.294'E; CTD 121-132 sequence] . Station 118 was ~1 nm from the Tablas ADCP mooring [12° 00.288'N; 121° 49.608'E] . Station 88 was obtained ~1 nm from the MP1 mooring at 12°49.668'N; 120°36.930'E, the northern end of Mindoro Strait. The mooring sites are shown by the blue triangles [if you can find them] on Figure 2.

III Some Comments of our Findings:

The group θ/S scatter, providing a view of the water mass stratification of the Philippine seas, of the three PhilEx cruises to date is given in Figure 3. There are some important differences between the June/July 07 Exp Cru and the RIOP-08, with the Joint cruise data showing lead into the winter stratification and circulation conditions. The main differences are the increased freshwater inventory down to roughly 130 m throughout the region, the reversal of the Sulu gyre, the changes in the South China Sea / Sulu Sea connectivity by way of Mindoro and Panay Straits. By the way- a few names changes since my Exploratory Cruise reports: Bohol Sea is now Mindanao sea; Mindoro Strait south is now Panay Strait.

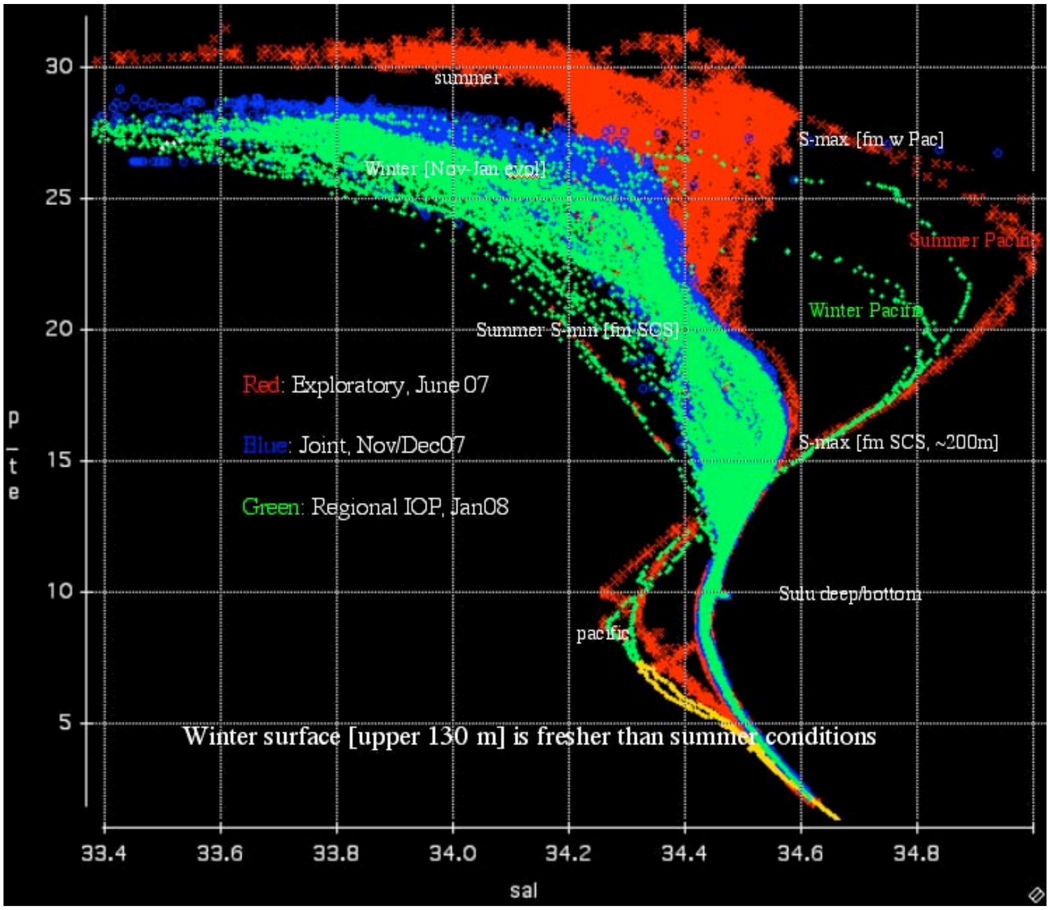

Figure 3 θ/S scatter for the Exploratory, Joint and Regional IOP08 PhilEx cruises

• Large Scale Surface Layer Circulation:

Surface layer circulation from the hull ADCP, 150 KHz [Figure 4a,b] reveals a the general pattern of surface circulation. Of course, tides are embedded in the observed currents. The flow in the San Bernandino and Surigao Straits where strong tidal currents are found may mask the non-tidal flow, so caution is suggested in interpreting these vectors as vigorous mean flow of Pacific water into the interior Philippine seas [though I think they are]. Comments added to Figure 4a provide some thoughts about the circulation pattern. The January surface currents in the Sulu Sea are cyclonic, whereas the gyre was anti-cyclonic in June 07, though [maybe] more meso-scale activity in January; in the Mindoro and Panay Straits the January currents form energetic eddies, a response to the complex wind stress curl, in June the surface flow was weak, towards the South China Sea. The deeper flow in both seasons is towards the Sulu Sea.

Comparison of the measured currents to the output of the various models of PhilEx will be interesting. I suggest that the Hull ADCP comparison to model output may be pursued in a quantitative way by picking out of the model the current info at the time, depth and lat/long of the Hull ADCP observational data. This is like: driving the ship based sensors thru the model "world". An observational and model "time series" may then be compared in a quantitative manner using many methods. Similar comparison to the Lowered ADCP, to underway SST, SSS and chlorophyll, as well as the stratification from the CTD-O_2 stations, can be performed with model output [and satellite data]. The observations represent the real world, within the limits of instrument measurements and however the measurement devices disturb the natural system, but observational data sets have gaps in space and time. The model data offer uniformly gridded data and offer the possibility of looking at conditions beyond what is feasible by observations alone, but then the model world [physics, resolution] may be flawed. Together observations and models lead to insight, only if both are fully understood and appreciated.

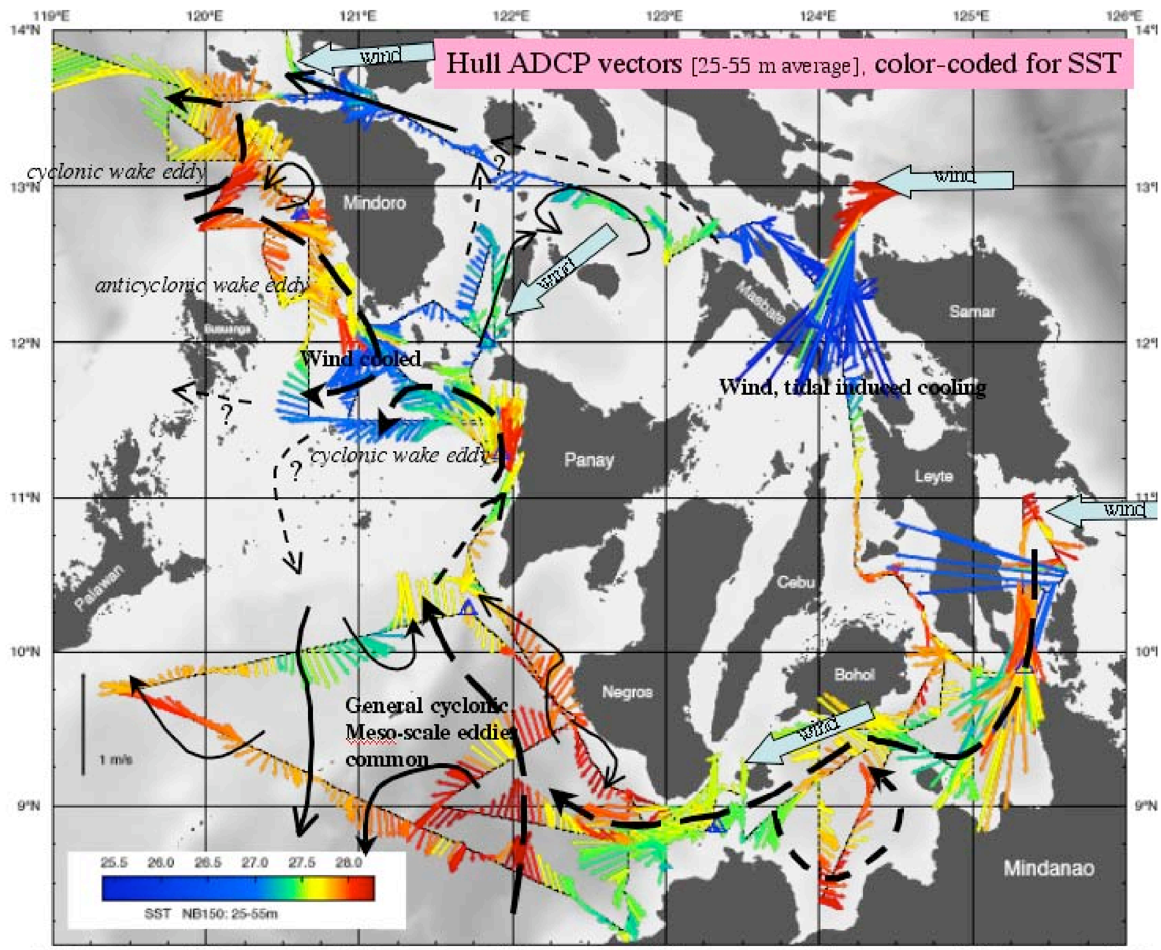

Figure 4a. Underway Hull ADCP derived currents, averaged in the 25-55 m interval, color coded by SST along the path of RIOP08. The black arrows show suggested circulation features, with question marks added where the source or fate of the measured flow is uncertain.

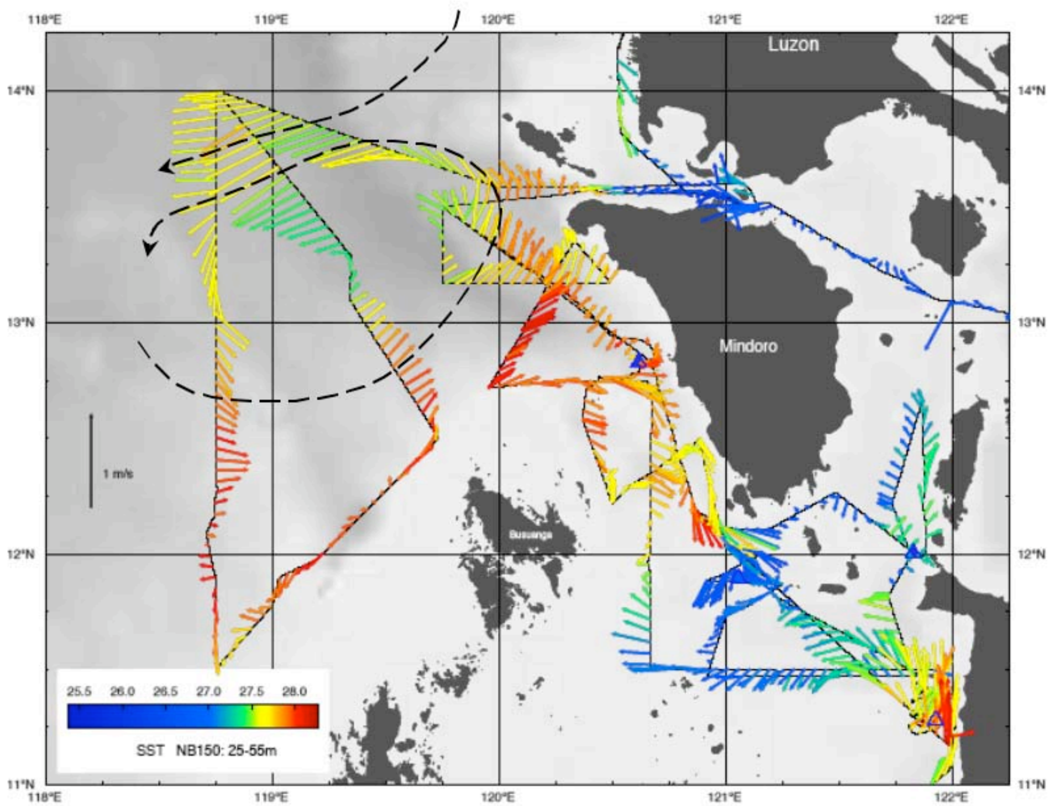

Figure 4b View of the hull ADCP 25-55 m average along the Mindoro and Panay tracks. Inferred circulation arrows are added to the large cyclonic eddy west of Mindoro. The ship line from 14N 118› 45'E to Manila will be added after the arrival in Manila.

• Verde Island Passage: It is likely that San Bernardino water derived from the western Pacific spreads westward to pass into the South China Sea via Verde Island Passage. Westward currents of ~ 1kt . were observed in the entire ~325 m Verde Island Passage water column at stations 152 and 153. There is possibility that some of this water is coming from Panay via Tablas Sea, but Tablas [sampled about a week before Verde Island Passage] is too salty in the thermocline to be the sole source. The Sibuyan Sea is also somewhat saltier in the 20-25C [~100 m] layer than that layer in Verde Island Passage or San Bernardino Strait, but this may be more of a time issue, as the low salinity winter monsoon stratification may have spread westward during the 3 week period between sampling Sibuyan and Verde Island Passage. The amount of Pacific water entering the Philippine Seas and its advective pathways within the interior seas is not all that clear from the observations, here models may help. The Surigao contribution and fate is clearer, though there may be some difficulty in explaining the conversion of the salty Pacific surface water into Surigao surface water if the transport were substantial [>0.1 Sv] in the winter season.

• Pervasive O_2-min: From 12-14°C, 250-350 m, within the Philippine waters [excluding the western Pacific and South China Sea] there is an oxygen minimum. Its source is the displaced deep water of the isolated basins of the Mindanao and Sibuyan Seas,. These waters are forced out as 'new' water ventilates the deep/bottom layers. Mindanao Sea presumably as it's the largest interior sea, is the primary source of the regional pervasive O_2-min stratum. The O_2-min water derived from the Sibuyan Sea is also observed in this layer, but its spatial reach is limited.

• Stratification and Circulation within the Mindoro and Panay Straits:

§ Overflow into topographic depressions within the Mindoro and Panay Straits: Three topographic sills are encountered between the South China Sea and the Sulu Sea [Figure 5]. Basin scale effective sill depth is less than the deepest connecting level due to the mixing, and the form of passage cross-section at the sill. For sills 2 and 3 shown in Figure 5 the difference is 120 and 175 m, respectively. This suggest fairly strong mixing of the benthic layer at the sills within the Mindoro and Panay Straits.

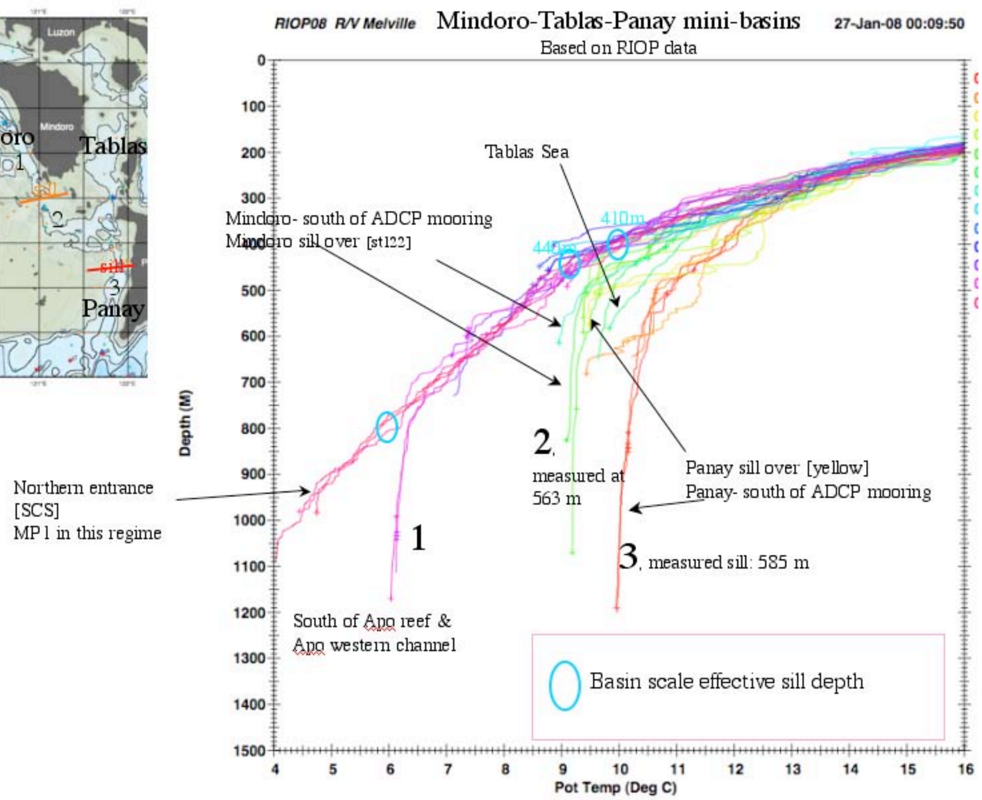

Figure 5 The mini-basins within the Mindoro and Panay Straits are revealed by the temperature profiles.

§ Seasonality: During the Exploratory Cruise of June/July 2007 we observed a transfer of surface water from the Sulu Sea into the South China Sea [SCS]. There was flow from the SCS to the Sulu Sea associated with a salinity maximum [S-max] near ~200 –250 meters [lower thermocline]. The SCS S-max is found throughout the Sulu

Sea, and enters into the Mindanao Sea. The S-max persisted into July 2007, though the southward speed decreased, presumably a consequence of the maturing summer monsoon. Below 400 m there was more substantial southward flow associated with the overflow into the deep Sulu Sea.

The RIOP08 reveals that during the winter monsoon the surface layer transfer between the SCS and Sulu sea is masked by the far more energetic wake eddies produced by the textured wind stress curl patterns as the NE monsoon winds encounter the mountainous Philippine Islands [Figure 4]. The southward flow at the 200 m S-max drawn from the SCS is evident]Figure 6].

Figure 6a-f offer informative series of profiles derived from the CTD and lowered ADCP, whose discussion would take too much text for this progress report, but as a picture is worth a lot of words, these are offered with few words embedded within the within the figures and their captions.

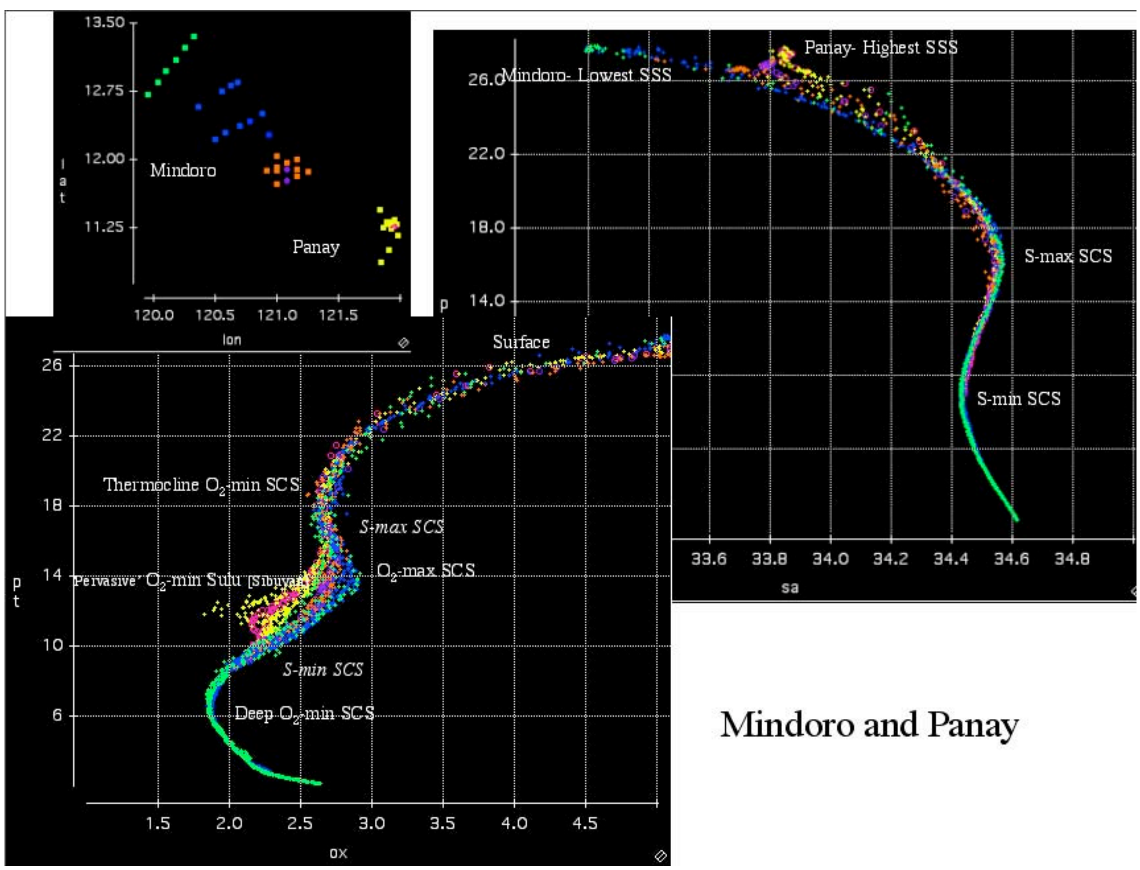

Figure 6a: Potential temperature /Salinity and the Potential temperature / oxygen scatter, color coded for 4 sub-regions within the Mindoro and Panay Straits, see map insert. The S-max near 16°C is derived from the South China Sea [SCS] as is the S-min at cooler deeper levels. The S-max is what is left of the inflow of Pacific thermocline water via the Luzon Strait into the SCS. The S-min is the North Pacific Intermediate Water,

which also enters the SCS via Luzon Strait. The pervasive oxy-min is seen near the 12°C layer.

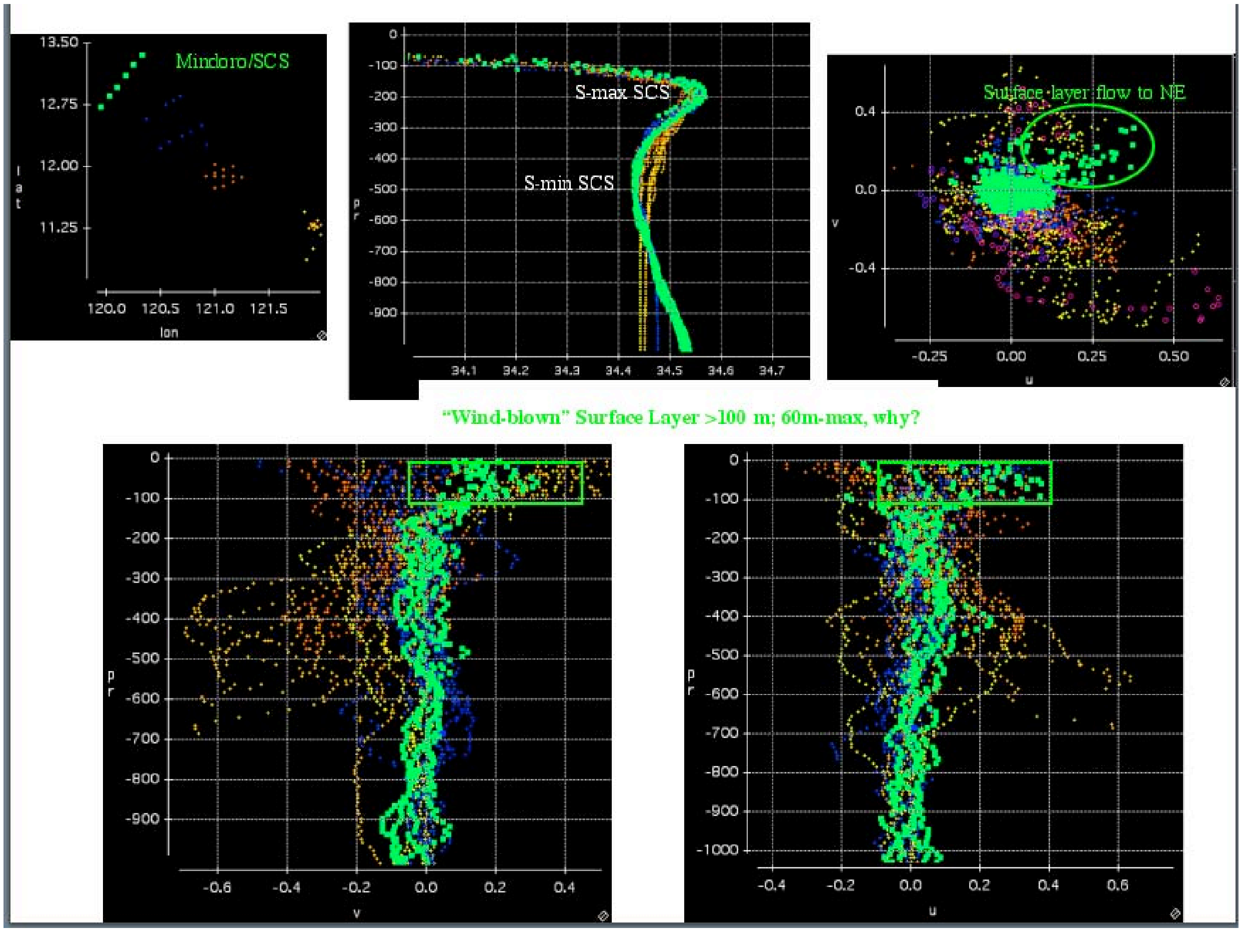

Figure 6b: The northern Mindoro profiles of salinity and of the zonal [u] and meridional [v] flow observed by the lowered ADCP. The u/v scatter is shown in the upper right panel. The surface flow is towards the NE, part of the cyclonic wake eddy characteristic of that region, see Figure 4. Below 100 m the u and v components are less than 0.1 m/s. From 100 to 600 m the flow averages slightly toward the SE, consistent with the movement of the SCS S-max and S-min towards the Sulu Sea. A maximum eastward flow near 400 m is within the SCS derived S-min layer.

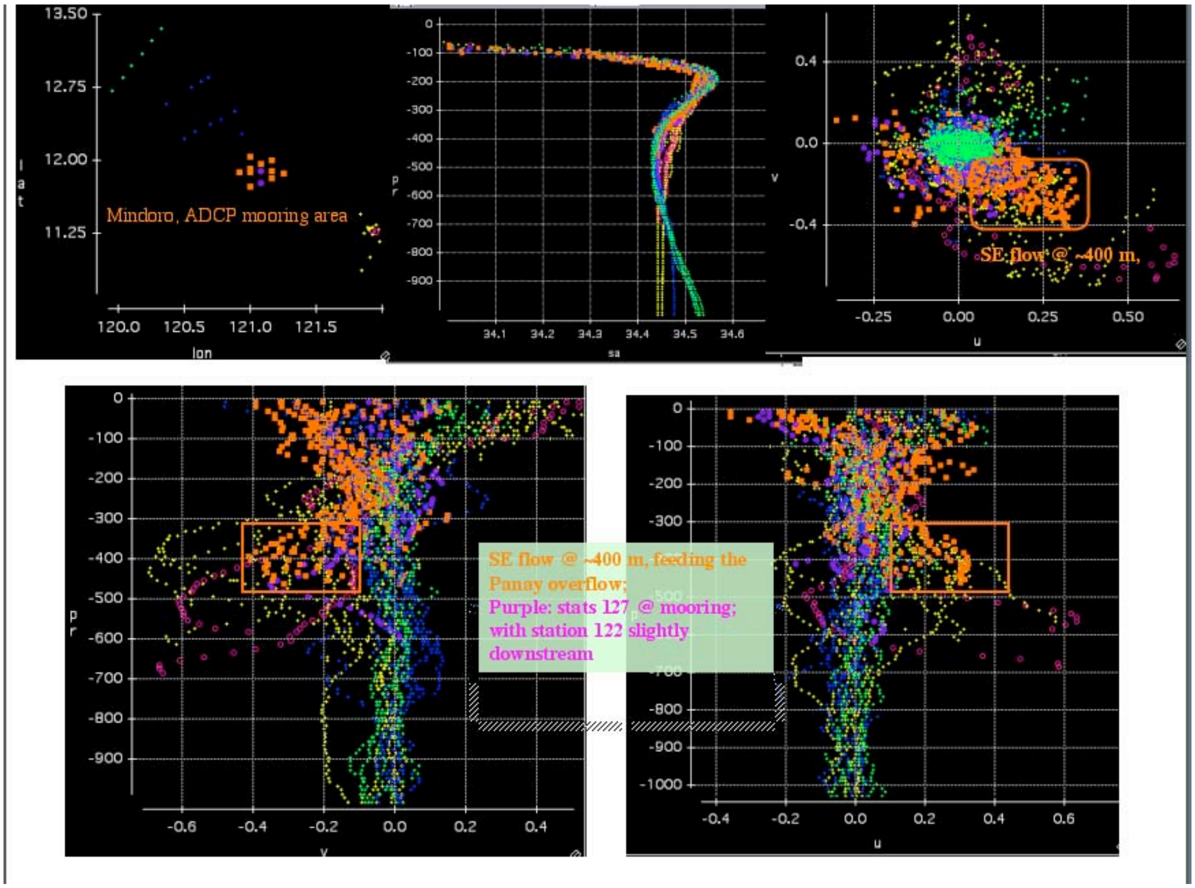

Figure 6c: Mindoro at the ADCP mooring site. The surface flow has a strong component towards the south [though split between to the east and to the west], likely part of the wake eddy off the southern tip of Mindoro [Figure 4]. Strong flow towards the SE is found at 300-500 meters, which feeds the overflow in Panay Strait. This and the overflow to the Sulu sea is the major aspect of the sub-surface circulation within Mindoro and Panay Straits.

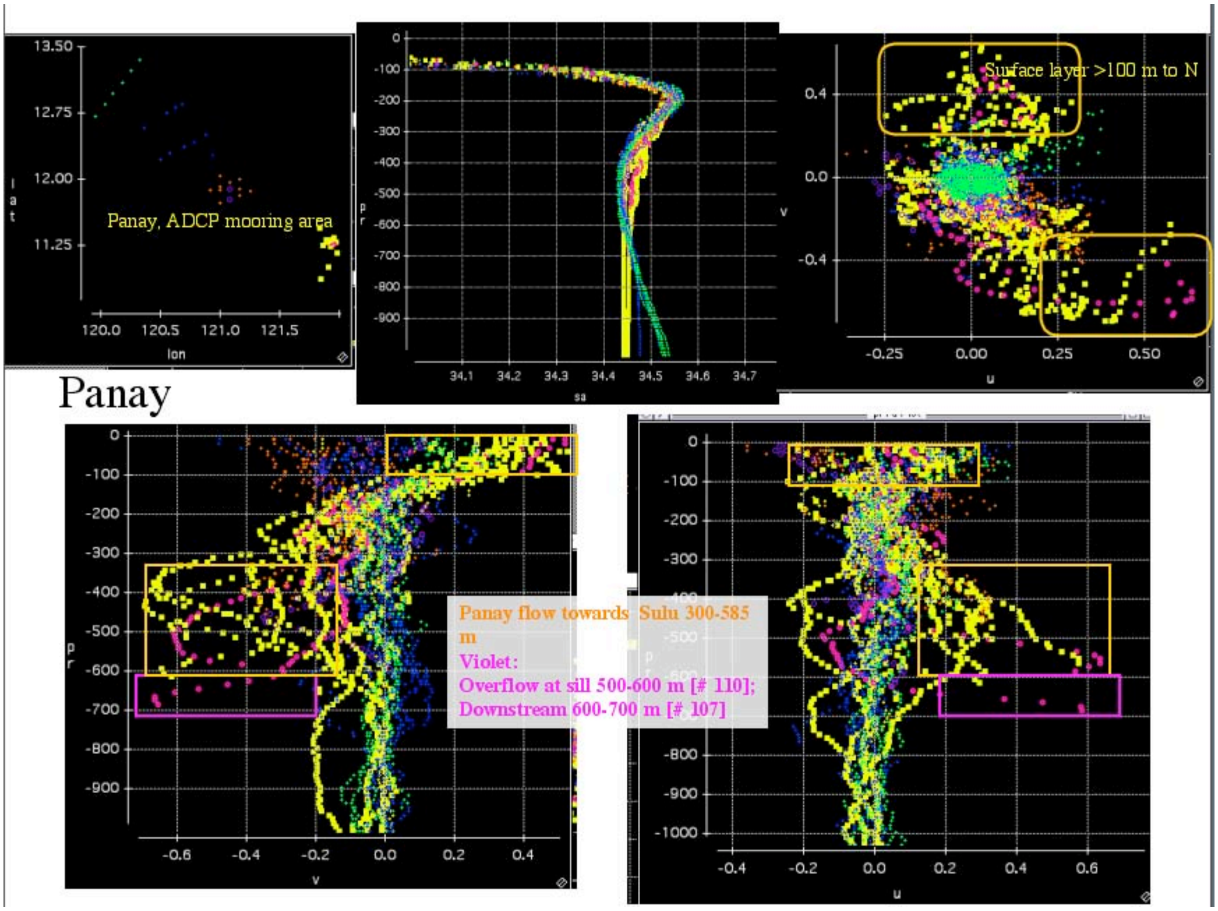

Figure 6d: The Panay Strait at the ADCP mooring site. The surface layer has a strong northerly component, part of a wake eddy formed off he northern tip of Panay. At depth things get interesting, within the vigorous overflow into the Sulu Sea [see report from the Exploratory Cruise]. The flow below 300 m attains values of a knot.

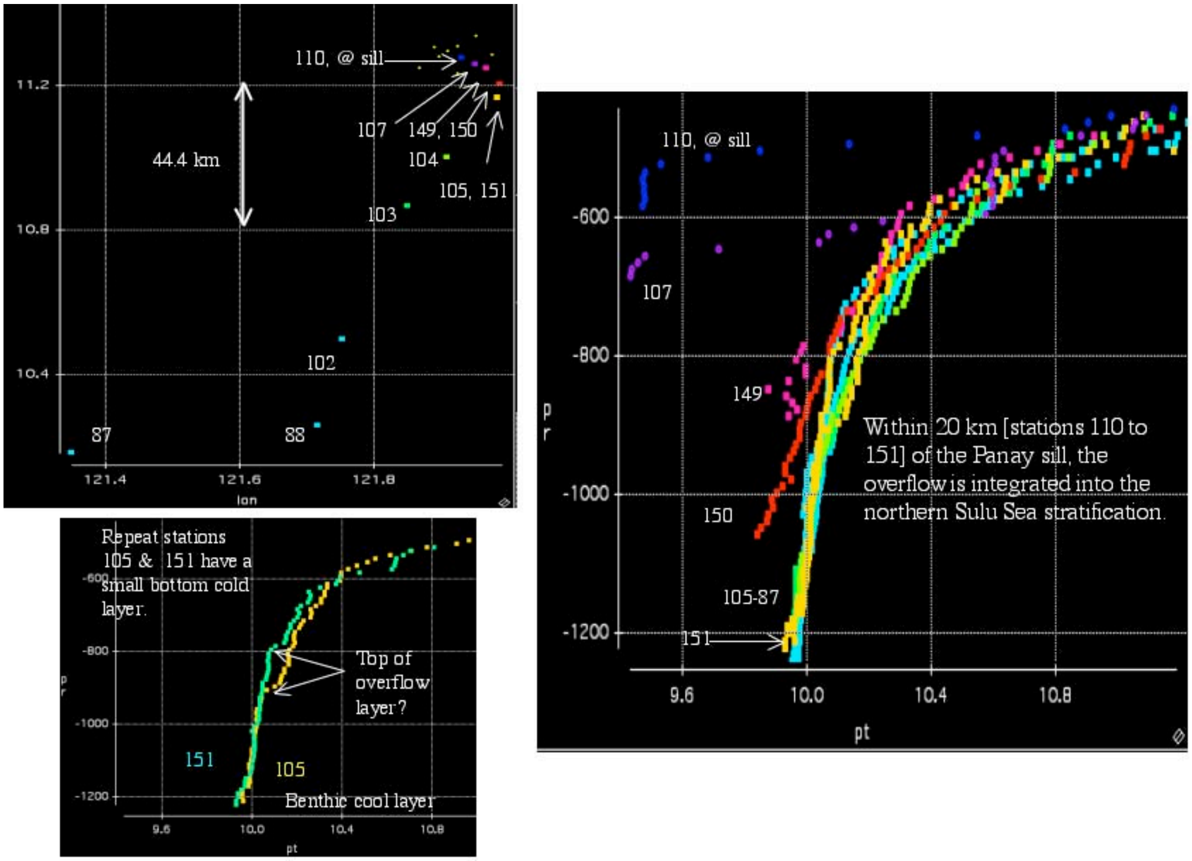

Figure 6e: A sequence of CTD stations from the Panay overflow sill [station 110] downstream towards the Sulu Sea. The attenuation of the cold benthic layer to the ambient water is essentially complete at station 151, only ~20 km south of the sill. This suggest rather energetic mixing of the gravity current with the ambient water.

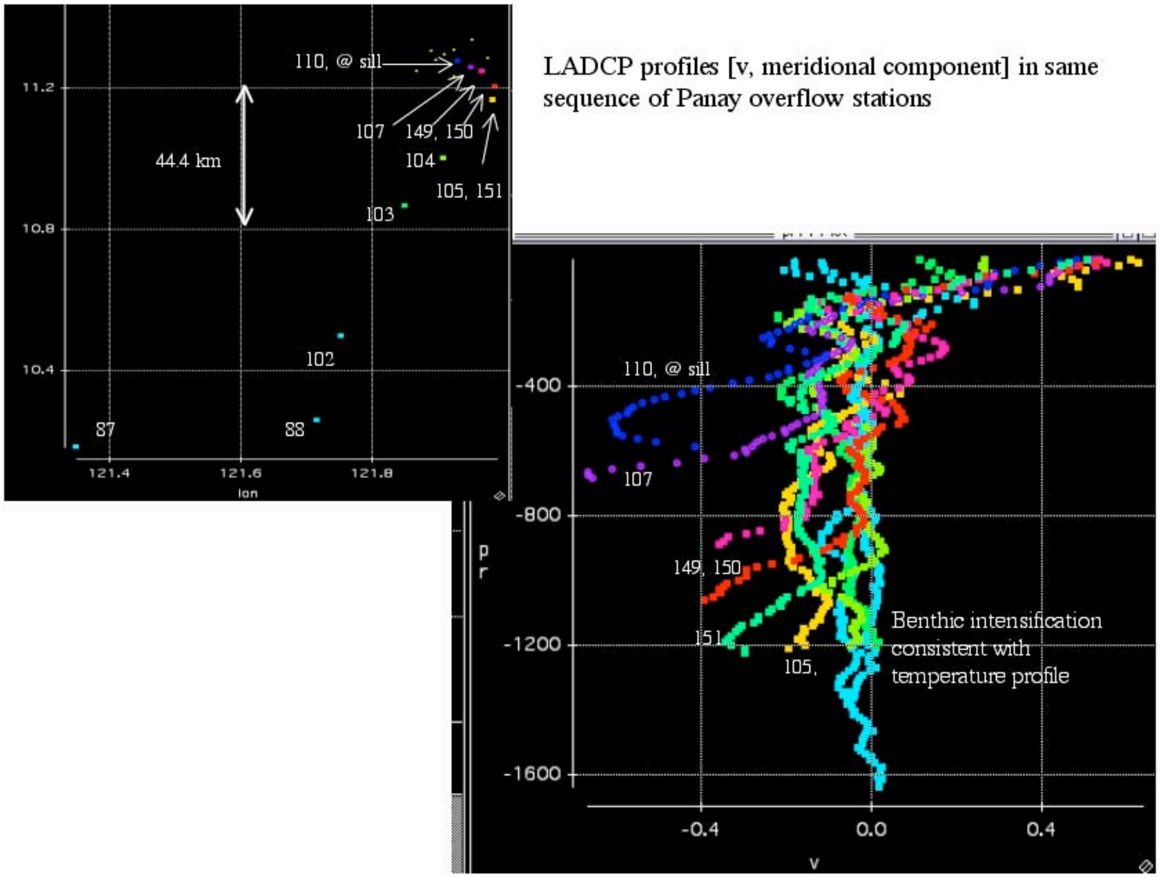

Figure 6f: The meridional speed at the CTD stations shown in Figure 6e. As the temperature of the benthic layer is mixed upward so is the kinetic energy of the gravity current, with the benthic speeds decreasing from ~1 kt to effectively zero in ~20 km.

• Dipolog Strait

The CTD and lowered ADCP profiles reveal a circulation system consistent with the schematic of the Mindanao [Bohol] Sea drawn up during the Exploratory Cruise. Of June 2007. Here we provide some further features of the Dipolog Strait [Figures 7a, 7b, 8].

There are 2 systems exchanging water between the Mindanao and Sulu Seas through Dipolog Strait [fig 7a, 7b]. The upper one is composed of surface outflow to the Sulu Sea, compensated with ~150 m inflow to the Mindanao Sea. This system is akin to an estuary circulation, with Pacific waters exiting the Mindanao Sea within the surface layer. Another exchange system is observed at deeper levels. There dense water overflows to the depths of the Mindanao Sea within the lower ~50 m, with export in the 300-350 m interval towards the Sulu Sea of the displaced resident water. This may be considered as buoyancy driven overturning circulation. Above the confines of the deep channel the flow circulation patterns is tilted across the Dipolog Strait [best seen >200 m in fig 8], so that the estuary outflow is stronger on the north side, estuary inflow stronger on the south side.

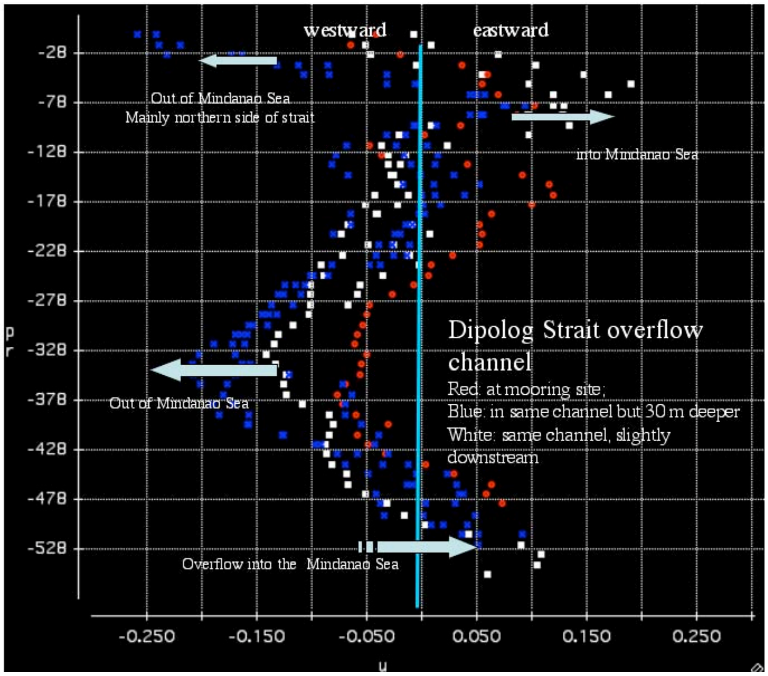

Figure 7a- LADCP profile of zonal flow in Dipolog overflow channel

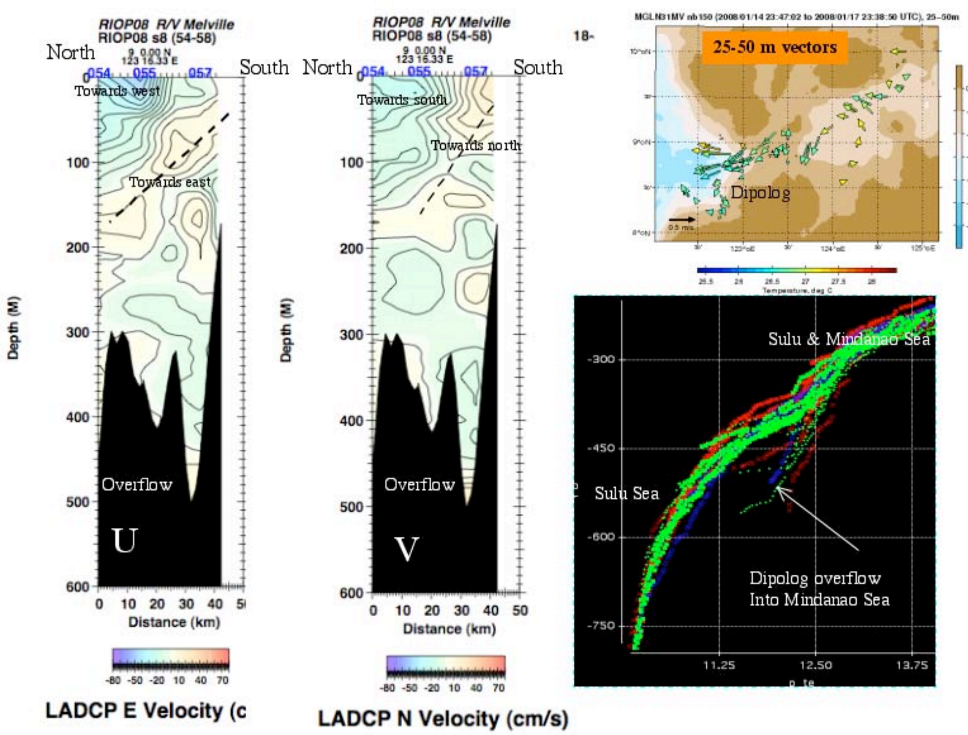

Figure 7b. Left panel: Lower ADCP section across Dipolog Strait. Upper right: hull ADCP measured currents in the 25-50 m layer. Lower right: θ°C profiles at Dipolog and in adjacent Sulu Sea

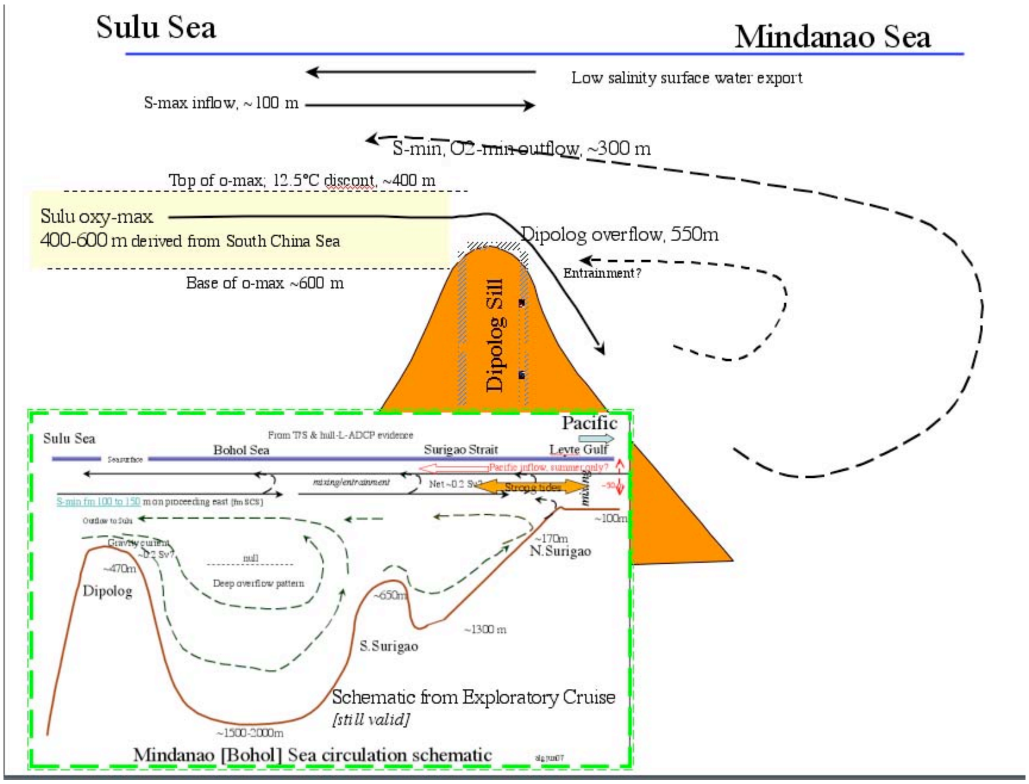

Figure 8 Extension of the Mindanao Sea schematic to the adjacent Sulu Sea.

2. Sulu Sea

• Surface layer circulation [Figures 9 & 10]:

The salinity maximum found in the western Sulu Sea near 150 m is derived from the South China Sea by way of Mindoro/Panay Straits. At 300 m a weak salinity minimum, with a more pronounced oxygen minimum is derived from the outflow from the Mindanao Sea [figure 9]. The surface circulation in the 'winter' Sulu Sea is cyclonic, though the presence of meso-scale eddies are suggested by the hull mounted ADCP and as shown by the NRL 32° model [figure 10]. At 150 m the gyre is shifted westward.

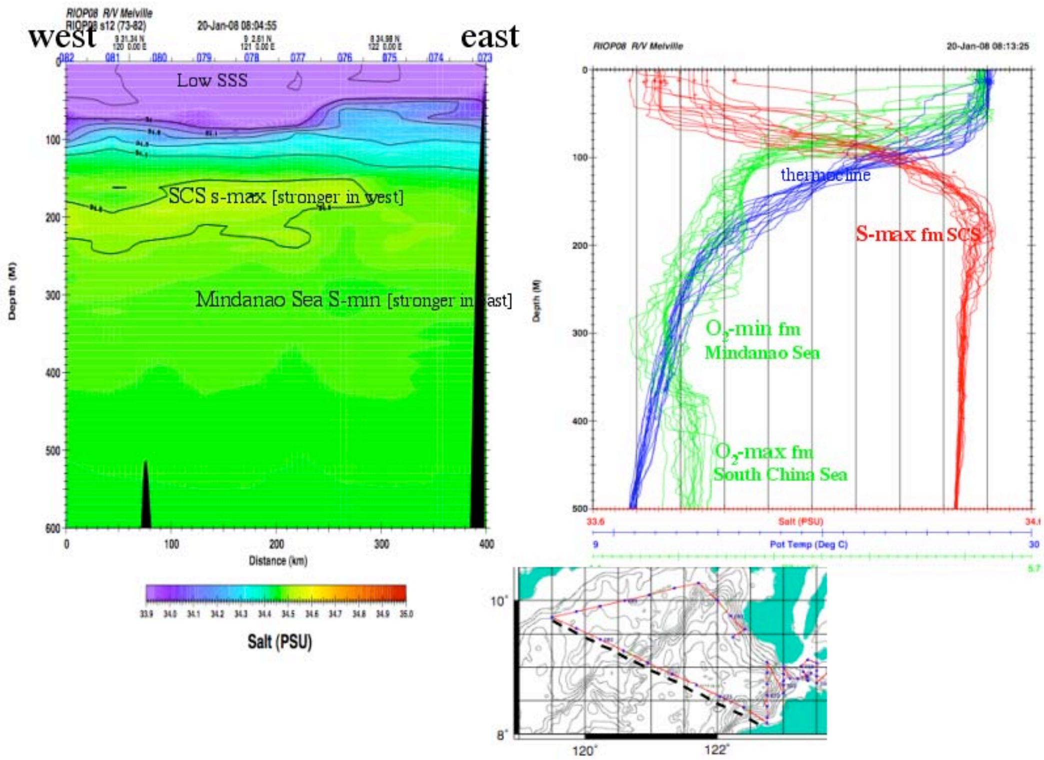

Figure 9 Sulu Sea stratification

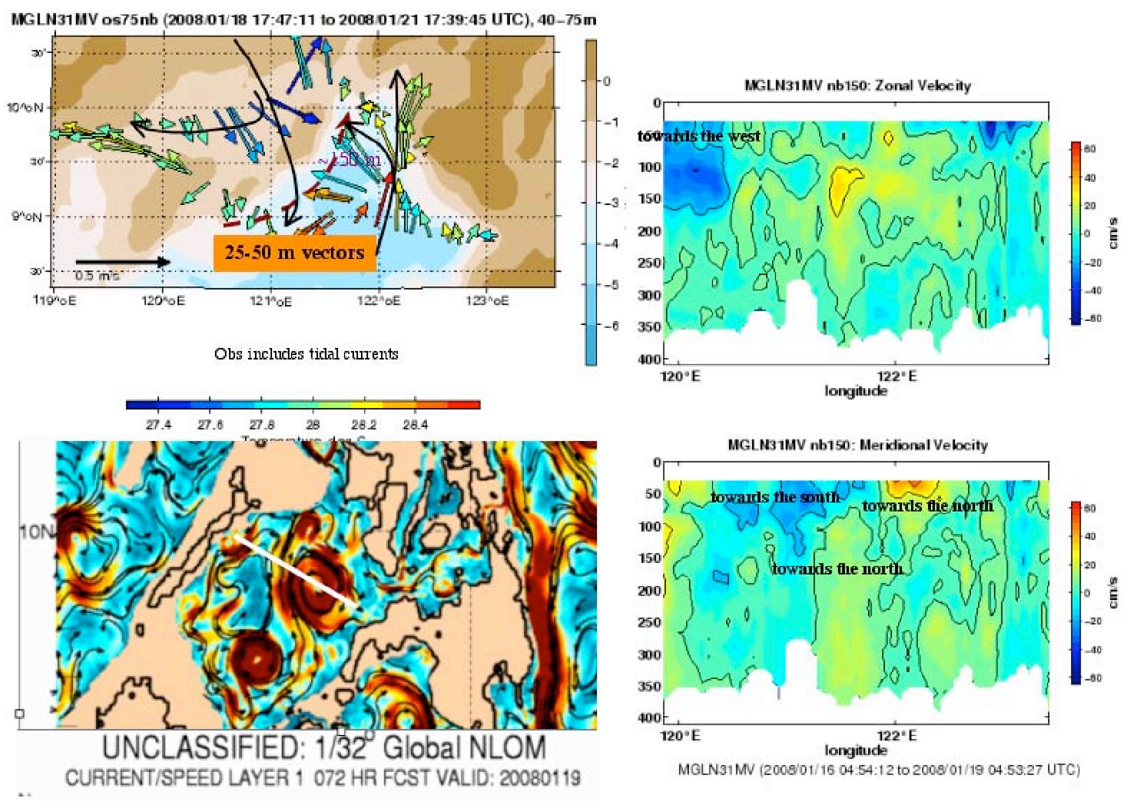

Figure 10 Sulu Sea circulation. Upper left panel is from hull ADCP at 0200L 22 Jan 08

• Deep Sulu Sea Puzzle [see figures 11, 12 and 13]:

Below 1000m the Sulu Sea is nearly adiabatic though it warms slightly from a θ-min near 2800 m, but yet salinity increases with depth, oxygen decreases with depth. For a single source for the water within the isolated confines of the Sulu basin one would expect both conservative properties of potential temperature and salinity to be homogeneous, oxygen, a non-conservative property would be expected to be reduced]. Geothermal heating would boost the temperature a bit, so a source somewhat cooler than the resident deep water is needed.

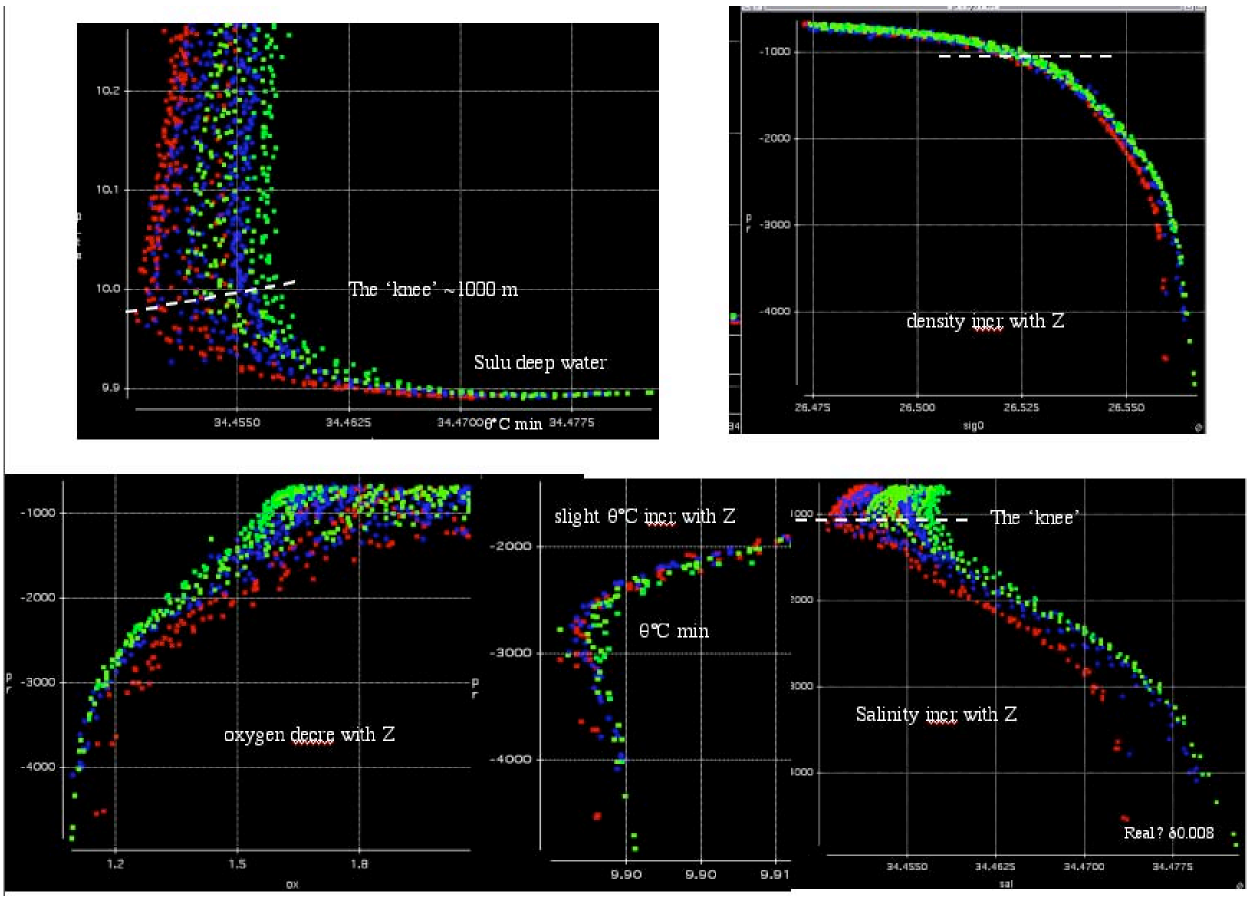

Figure11 Deep and bottom waters of the Sulu Sea. ***After plotting these figures we found that the regional CTD, and likely the joint cruise, require a pressure dependent correction to salinity. At >3000 m the correction is ~0.0079, so no real change in salinity in the Sulu basin. This has a slight effect on the depth of the southern source- from ~400m to ~420 m. The story does not change. As there is no modern data at the southern source, a survey at that site is recommended.***

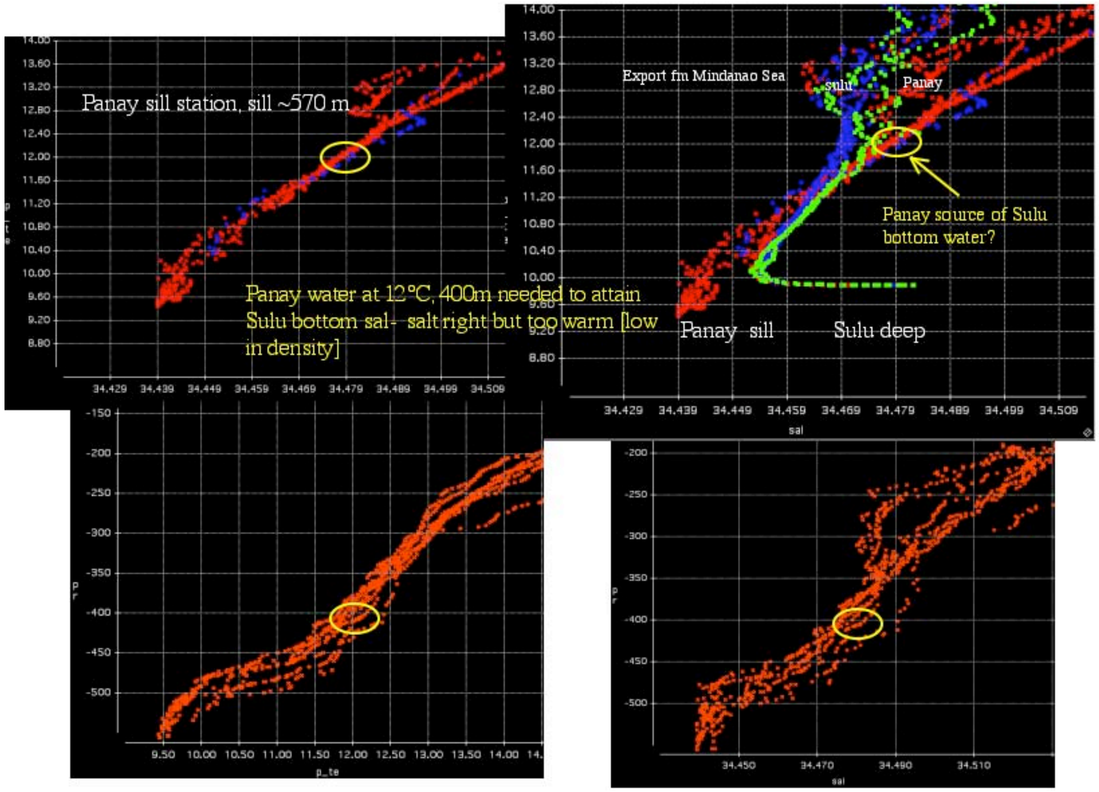

Figure 12 Panay overflow stations [red and blue], and the Sulu Sea deep water [green]. The yellow oval marks the water type that has the salinity to account for the Sulu Sea bottom water, but its temperature is too high to serve as the source water.

The Deep Sulu puzzle: Isolated basins ventilated from a relatively shallow topographic sill are filled with a homogeneous layer…so: What is the cause of the stratified water column within the Sulu Sea below the Panay sill depth?

The Sulu bottom water is 34.48 and 9.8°C. The Sulu bottom water source can't come from the north, from the South China Sea via Panay - to get the right salinity from Panay would be coupled to water too warm, around 12°C, to be the source of the Sulu bottom water.

Using 1993/94 Arlindo data [Figure 9] in the Sulawesi Sea [the sea south of Sulu] the right water is found at a depth of 400m . The Sulu solitons are produced just east of Pearl Bank [Apel et al 1985[1]] at 5.9°N and 120°E, in a 340 meter channel. The deepest sill connecting the Sulawesi to the Sulu may be south of the Pearl Bank at the Sibutu Passage, which may be closer to 300 m.

[1] Apel, J.R., J.R. Holbrook, J. Tsai, and A.K. Liu, 1985: The Sulu Sea internal soliton experiment. J. Phys. Oceanogr., 15 (12), 1625-1651.

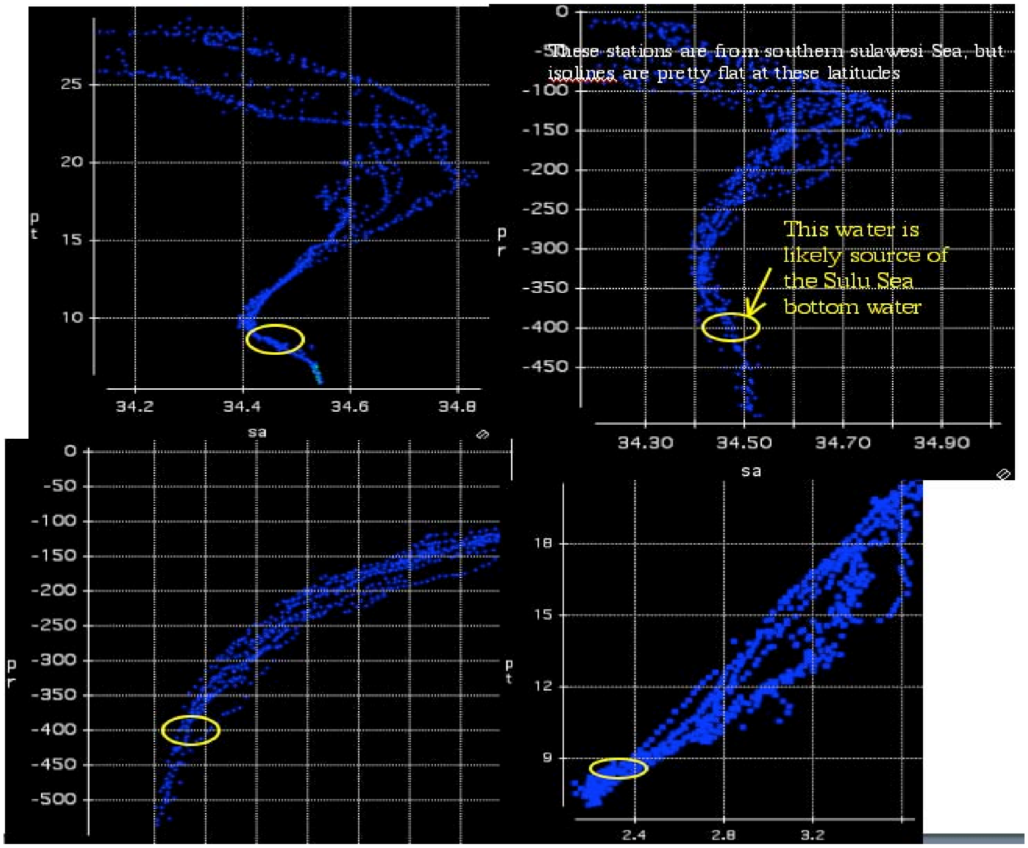

Figure 13 CTD stations from the Sulawesi Sea. The yellow oval marks the properties that can be the southern source of the Sulu Sea bottom water.

Hypothesis: bursts of sub-sill water make it over the Pearl Sill from the Sulawesi Sea at Spring tide when the solitons are produced.

The deep Sulu Sea has two 'competing' sources [I don't know any other deep ocean isolated basin that has this, except the open Atlantic Ocean]**:**

• Panay allows South China Sea water of 9.5°C, 34.44 to enter the Sulu Sea at 570 m; this water forms the deep layers within the Sulu Sea.

• Pearl Sill allows water of 8 to 9°C, 34.48 to enter the Sulu Sea at 400 m to get into the Sulu from the Sulawesi; this water produces the bottom water in the Sulu Sea

The Panay is not the only source for ventilation of the deep Sulu Sea- residence time estimates derived from the Panay over flow would be too long. Geochem and paleo analysis of Sulu data assuming a single ventilation source from the north may be wrong.

IV The Science Team for Regional IOP08

Leg 1, 9-22 January 2008:

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5. Debra Tillinger,	Lamont-Doherty
6. Zachary Tessler,	Lamont-Doherty
7. Jacob Greenberg,	Lamont-Doherty
8. David Sprecher,	Lamont-Doherty
9. Michael Gilligan,	NavOceano
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13. Bernardo, L.,	UPD/MSI/PH
14. Cabrera, Olivia	UPD/MSI/PH
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16. Solera, Leilani	UPD/MSI/PH
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19. Frank Delahoyde,	STS/UCSD, Computer Technician
20. Kevin Bartlett,	U. Victoria

Leg 2, 22 January to 1 February 2008:

1. A.L.Gordon,	Chief Scientist, Lamont-Doherty
2. Laura David	co-Chief Scientist, UPD/MSI/PH
3. Phil Mele	Watch Leader, Lamont-Doherty
4. Claudia Giulivi	Watch Leader, Lamont-Doherty
5. Debra Tillinger	Lamont-Doherty
6. Zachary Tessler	Lamont-Doherty
7. Jacob Greenberg	Lamont-Doherty
8. David Sprecher	Lamont-Doherty
9. Michael Gilligan	NavOceano
10. Julie Pullen	NRL
11. Bernadette de Venecia	UPD/MSI/PH
12. Joseph Dominic Palermo	UPD/MSI/PH
13. Kristina Cordero	UPD/MSI/PH
14. Rommel Maneja	UPD/MSI/PH
15. Roselle Borja	UPD/MSI/PH
16. Victor Ticzon	UPD/MSI/PH
17. Aletta Yniguez	UPD/MSI/PH
18. Drew Cole	STS/UCSD, Resident Technician
19. Frank Delahoyde	STS/UCSD, Computer Technician

20. Loyd Ayonayon — The Philippine Navy
21. Lawrence L Tamayo — The Philippine Coast Guard

V Appendices:

[A] Phil Mele: CTD/LADCP [RIOP08_ctd.pdf]
[B] Laura David & Cesar Villanoy: Bio-optical [RIOP08_David.pdf]
[C] Frank Delahoyde: Ship support data collection
[D] Julie Pullen: Comparison of observations to the Coupled Ocean/Atmosphere Mesoscale Prediction System, COAMPS model [RIOP08_pullen.pdf]

ARNOLD L. GORDON

1 February 2008

January 31, 2008

Modeling for RIOP08

Julie Pullen

Forecasting and support: Jim Doyle, Paul May, John Cook, Dan Geiszler

The design of the underway hull ADCP surveys was motivated in part by several questions related to the anticipated use of the data for model evaluation purposes:
1.) What are the wintertime horizontal and vertical scales of motion and
2.) How are those scales influenced by wind variability associated with dynamic monsoon wind jets and island wakes
Our strategy was to occupy multiple times, if possible, regions of expected high eddy variability as determined from high-resolution hindcast (3 km ocean modeling for December 2004-February 2005) and forecast (9 km) simulations.

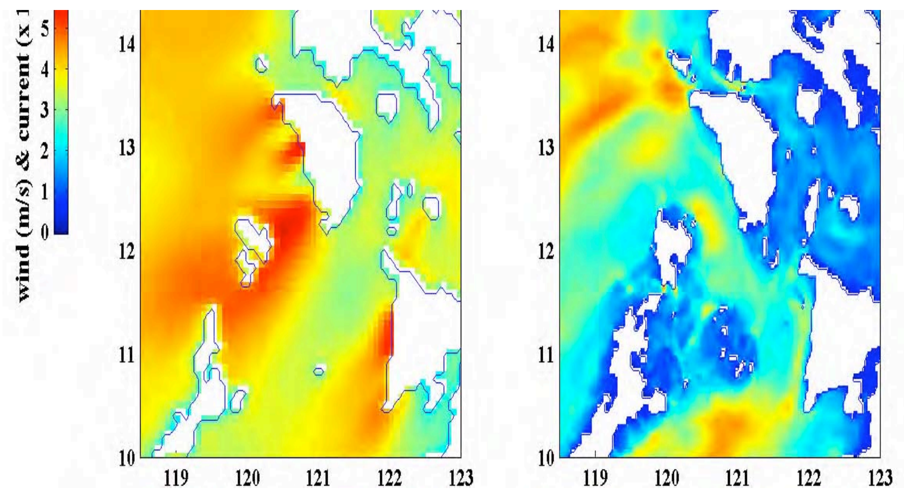


Figure 1: Standard deviation of 10-m winds and surface ocean current (December 2004-February 2005) from the 3 km/ 9 km ocean (NCOM) and atmosphere (COAMPS) simulation.

Regions of elevated variability in the hindcast simulation include the southeastern side of Mindoro Strait (off the eastern tip of Palawan), the west side of Panay, and the South China Sea west/northwest of Mindoro. In these hotspots of model variability we saw energetic currents in the observations as detailed below.

We conducted real-time regional data-assimilating forecasting using COAMPS/NCOM (both down to 9 km resolution). Forecasts were produced initially out to 1 day, and then extended to 2 days partway through the cruise.

COAMPS accurately predicted a monsoon intensification that possessed a more easterly component early on. The event began ~24 Jan. (following the crew exchange stop in Dumaguete) and lasted until ~27 Jan. Monsoon winds continued after that for the remainder of the cruise, but were weaker. The monsoon intensification was preceded by a storm system that moved northwestward through the Philippines over a period of several days.

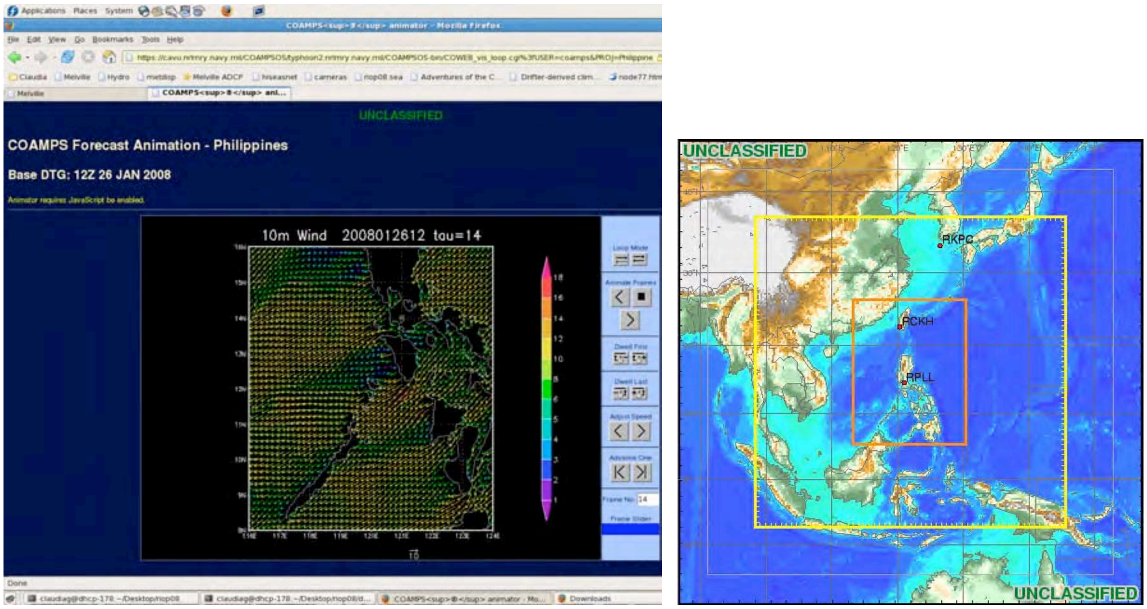


Figure 2: (left) COAMPS animations of daily forecast fields, as well as hourly images, are available on the web and were consulted throughout the research cruise. (right) Domain of the triply nested (81/ 27/ 9 km) simulation with ocean model (NCOM) forecasts produced on the innermost nest (9 km) outlined in red.

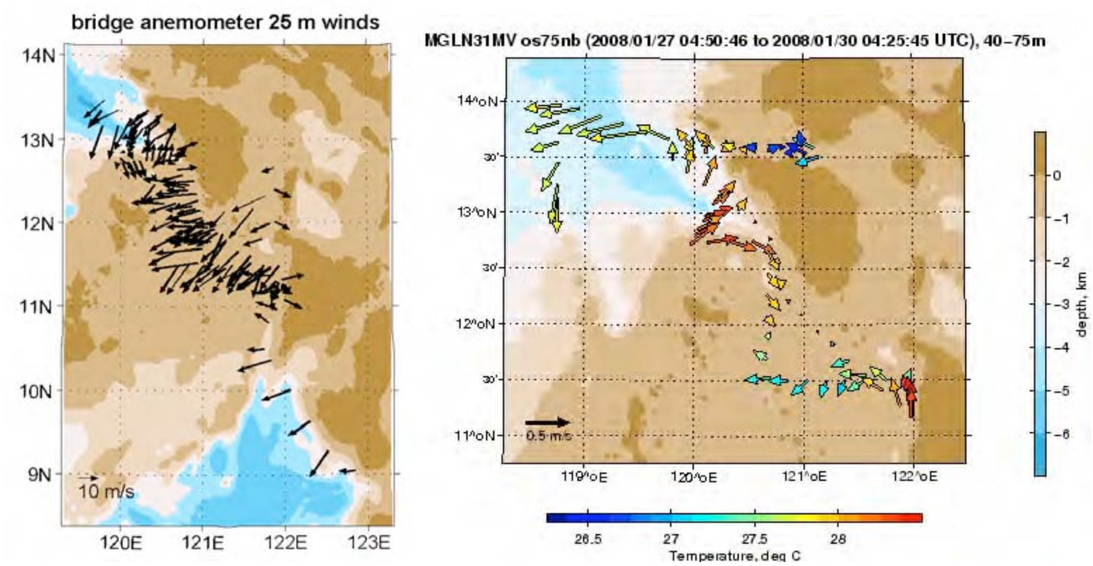


Figure 3: (left) 25 m winds transcribed from the bridge anemometer (22 Jan – 28 Jan) are awaiting final calibration; (right) underway hull ADCP ocean current measurements along with ship-measured ocean temperature (27 Jan – 30 Jan).

The ship transited several wind regimes. Sampling included (Figure 3, left) the lee regions of Mindoro and Panay and the wind jets north of Mindoro and Panay. The strong curvature in the winds near the tips of Mindoro (especially the north) and an atmospheric eddy in the lee of Mindoro are evident. The "strong curvature" is consistent with atmospheric flow blocking upstream of the island and flow being forced around the island in the tip jets. The occurrence of onshore winds, possibly associated with the sea breeze, is a feature in the lee of Mindoro and Panay. The wind jet and wake features identified in the observations are also apparent in the output from COAMPS during the monsoon winds (Figure 4). At times there is an easterly orientation of the winds between Panay and Mindoro, as was forecast by the model.

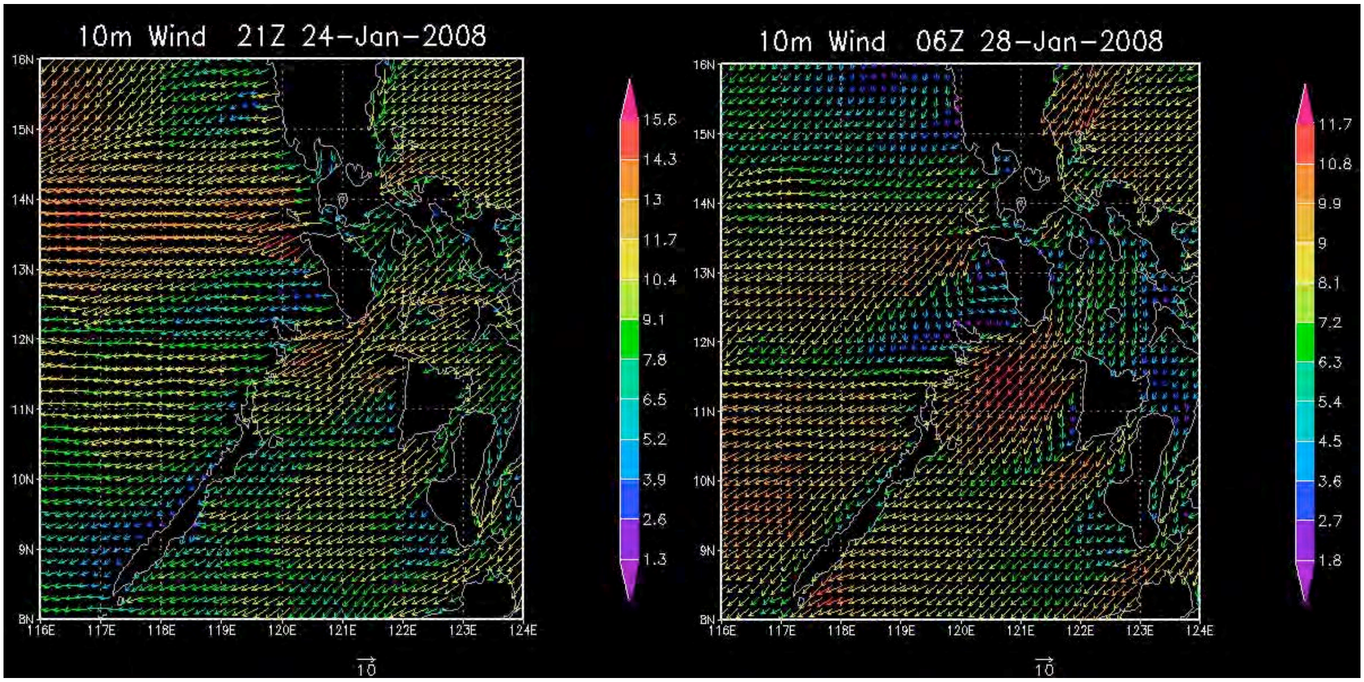


Figure 4: COAMPS 10 m forecast winds (9 km resolution) at two times during the monsoon event. Left panel represents a 21 hour forecast, while the right panel shows an 18 hour forecast. Forecasts are valid at the time, GMT, listed in the title.

The long Panay wake region associated with the easterly orientation of the winds early in the monsoon event (Figure 4, left) is striking and was one of the reasons the ship reoccupied the area in order to investigate the impact of this pronounced wind feature on the Panay ocean eddy.

The observed currents (Figure 3, right) reveal portions of the eddy structures that are prevalent in response to the winter forcing. Often these eddies are located in wind wake regions (e.g., cyclonic circulations off Panay and Mindoro). Forecast ocean currents and temperatures at two times show a correspondence with observations, although discrepancies do exist (Figure 5). For instance, the observed warm waters and strong currents adjacent to Panay merging cyclonically with colder offshore waters from the north is represented in the model. As is the cold (~26°C) water in Verde Island passage between Luzon and Mindoro and the warm (~28°C) water impinging on Mindoro in the large cyclonic eddy. However, based on the currents and SST west of Palawan, the strong westward model flow between the northern islands of Palawan is presumably an artifact of the 9 km model resolution and underlying bathymetry/topography dataset which does not represent the smaller islands and shallow depths that should obstruct flow. (These islands do appear in the 3 km resolution simulations of Figure 1.)

Using 2 day ocean forecasts, the path of the final underway hull ADCP survey was designed to pass over the offshore region of the Mindoro eddy (Figure 5, right). The cyclone/anticyclone pair located offshore of Mindoro and Luzon in the South China Sea are persistent features in the region (Pullen et al., 2007), and the cyclone was mapped by the ship (Figure 3, right). The large anticyclone forecast by the model drifted outside the uncontested EEZ of the Philippines so we were not able to pursue it.

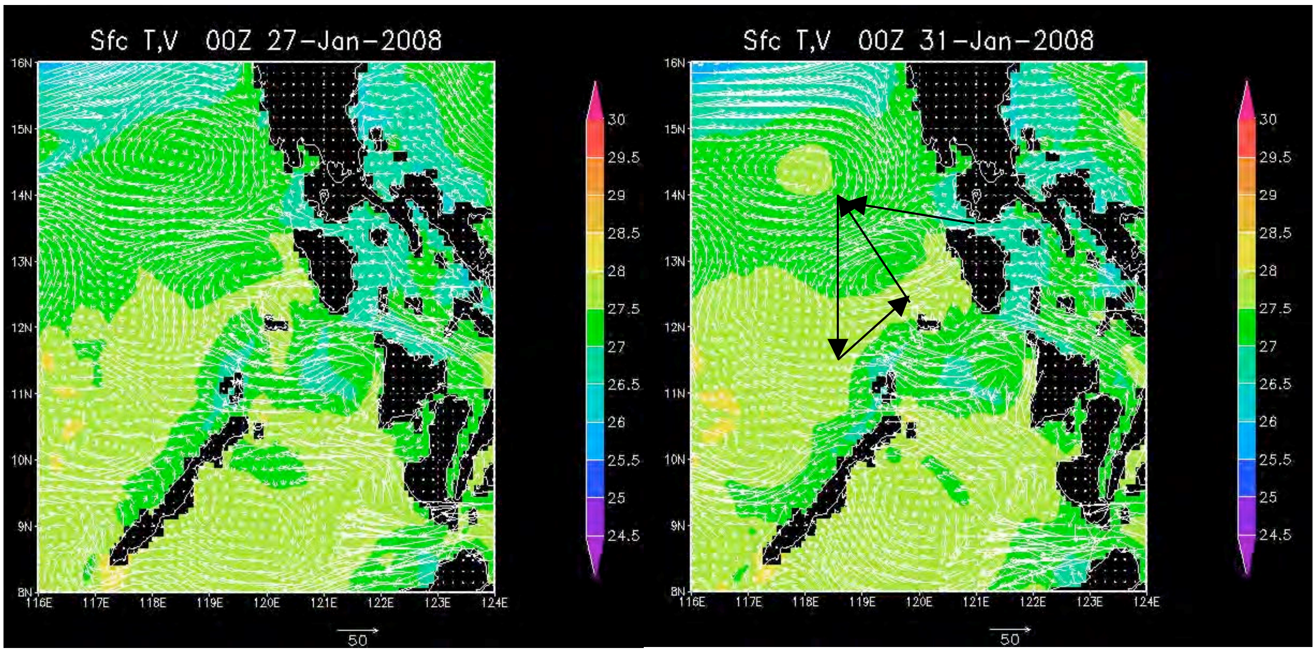


Figure 5: NCOM (9 km) surface current and temperature from (left) 1 day and (right) 2 day forecasts valid at the time (GMT) indicated in the title.

Reference:

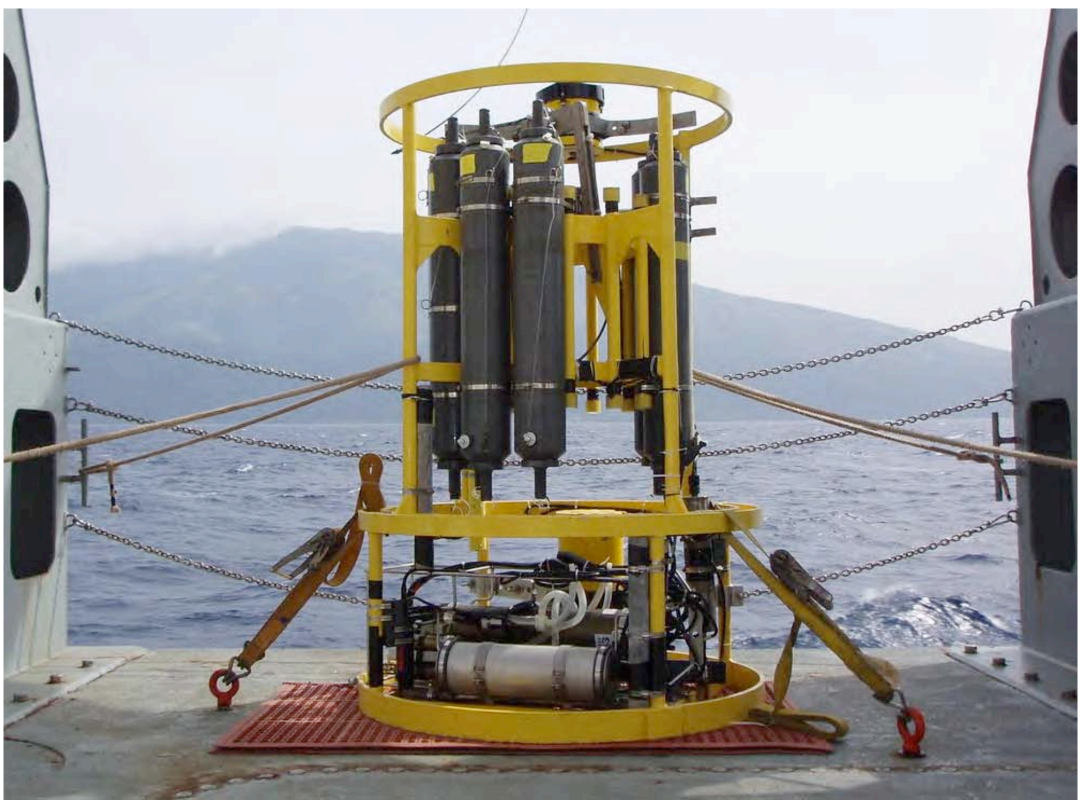
Pullen, J., J. D. Doyle, P. May, C. Chavanne, P. Flament, and R. A. Arnone, “Eddy shedding in the South China Sea triggered by monsoon surges,” *Geophysical Research Letters*, submitted, 2007.

CTD

153 profiles of temperature, salinity and dissolved oxygen were obtained using equipment provided by ODF/SIO. The basic package consisted of a SeaBird Electronics SBE911+ CTD system fitted with two sets of ducted conductivity and temperature sensors, dual pumps, and a single SBE43 dissolved oxygen sensor. The sensor suite was mounted vertically. One second GP90 GPS data was merged with the CTD data stream and recorded at every CTD scan. Dual LADCP data were collected separately. Data were acquired using a Windows PC and SeaBird Seasave software. Data was processed by a suite of ODF programs. The CTD package remained on deck during the cruise.

Most profiles were planned to reach within 10 m of the bottom. Approach to the bottom was guided by a Benthos altimeter mounted on the frame. The altimeter worked well for most casts.

Water samples were collected using a 12-position carousel fitted with seven 10 liter water sample bottles. Water samples were collected for on board analysis of salinity and disolved oxygen for standardizing the CTD data. Water sample salinity was determined using a Guildline Autosal 8400A laboratory salinometer, standardized with batch P148 standard water from OSIL, date: 10-Oct-2006. The salinometer was housed in a temperature controlled lab. Water sample dissolved oxygen was determined by modified Winkler method for a spectrophotometer.



CTD Summary Table:

depth: seafloor depth calculated from LADCP data. Italicized values are MultiBeam data.

DAB: Distance Above seafloor Bottom calculated from LADCP data. Italicized values are estimates.

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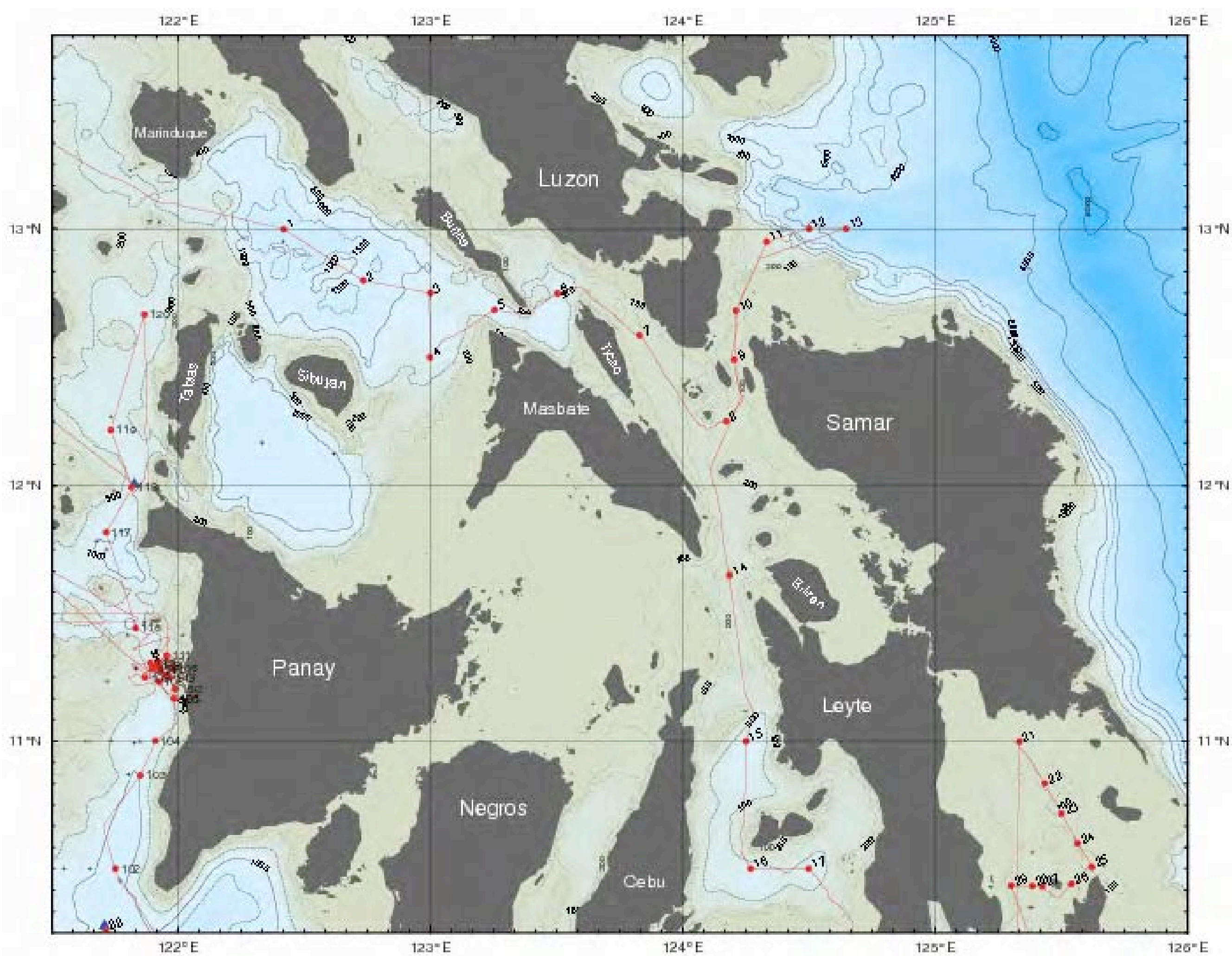
1	12 59.90	122 25.08	2008/01/10	00:55	1635	11
2	12 47.90	122 44.01	2008/01/10	04:27	1503	9
3	12 44.97	122 59.98	2008/01/10	07:24	642	9
4	12 29.95	122 59.89	2008/01/10	09:58	680	10
5	12 41.07	123 15.17	2008/01/10	12:41	851	9
6	12 44.93	123 30.22	2008/01/10	15:12	540	11
7	12 35.07	123 49.74	2008/01/10	18:48	187	9
8	12 15.00	124 10.31	2008/01/10	22:17	173	10
9	12 29.37	124 12.20	2008/01/11	00:23	135	13
10	12 40.87	124 12.57	2008/01/11	02:40	170	9
11	12 56.95	124 19.95	2008/01/11	05:31	314	6
12	13 0.02	124 29.97	2008/01/11	07:22	1952	8
13	13 0.01	124 38.79	2008/01/11	09:59	*3545*	*600*
14	11 39.02	124 11.06	2008/01/11	19:46	193	11
15	11 0.03	124 15.01	2008/01/11	23:33	826	12
16	10 30.02	124 16.07	2008/01/12	03:01	810	11
17	10 30.05	124 29.92	2008/01/12	05:07	757	10
18	9 51.35	125 23.31	2008/01/12	12:53	409	9
19	9 52.85	125 21.53	2008/01/12	13:55	258	8



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21	10 59.87	125 20.00	2008/01/12	21:09	83	12
22	10 50.13	125 25.96	2008/01/12	22:37	117	11
23	10 43.01	125 30.03	2008/01/12	23:46	115	11
24	10 36.00	125 33.80	2008/01/13	00:56	118	10
25	10 30.49	125 37.21	2008/01/13	02:08	133	17
26	10 26.52	125 32.38	2008/01/13	03:11	105	38
27	10 25.85	125 25.50	2008/01/13	04:26	190	9
28	10 26.04	125 23.06	2008/01/13	05:11	170	7
29	10 26.06	125 18.03	2008/01/13	06:06	120	8
30	10 14.78	125 22.21	2008/01/13	07:35	193	10
31	9 59.82	125 20.99	2008/01/13	09:28	714	10
32	9 54.17	125 19.22	2008/01/13	10:48	582	9
33	9 50.06	124 59.96	2008/01/13	13:20	1311	9
34	9 39.99	125 0.02	2008/01/13	15:53	791	11
35	9 30.00	124 59.95	2008/01/13	17:36	1805	10
36	9 19.94	124 59.84	2008/01/13	20:04	1816	10
37	9 9.93	124 59.91	2008/01/13	22:23	1785	9
38	9 30.12	124 29.81	2008/01/14	02:43	1812	10
39	9 30.00	123 59.97	2008/01/14	06:39	962	9
40	9 19.98	123 59.98	2008/01/14	08:42	1775	9
41	9 10.00	123 59.99	2008/01/14	11:05	1359	10
42	8 59.91	123 59.77	2008/01/14	13:13	1550	9
43	8 49.96	123 59.97	2008/01/14	15:24	1499	9
44	8 40.00	124 0.04	2008/01/14	17:38	1369	12
45	8 30.01	124 0.08	2008/01/14	19:51	1213	11
46	8 22.96	124 0.09	2008/01/14	21:36	1059	11
47	9 35.01	124 46.94	2008/01/15	10:30	1579	9
48	9 19.99	124 14.79	2008/01/15	14:56	1779	8
49	8 59.98	123 44.98	2008/01/15	19:27	1482	11
50	8 45.96	123 30.02	2008/01/15	22:31	319	12
51	8 52.02	123 29.89	2008/01/15	23:35	471	11
52	8 56.99	123 29.91	2008/01/16	00:33	509	14
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54	9 6.85	123 22.05	2008/01/16	03:26	466	14
55	9 0.99	123 15.92	2008/01/16	04:51	435	9
56	8 56.01	123 17.98	2008/01/16	05:58	296	6
57	8 51.99	123 20.92	2008/01/16	07:00	492	6
58	8 48.05	123 21.95	2008/01/16	08:09	436	8
59	8 54.99	123 24.97	2008/01/16	09:28	564	10
60	8 49.89	123 12.88	2008/01/16	11:24	863	9
61	8 49.92	123 5.90	2008/01/16	12:53	1691	8
62	8 59.90	122 59.99	2008/01/16	15:20	450	7
63	8 53.98	122 59.98	2008/01/16	16:31	1627	15
64	8 48.04	123 0.00	2008/01/16	18:22	2263	8
65	8 43.86	122 59.88	2008/01/16	20:30	1527	10
66	8 36.79	122 59.82	2008/01/16	22:17	1069	18
67	9 4.86	122 44.84	2008/01/17	02:04	1846	0
68	8 55.03	122 45.00	2008/01/17	04:38	3036	9
69	8 45.01	122 44.97	2008/01/17	07:47	3965	12
70	8 34.95	122 45.00	2008/01/17	11:25	3005	10
71	8 24.98	122 44.96	2008/01/17	14:36	2413	12
72	8 14.98	122 44.99	2008/01/17	17:15	1235	12
73	8 10.01	122 45.03	2008/01/17	18:48	379	12
74	8 24.06	122 23.95	2008/01/17	21:31	3338	10
75	8 34.01	122 2.02	2008/01/18	01:46	4282	13
76	8 43.95	121 40.96	2008/01/18	06:48	4764	9
77	8 53.94	121 18.92	2008/01/18	12:45	2795	12
78	9 3.98	120 56.98	2008/01/18	16:49	3763	12
79	9 14.96	120 34.81	2008/01/18	21:39	1653	14

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82	9 45.01	119 29.99	2008/01/19	07:40	1403	7
83	9 50.03	119 52.00	2008/01/19	11:15	1241	8
84	9 54.94	120 13.94	2008/01/19	14:16	1536	8
85	9 59.97	120 35.99	2008/01/19	17:30	1548	11
86	10 4.96	120 58.09	2008/01/19	20:41	1479	11
87	10 11.00	121 20.93	2008/01/19	23:52	1034	13
88	10 15.57	121 42.92	2008/01/20	02:41	1631	89
89	10 0.01	121 59.98	2008/01/20	05:55	3808	7
90	9 46.05	122 11.94	2008/01/20	10:07	2202	10
91	9 34.17	122 25.12	2008/01/20	13:26	772	10
92	9 27.09	122 14.06	2008/01/20	15:23	3025	13
93	9 18.78	122 0.14	2008/01/20	19:09	*3780*	*780*
94	9 10.02	121 44.94	2008/01/20	22:36	*4610*	*1610*
95	9 0.03	121 30.08	2008/01/21	02:18	*4530*	*1530*
96	8 51.99	122 15.10	2008/01/21	08:19	*4060*	*1031*
97	8 45.02	122 44.78	2008/01/21	13:26	*3985*	*902*
98	8 49.94	123 5.92	2008/01/21	17:51	*1670*	*485*
99	8 53.18	123 18.40	2008/01/21	20:04	525	12
100	8 53.15	123 18.42	2008/01/21	21:31	527	14
101	8 53.15	123 18.42	2008/01/21	22:49	528	15
102	10 30.00	121 45.09	2008/01/22	18:01	1377	12
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105	11 10.12	121 59.07	2008/01/23	01:28	1213	13
106	11 17.16	121 58.61	2008/01/23	03:26	655	11
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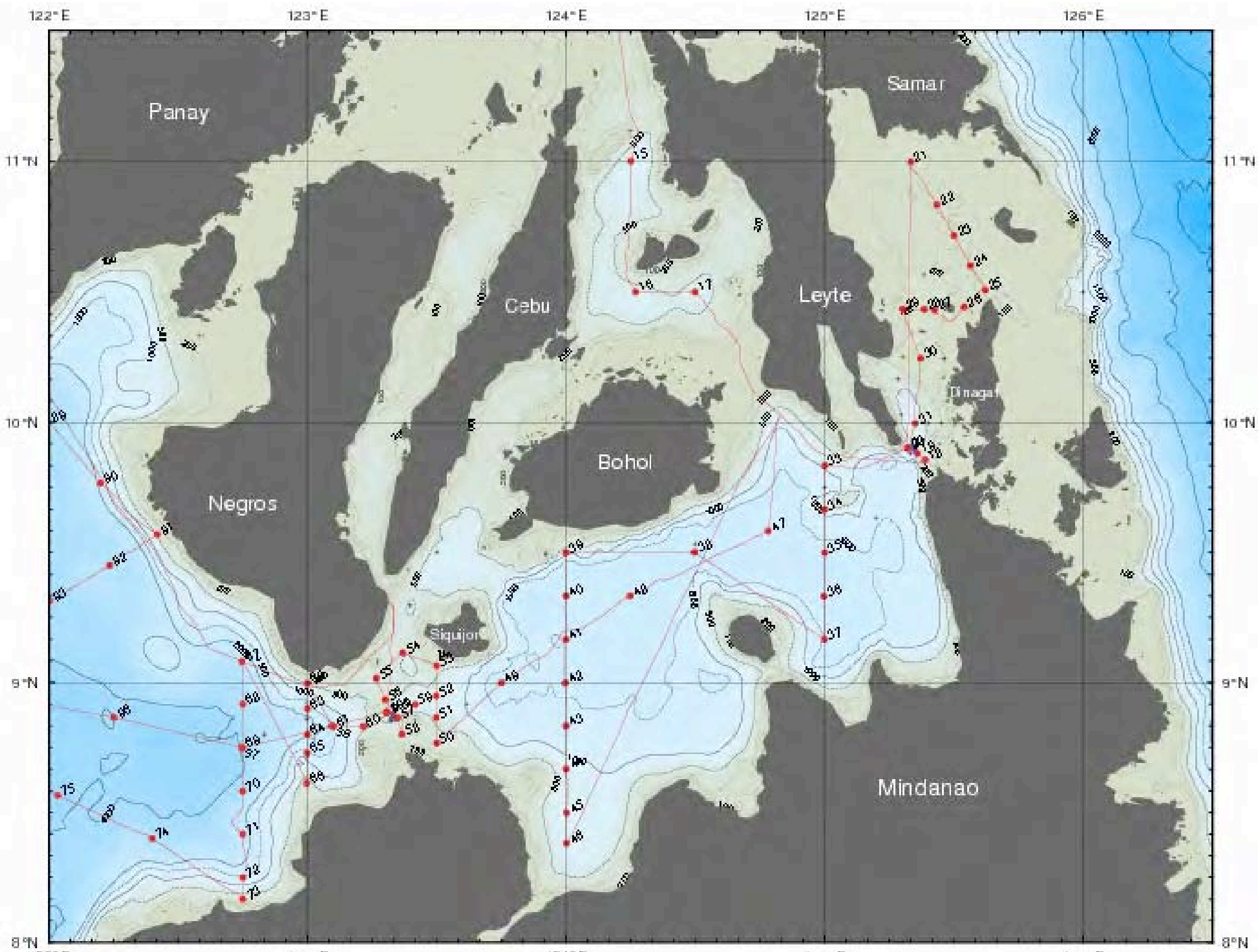

122° E
123° E
124° E
125° E
126° E
11 °N
10 °N
9 °N
8 °N
Panay
Cebu
Samar
Leyte
Bohol
Dinagat
Negros
Siquijor
Mindanao

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114	11 16.89	121 53.81	2008/01/23	12:31	516	11
115	11 18.42	121 53.36	2008/01/23	14:14	598	5
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117	11 49.06	121 42.88	2008/01/23	20:20	839	12
118	11 59.53	121 48.92	2008/01/23	22:21	398	11
119	12 12.93	121 43.98	2008/01/24	00:11	664	12
120	12 39.95	121 51.96	2008/01/24	03:30	596	14
121	11 43.91	120 59.91	2008/01/25	02:58	342	15
122	11 45.99	121 4.97	2008/01/25	03:58	620	7
123	11 48.99	121 10.00	2008/01/25	05:20	209	6
124	11 51.99	121 14.98	2008/01/25	06:23	269	11
125	11 53.00	121 9.98	2008/01/25	07:21	384	8
126	11 53.07	121 4.88	2008/01/25	08:26	421	7
127	11 52.96	120 59.94	2008/01/25	09:32	468	7
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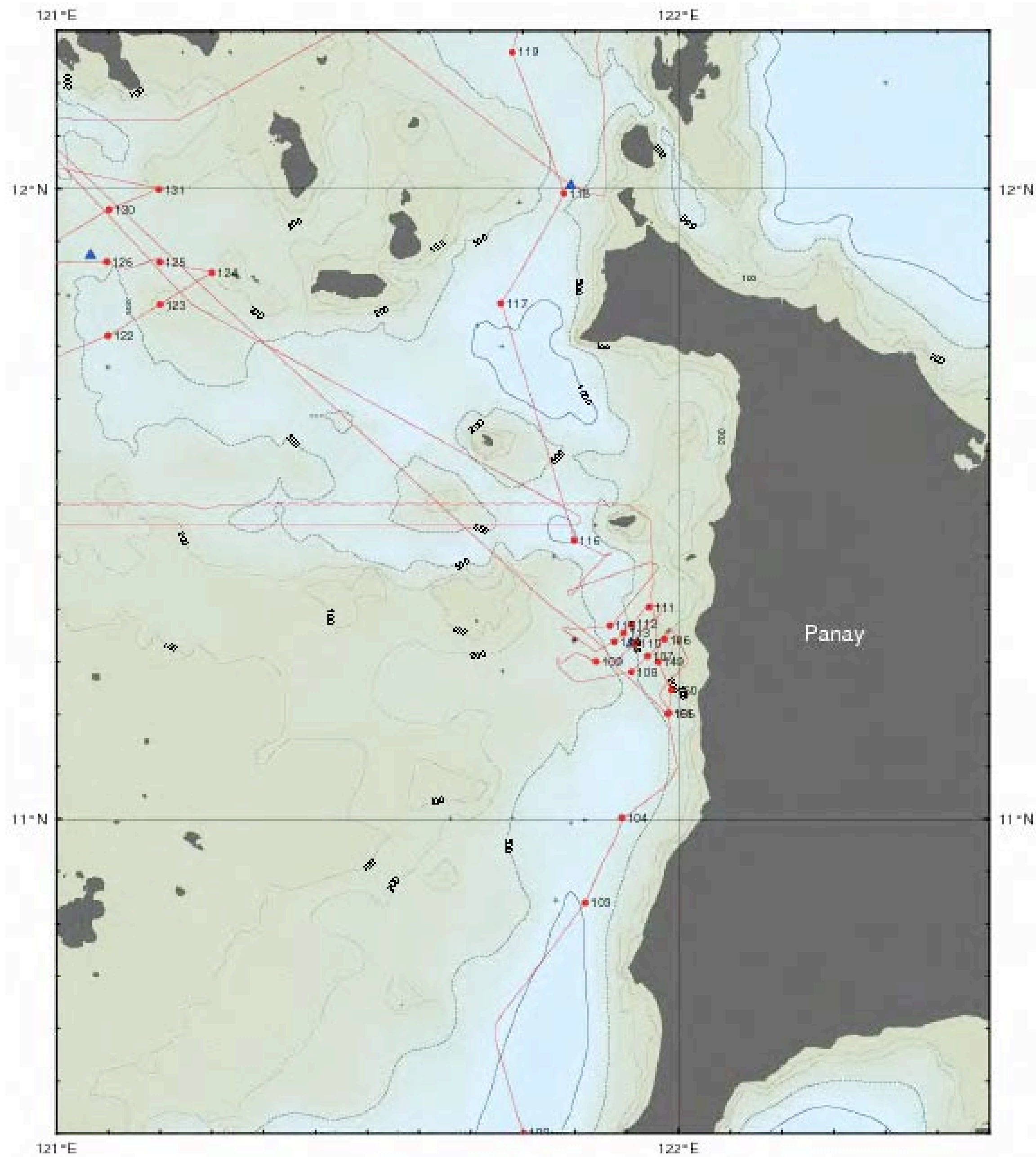

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132	12 1.96	120 59.94	2008/01/25	15:24	410	7
133	12 15.95	120 56.00	2008/01/25	17:31	744	13
134	12 29.99	120 52.97	2008/01/25	19:42	596	13
135	12 24.92	120 46.90	2008/01/25	21:09	659	17
136	12 21.98	120 41.98	2008/01/25	22:27	1127	12
137	12 17.92	120 35.07	2008/01/26	00:08	768	15
138	12 13.07	120 29.90	2008/01/26	01:33	504	13
139	12 35.01	120 22.03	2008/01/26	04:17	1178	7
140	12 44.98	120 33.08	2008/01/26	07:03	987	9
141	12 48.50	120 37.52	2008/01/26	08:27	1564	8
142	12 51.02	120 41.06	2008/01/26	10:11	988	7
143	13 21.03	120 19.88	2008/01/26	23:48	361	14
144	13 14.02	120 15.01	2008/01/27	01:21	2370	0
145	13 6.00	120 11.04	2008/01/27	03:54	2870	9
146	12 57.99	120 6.03	2008/01/27	06:44	2877	11

147	12	51.02	120	1.97	2008/01/27	09:29	1483	9
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149	11	14.99	121	58.03	2008/01/28	06:22	892	8
150	11	12.29	121	59.28	2008/01/28	07:34	1060	7
151	11	10.03	121	58.96	2008/01/28	09:03	1222	7
152	13	30.09	121	8.76	2008/01/29	10:41	320	7
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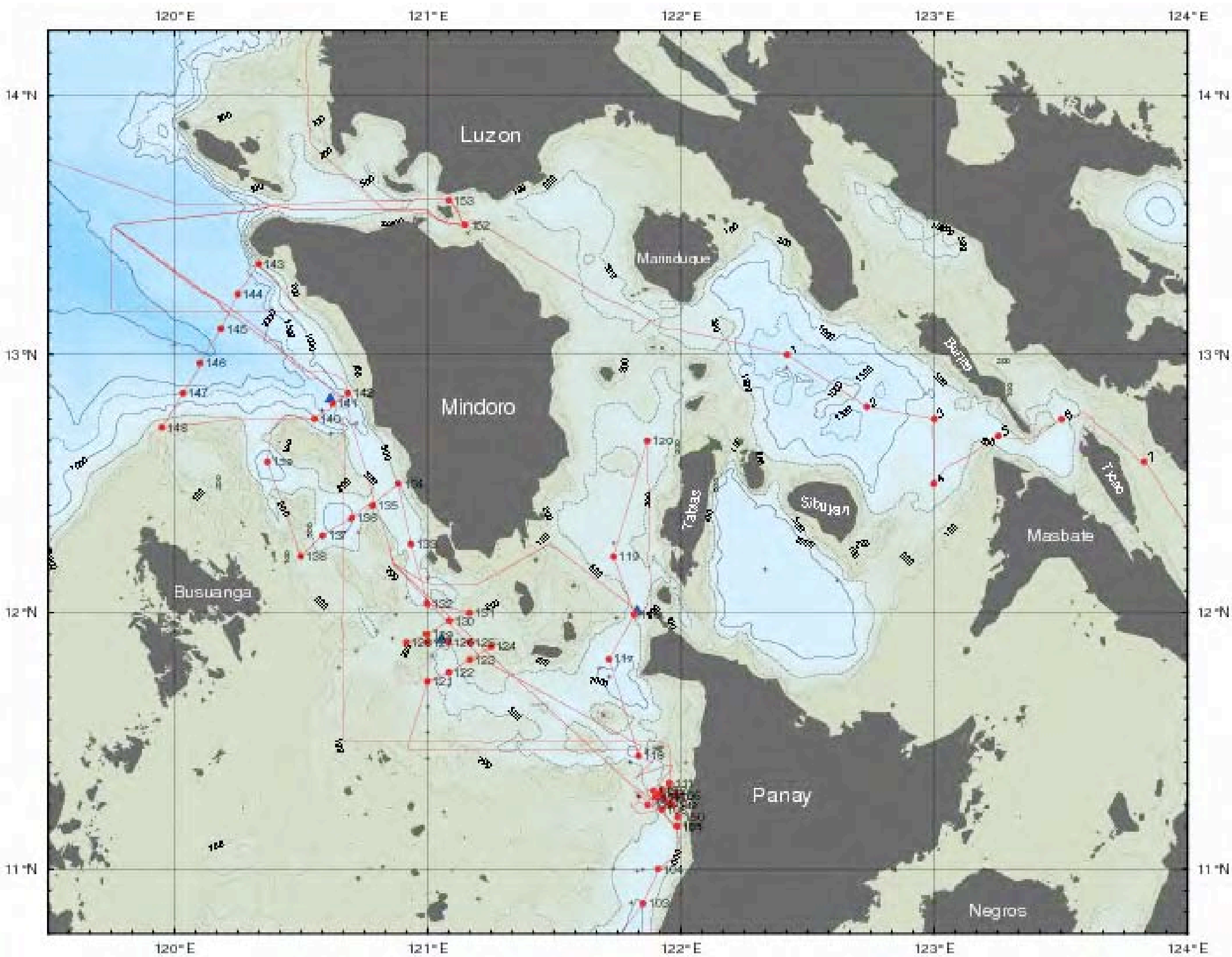

RIOP08/MGLN31MV

R/V Melville, RIOP08/MGLN31MV
9 January 2008 - 1 February 2008
Manila, Philippines - Manila, Philippines

Chief Scientist: Dr. A. Gordon
Lamont-Doherty Earth Observatory

Preliminary Cruise Report
31 January 2008

Data Submitted by:

Shipboard Technical Support
Scripps Institution of Oceanography
La Jolla, Ca. 92093-0214

Summary

A hydrographic survey consisting of CTD/LADCP/rosette and ADCP sections, float deployments and recoveries, and multibeam echosounder bathymetry was carried out in the Western Pacific January 2008. The R/V Melville departed Manila, Philippines, on 9 January 2008. A total of 153 CTD/LADCP stations were occupied from 10 January to 29 January. The cruise ended in Manila, Philippines on 1 February, 2008.

1. Description of Measurement Techniques

CTD measurements consisted of pressure, temperature, conductivity, dissolved oxygen, transmissometer and fluorometer sensor measurements plus salinity check samples taken from rosette bottles for conductivity sensor calibration. A total of 153 CTD casts were made. No major problems were encountered during the operation.

1.1. Water Sampling Package

CTD casts were performed with a package consisting of a 12-bottle rosette frame (STS), a 12-place carousel (SBE32) and 6 10-liter bottles (STS). Only 7 of 12 bottle positions were occupied to better accommodate 2 LADCPs and auxiliary sensors. This was considered a reasonable tradeoff since water samples were collected primarily for CTD conductivity sensor check samples. Underwater electronic components consisted of a Sea-Bird Electronics SBE32 12-place Carousel water sampler, a Sea-Bird Electronics SBE9*plus* CTD (STS #830) with dual pumps, dual temperature (SBE3), dual conductivity (SBE4), dissolved oxygen (SBE43), a Chelsea fluorometer, a Wetlab CDOM fluorometer, an OBS Backscatterance sensor, a Wetlab CStar transmissometer, a Benthos altimeter, and 2 RDI LADCPs.

The CTD was mounted horizontally across one side of the bottom of the rosette frame. The fluorometers, OBS BS and transmissometer were mounted horizontally along one side of the bottom ring of the frame, opposite the LADCP battery pack. The altimeter was mounted on the inside of a support strut adjacent to the bottom frame ring.

The rosette was suspended from a UNOLS-standard three-conductor 0.322" electro-mechanical sea cable. The R/V Melville’s aft starboard-side CTD winch and starboard a-frame were used for all casts. One seacable retermination was made after station 33/1 when a kink in the seacable close to the rosette was noticed.

The deck watch prepared the rosette 5-10 minutes prior to each cast. All valves, vents and lanyards were checked for proper orientation. The bottles were cocked and all hardware and connections rechecked.

Once stopped on station, the rosette was unstrapped from its tie down location under the starboard a-frame. Tag lines were threaded through the rosette frame. As directed by the deck watch leader, the CTD was powered up and the data acquisition system started. The syringes were removed from the CTD sensor intake ports. The deck watch leader directed the winch operator to raise the package, the a-frame and rosette were extended outboard and the package quickly lowered into the water. The tag lines were removed and the package was lowered to 10 meters. After one minute to allow the sensor pumps to turn on and pumped sensors to stabilize, the winch operator was instructed to bring the package back to the surface (0 winch wireout) and to begin the descent.

During the up cast the winch operator was directed to stop the winch at each bottle trip depth where check samples were to be collected. The CTD console operator waited 30 seconds before closing a bottle to insure the package wake had dissipated and the bottles were flushed, then an additional 10 seconds after bottle closure to insure that stable CTD comparison data had been acquired. Once a bottle had been closed, the winch operator was directed to haul in the package to the next bottle stop.

Salinity samples were taken to calibrate the CTD conductivity sensors. Water samples were also collected for zooplankton and dissolved oxygen.

Recovering the package at the end of the deployment was essentially the reverse of launching, with the additional use of poles and snap-hooks to attach tag lines. The rosette was secured on deck under the block for sampling.

Routine CTD maintenance included soaking the conductivity sensors in fresh water between casts to maintain sensor stability and occasionally putting dilute Triton-X solution through the conductivity sensors to eliminate any accumulating biofilms. Rosette maintenance was performed on a regular basis. O-rings were changed and lanyards repaired as necessary. Bottle maintenance was performed each day to insure proper closure and sealing. Valves were inspected for leaks and repaired or replaced as needed.

A kink in the seacable close to the rosette was noticed at the end of cast 33/1. The seacable was subsequently reterminated.

1.2. Underwater Electronics Packages

CTD data were collected with a SBE9*plus* CTD (STS #830). This instrument provided pressure, dual temperature (SBE3), dual conductivity (SBE4), dissolved oxygen (SBE43), fluorometers (Chelsea and Wetlab CDOM), OBS Backscatterance sensor, transmissometer (Wetlab) and altimeter (Benthos) channels. CTD #830 supplied a standard Sea-Bird format data stream at a data rate of 24 frames/second.

Sea-Bird SBE32 12-place Carousel Water Sampler S/N xxx	
Sea-Bird SBE9*plus* CTD	#830
Paroscientific Digiquartz Pressure Sensor	S/N 99676
Sea-Bird SBE3*plus* Temperature Sensor	S/N 03P-4226 (Primary)
Sea-Bird SBE3*plus* Temperature Sensor	S/N 03P-4588 (Secondary)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2766 (Primary)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2593 (Secondary)
Sea-Bird SBE43 Dissolved Oxygen Sensor	S/N 43-1138
Chelsea Aqua 3 Fluorometer	S/N 088190
Wetlab CDOM Fluorometer	S/N WS3S-1081P
OBS Backscatterance Sensor	BBRT-142r
Wetlab CStar Transmissometer	S/N CST-497DR
Benthos Altimeter	S/N 1183
RDI LADCPs	

Table 1.2.0 RIOP08 Rosette Underwater Electronics.

The CTD was outfitted with dual pumps. Primary temperature, conductivity and dissolved oxygen were plumbed on one pump circuit and secondary temperature and conductivity on the other. The sensors were deployed horizontally. The primary temperature and conductivity sensors (T1 #4226 and C1 #2766) were used for reported CTD temperatures and conductivities on all casts. The secondary temperature and conductivity sensors (T2 #4588 and C2 #2593) were used for calibration checks.

The SBE9 CTD was connected to the SBE32 12-place carousel providing for single-conductor sea cable operation. Two of the three sea cable conductors were connected together for signal and power, the other conductor was used for the return. Power to the SBE9 CTD, SBE32 carousel, optical sensors and Benthos altimeter was provided through the sea cable from the SBE11*plus* deck unit in the main lab.

1.3. Navigation and Bathymetry Data Acquisition

Navigation data were acquired (at 1-second intervals) from the ship’s GP90 GPS receiver by a Linux server beginning January 9.

Swath bathymetric data from the ship’s multibeam echosounder (Kongsberg EM120) were also acquired and processed by the R/V Melville’s underway system.

1.4. Acoustic Doppler Current Profiler (ADCP) Data Acquisition

ADCP data were acquired and processed from the Melville’s RDI NB150 and RDI OS75 ADCP systems using UHDAS and CODAS processing software from University of Hawaii [Firi95]. 15-minute and 1-hour ensemble averages were transformed to earth coordinates and processed, producing various plots and sections in near real time. The RDI Ocean Surveyor 75 (OS75) acquired narrowband data only. There were no major problems with the instruments, data acquisition or processing. A minor problem with the shipboard Ashtech differential GPS receiver occasionally hanging or outputting null values and requiring a reset occurred infrequently.

1.5. Underway Sea Surface and Meteorological Measurements

Underway sea surface and meteorological measurements were made continuously at 30-second intervals by the R/V Melville’s underway system. All sensors with the exception of the anemometer were operational and exhibited no problems. The anemometer had failed on the previous leg and although a spare sensor was on board, it was not until the failed sensor was removed from the Met sensor mast that it was discovered that the sensor cable was badly corroded and that there was no spare cable. The bridge anemometer was then used, logged manually every 15 minutes.

1.6. CTD Data Acquisition and Rosette Operation

The CTD data acquisition system consisted of an SBE-11*plus* (V2) deck unit and a networked generic PC workstation running Windows XP. SBE SeaSave software was used for data acquisition and to close bottles on the rosette.

CTD deployments were initiated by the console watch after the ship had stopped on station. The watch maintained a console operations log containing a description of each deployment, a record of every attempt to close a bottle and any pertinent comments.

Once the deck watch had deployed the rosette, the winch operator would lower it to 10 meters. The CTD sensor pumps were configured with a 30 second startup delay, and were usually on by this time. The console operator checked the CTD data for proper sensor operation, waited an additional 60 seconds for sensors to stabilize, then instructed the winch operator to bring the package to the surface, pause for 10 seconds, and descend to a target depth (wire-out). The profiling rate was no more than 30m/min to 50m, no more than 45m/min to 200m and no more than 60m/min deeper than 200m depending on sea cable tension and the sea state.

The console watch monitored the progress of the deployment and quality of the CTD data through interactive graphics and operational displays. Additionally, the watch created a sample log for the deployment which would be later used to record the correspondence between rosette bottles and analytical samples taken. The altimeter channel, CTD pressure, wire-out, pinger and bathymetric depth were all monitored to determine the distance of the package from the bottom, usually allowing a safe approach to within 10-20 meters.

Bottles were closed on the up cast by operating an on-screen control, and were tripped at least 30 seconds after stopping at the trip location to allow the rosette wake to dissipate and the bottles to flush.

The winch operator was instructed to proceed to the next bottle stop at least 15 seconds after closing bottles to insure that stable CTD data were associated with the trip.

After the last bottle was closed, the console operator directed the deck watch to bring the rosette on deck. Once on deck, the console operator terminated the data acquisition, turned off the deck unit and assisted with rosette sampling.

1.7. CTD Data Processing

Shipboard CTD data processing was performed automatically at the end of each deployment using SIO/ODF CTD processing software. The raw CTD data and bottle trips acquired by SBE SeaSave on the Windows XP workstation were copied onto the Linux database and web server system, then processed to a 0.5 second time series. Bottle trip values were extracted and a 2 decibar down cast pressure series created. This pressure series was used by the web service for interactive plots, sections and CTD data distribution (the 0.5 second time series were also available for distribution). During and after the deployment the data were redundantly backed up to another Linux system.

CTD data were examined at the completion of each deployment for clean corrected sensor response and any calibration shifts. Shipboard conductivity sensor calibrations were refined as bottle salinity checksample results became available.

TS comparisons were made between down and up casts as well as between groups of adjacent deployments. Vertical sections of measured and derived properties from sensor data were checked for consistency.

Few CTD acquisition and processing problems were encountered during RIOP08, the major one being restarted casts due to deployment problems.

A total of 153 casts were made.

1.8. CTD Laboratory Calibration Procedures

Laboratory calibrations of the CTD pressure, temperature, conductivity and the SBE35RT Digital Reversing Thermometer sensors were performed prior to RIOP08. The calibration dates are listed in table 1.8.0.

Sensor	S/N	Calibration Date	Calibration Facility
Paroscientific Digiquartz Pressure	99676	17-September-07	SIO/ODF
Sea-Bird SBE3*plus* T1 Temperature	03P-4226	27-September-07	SIO/ODF
Sea-Bird SBE3*plus* T2 Temperature	03P-4588	12-June-07	SIO/ODF
Sea-Bird SBE4C C1 Conductivity	04-2766	05-September-07	SBE
Sea-Bird SBE4C C2 Conductivity	04-2593	12-September-07	SBE
Sea-Bird SBE43 Dissolved Oxygen	43-1138	NA	
Chelsea Fluorometer	088190	NA	
Wetlab CDOM Fluorometer	WS3S-1081P	NA	
Wetlab Cstar Transmissometer	CST-497DR	NA	
OBS Backscatterance	BBRT-142r	NA	

Table 1.8.0 RIOP08 CTD sensor laboratory calibrations.

1.9. CTD Shipboard Calibration Procedures

CTD #830 was used for all RIOP08/MGLN31MV casts. The CTD was deployed with all sensors and pumps aligned horizontally. The primary temperature and conductivity sensors (T1 & C1) were used for reported CTD data on all casts, the secondary sensors (T2 & C2) serving as calibration checks. *In-situ* salinity check samples collected during each cast were used to calibrate the conductivity sensors.

The variability of the environment that was observed on most deployments made sensor and check sample comparisons somewhat problematic. On many casts no deep check samples were collected and metrics of variability had to be inferred from sensor comparisons. The differences between primary and secondary temperatures were used as filtering criteria in these cases.

1.9.1. CTD Pressure

Pressure sensor conversion equation coefficients derived from the pre-cruise pressure calibration were applied to raw pressure data during each cast. No additional adjustments were made to the calculated pressures.

Residual pressure offsets (the difference between the first and last out-of-water pressures) were examined to check for calibration shifts. All were < 1.0db (excepting 51/1, 94/1, 106/1 and 118/1 which were inadvertently started in the water), as illustrated in figure 1.9.1.0.

There was no apparent shift in pressure calibration during the cruise. This will be verified by a post-cruise laboratory pressure calibration.

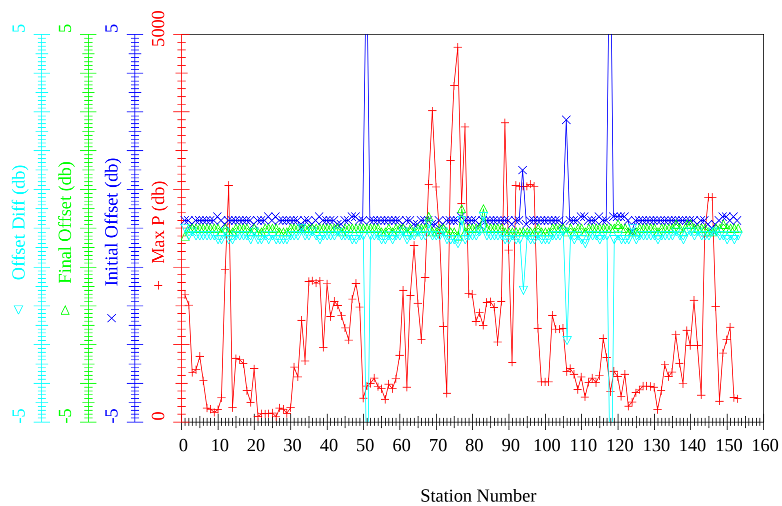

Figure 1.9.1.0 Pressure offsets by station.

1.9.2. CTD Temperature

Temperature sensor conversion equation coefficients derived from the pre-cruise temperature calibrations were applied to raw primary and secondary temperature data during each cast. No shipboard corrections to these calibrations were made during RIOP08/MGLN31MV.

The primary and secondary temperatures were compared at each rosette trip. The mean of differences between T1 and T2 temperatures for pressures > 1000db was < 0.07 m°C over the cruise. These differences are summarized in figure 1.9.2.1.

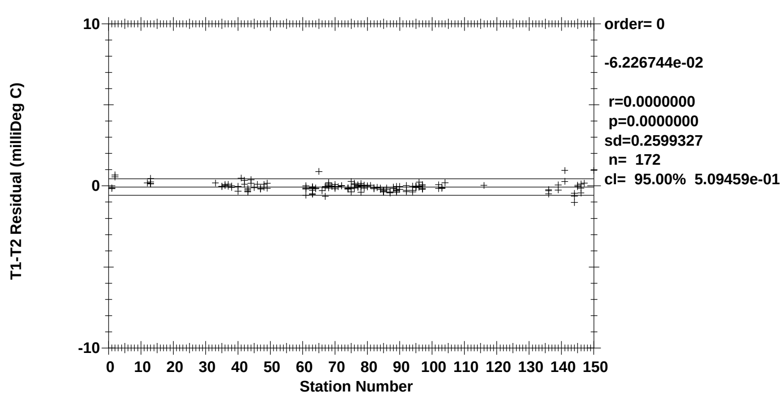

Figure 1.9.2.1 Primary and secondary temperature differences by station, pressures > 1000db.

1.9.3. CTD Conductivity

Conductivity sensor conversion equation coefficients were derived from the pre-cruise calibrations and applied to raw primary and secondary conductivity data during each cast. Shipboard corrections to these calibrations were made during RIOP08/MGLN31MV.

A single pair of primary (C1, S/N 2766) and secondary (C2, S/N 2593) conductivity sensors was used on RIOP08: The primary sensor was used for all reported conductivities.

Comparisons between the primary and secondary sensors and between the sensors and check sample conductivities were used to derive sensor corrections. C1 and C2 were found to be offset by 0.003 PSU, with the offset drifting by station (figure 1.9.3.0). Bottle salinity comparisons attributed this offset to C2 (figures 1.9.3.1 and 1.9.3.2).

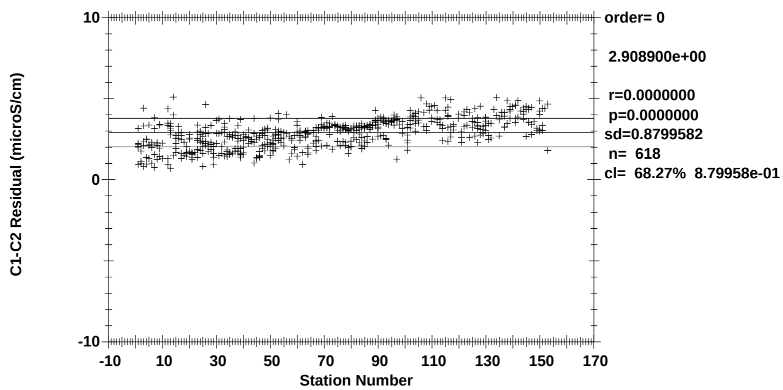

Figure 1.9.3.0 Uncorrected primary and secondary conductivity differences by station.

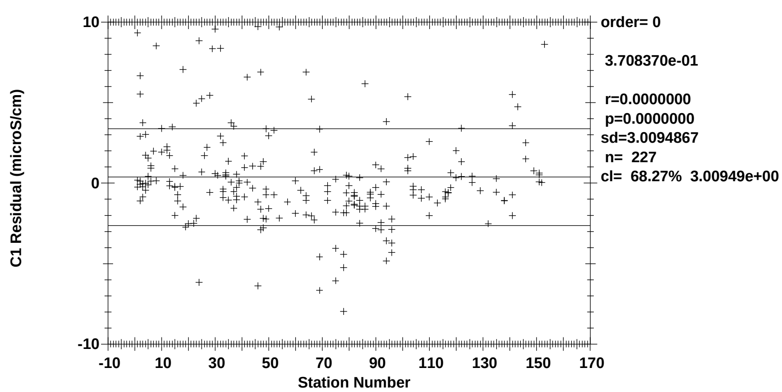

Figure 1.9.3.1 Uncorrected check sample and primary conductivity differences by station.

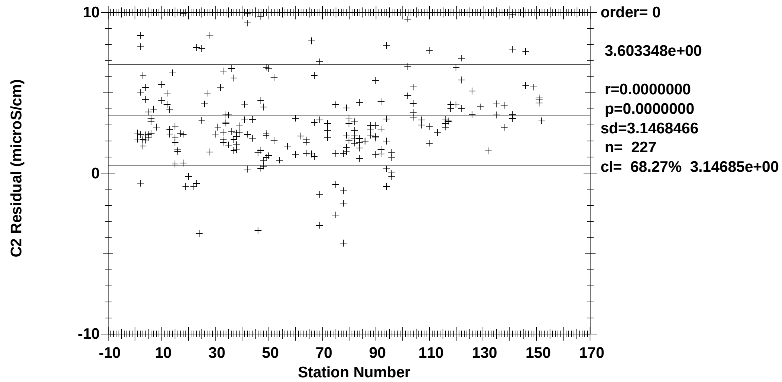

Figure 1.9.3.2 Uncorrected check sample and secondary conductivity differences by station.

Both sensors additionally exhibited a secondary pressure response (figures 1.9.3.3 and 1.9.3.4).

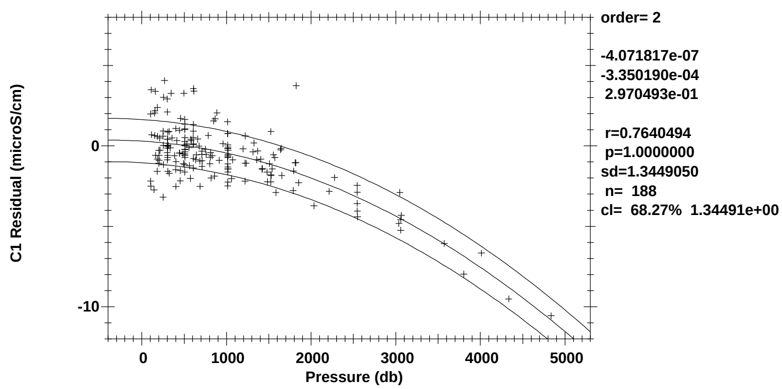

Figure 1.9.3.3 Uncorrected check sample and primary conductivity differences by pressure.

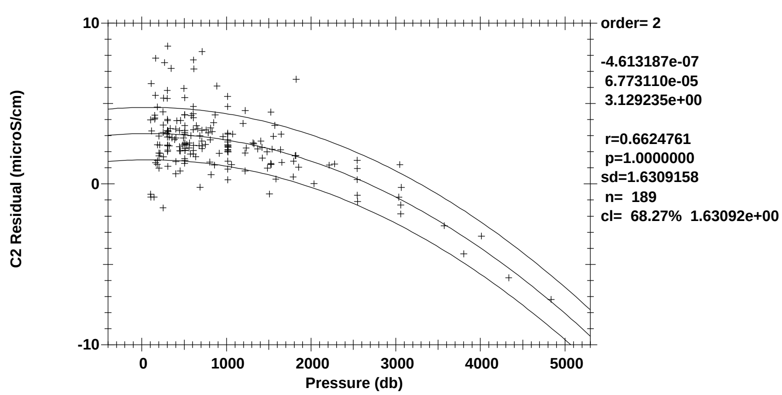

Figure 1.9.3.4 Uncorrected check sample and secondary conductivity differences by pressure.

The salinity residuals after applying the shipboard calibration are summarized in figures 1.9.3.5 and 1.9.3.6.

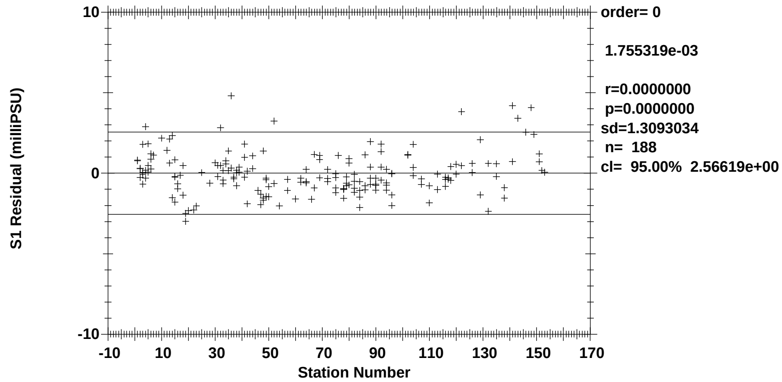

Figure 1.9.3.4 C1 salinity residuals by station (all pressures, excluding thermocline values).

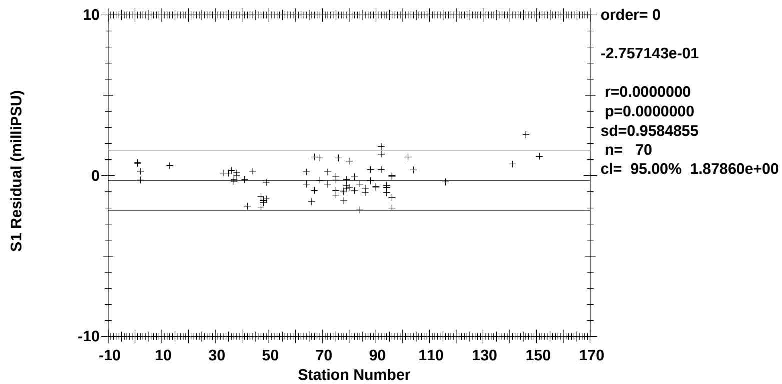

Figure 1.9.3.4 C1 salinity residuals by station (P > 1000.0 db).

The 95% confidence limit of .0026 PSU for all pressures excluding thermocline values, and .0019 PSU for pressures > 1000.0 db represent an estimate of the salinity accuracy of CTD #830 on RIOP08/MGLN31MV.

1.9.4. CTD Fluorometers LSS and Transmissometer

No laboratory or shipboard calibrations were applied to the fluorometer, LSS or transmissometer data. The data are reported in VDC, with a nominal range of 0.0 to 5.0..

1.9.5. CTD Dissolved Oxygen

Although dissolved oxygen check samples were collected and analyzed on RIOP08/MGLN31MV, the data were neither processed nor examined and so the sensor data are uncalibrated. A single SBE43 (#1138) was used the entire cruise. A single set of nominal conversion equation coefficients were employed for all casts.

STS makes no claims regarding the precision or accuracy of CTD dissolved O_2 data.

The general form of the STS O_2 conversion equation for Clark cells follows Brown and Morrison [Brow78] and Millard [Mill82], [Owen85]. ODF models membrane and sensor temperatures with lagged CTD temperatures and a lagged thermal gradient. *In-situ* pressure and temperature are filtered to match the sensor response. Time-constants for the pressure response τ_p, two temperature responses τ_{Ts} and τ_{Tf}, and thermal gradient response τ_{dT} are fitting parameters. The thermal gradient term is derived by low-pass filtering the difference between the fast response (T_f) and slow response (T_s) temperatures. This term is SBE43-specific and corrects a non-linearity introduced by analog thermal compensation in the sensor. The O_c gradient, dO_c/dt, is approximated by low-pass filtering 1st-order O_c differences. This gradient term attempts to correct for reduction of species other than O_2 at the sensor cathode. The timeconstant for this filter, τ_{og}, is a fitting parameter. Dissolved O_2 concentration is then calculated:

$$O_{2ml/l} = [c_1 O_c + c_2] \cdot f_{sat}(S,T,P) \cdot e^{(c_3 P_l + c_4 T_f + c_5 T_s + c_6 \frac{dO_c}{dt} + c_7 dT)} \qquad (1.9.5.0)$$

where:

$O_{2ml/l}$	= Dissolved O_2 concentration in ml/l;
O_c	= Sensor current (μamps);
$f_{sat}(S,T,P)$	= O_2 saturation concentration at S,T,P (ml/l);
S	= Salinity at O_2 response-time (PSUs);
T	= Temperature at O_2 response-time (°C);
P	= Pressure at O_2 response-time (decibars);
P_l	= Low-pass filtered pressure (decibars);
T_f	= Fast low-pass filtered temperature (°C);
T_s	= Slow low-pass filtered temperature (°C);
$\frac{dO_c}{dt}$	= Sensor current gradient (μamps/secs);
dT	= low-pass filtered thermal gradient (T_f - T_s).

1.10. Bottle Data Processing

Water samples collected and properties analyzed shipboard were managed centrally in a relational database (PostgreSQL-8.1.9) run on a Linux server. A web service (OpenAcs-5.3.2 and AOLServer-4.5.0) front-end provided ship-wide access to CTD and water sample data. Web-based facilities included on-demand arbitrary property-property plots and vertical sections as well as data uploads and downloads.

The sample log (and any diagnostic comments) was entered into the database once sampling was completed. Quality flags associated with sampled properties were set to indicate that the property had been sampled, and sample container identifications were noted where applicable.

Various consistency checks and detailed examination of the data continued throughout the cruise.

1.11. Salinity Analysis

Equipment and Techniques

A single Guildline Autosal Model 8400A salinometer (S/N 57-396) located in the forward analytical lab was used for all salinity measurements. The water bath temperature was set and maintained at a value near the laboratory air temperature. It was set to 27°C for the entire leg.

Salinity analyses were performed after the samples had equilibrated to laboratory temperature, usually within 8-12 hours after collection. The salinometer was standardized for each group of samples in a run using at least one fresh vial of standard seawater per group.

Sampling and Data Processing

Salinity samples were drawn into 200 ml Kimax high-alumina borosilicate bottles, which were rinsed three times with the sample prior to filling. The bottles were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. Prior to collecting each sample, inserts were inspected for proper fit and loose inserts were replaced to insure an airtight seal. The sample draw time and equilibration time were logged for each cast. Laboratory temperatures were logged at the beginning and end of each run.

PSS-78 salinity [UNES81] was calculated for each sample from the measured conductivity ratios. The difference between the initial vial of standard water and one run at the end as an unknown was applied as a linear correction to the data to account for any drift. The data were incorporated into the cruise database. 129 salinity measurements were made.

Laboratory Temperature

The air temperature in the analytical laboratory varied from 22.1 to 23.8°C, during the cruise. The temperature change during any single run of samples was less than ±1.4°C.

Standards

Approximately 20 vials of IAPSO Standard Seawater (batch P148) were used.

The estimated accuracy of bottle salinities run at sea is usually better than ±0.002 PSU relative to the particular standard seawater batch used.

References

Brow78.

Brown, N. L. and Morrison, G. K., “WHOI/Brown conductivity, temperature and depth microprofiler,” Technical Report No. 78-23, Woods Hole Oceanographic Institution (1978).

Firi95.

Firing, E., Ranada, J., and Caldwell, P., “Processing ADCP Data With the CODAS Software System Version 3.1,” *NODC* (1995).

Mill82.

Millard, R. C., Jr., “CTD calibration and data processing techniques at WHOI using the practical salinity scale,” Proc. Int. STD Conference and Workshop, p. 19, Mar. Tech. Soc., La Jolla, Ca. (1982).

Owen85.

Owens, W. B. and Millard, R. C., Jr., “A new algorithm for CTD oxygen calibration,” *Journ. of Am. Meteorological Soc.,* 15, p. 621 (1985).

UNES81.

UNESCO, “Background papers and supporting data on the Practical Salinity Scale, 1978,” UNESCO Technical Papers in Marine Science, No. 37, p. 144 (1981).

Philippines Straits Dynamics Experiment [PhilEx]
RIOP Gordon Cruise Leg 2
Cruise Summary

Vessel: R/V Melville, Scripps Institute of Oceanography, U.S.A

Chief Scientists:
United States:
Arnold L. Gordon
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OVERALL OBJECTIVE of PhilEx Cruise: Improve the understanding and ability to model the circulation within the Philippine archipelago with emphasis on oceanographic processes and features arising in and around straits

OVERALL FIELD PROGRAM: This study involves four planned oceanographic cruises in the Philippines (Figure 1). The first phase, named the EXPLORATORY CRUISE (PhilEx01) was from 6 June to 3 July 2007. The second phase, named JOINT CRUISE (PhilEx02) was conducted from 29 December 2007 to 4 January 2008. The third phase, named REGIONAL IOP CRUISE (PhilEx03) aimed to obtain a regional view of the stratification and circulation of the Philippine Seas was conducted from 9 January to 1 February 2008 and divided into 2-leg shifts (Figure 2). The first leg of PhilEx03 was from 9-22 January 2008 involved the investigation of the internal Philippine seas. The second leg of PhilEx03 was from 22 January to 1 February 2008 involved oceanographic studies of the Sulu Sea and the straits near Mindoro. This report pertains to activities of PhilEx 03 LEG 2.

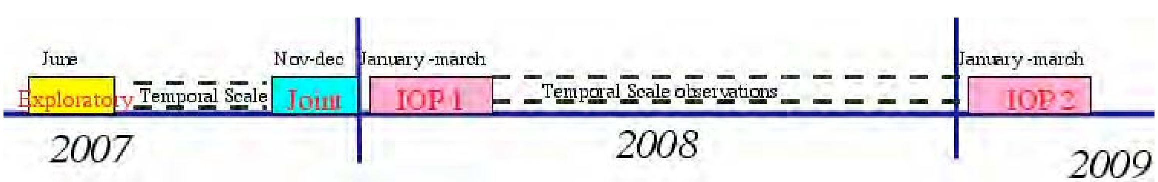

Figure 1. PhilEx overview

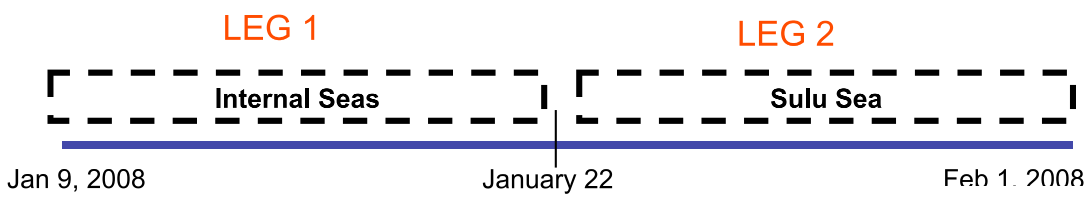

Figure 2. PhilEx2 overview

SUMMARY of ACTIVITIES of PhilEx02 LEG4
(please look at the appendices for more details on each sampling activity)

[1] CTD/LADCP/optics: Lowering of the CTD [Temperature, salinity, oxygen profiles], LADCP [shear profiles], were made to collect profiles of ocean characteristics. CTD/LADCP stations (52 in all) are given in dots in Figure 3.

[2] Repeat hull ADCP across specific passages over a 25 hour cycle was also conducted at Mindoro, Panay, and the northwest palawan to resolve the tidal currents. Areas surveyed are highlighted in Figure 3.

[3] Water Sampling: A 7-bottle rosette with a capacity of 10 liters each was lowered with the all the CTD cast (52). 2-4 of these bottles were used for water chemical analysis (dissolved oxygen (DO), and salinity).

[4] Plankton Sampling: From the CTD casts (52) 2-4 out of the 7-bottle rosette were also sampled for plankton [at the deep chlorophyll maximum (DCM), above DCM and below DCM].

[5] Live plankton Observations: Between CTD stations surface water was collected and observed for live microzooplankton behavior.

[6] Winds: Wind data was logged every 5-30 minutes for the entire duration of the cruise.

[7] Underway data: Aside from the 6 activities outlined above the R/V Melville routinely collects a suite of data while underway, including hull ADCP, multi-beam, sea surface temperature and salinity, chlorophyll.

All data collected during the PhilEx03 data shall be provided to the participating agencies in DVD format.

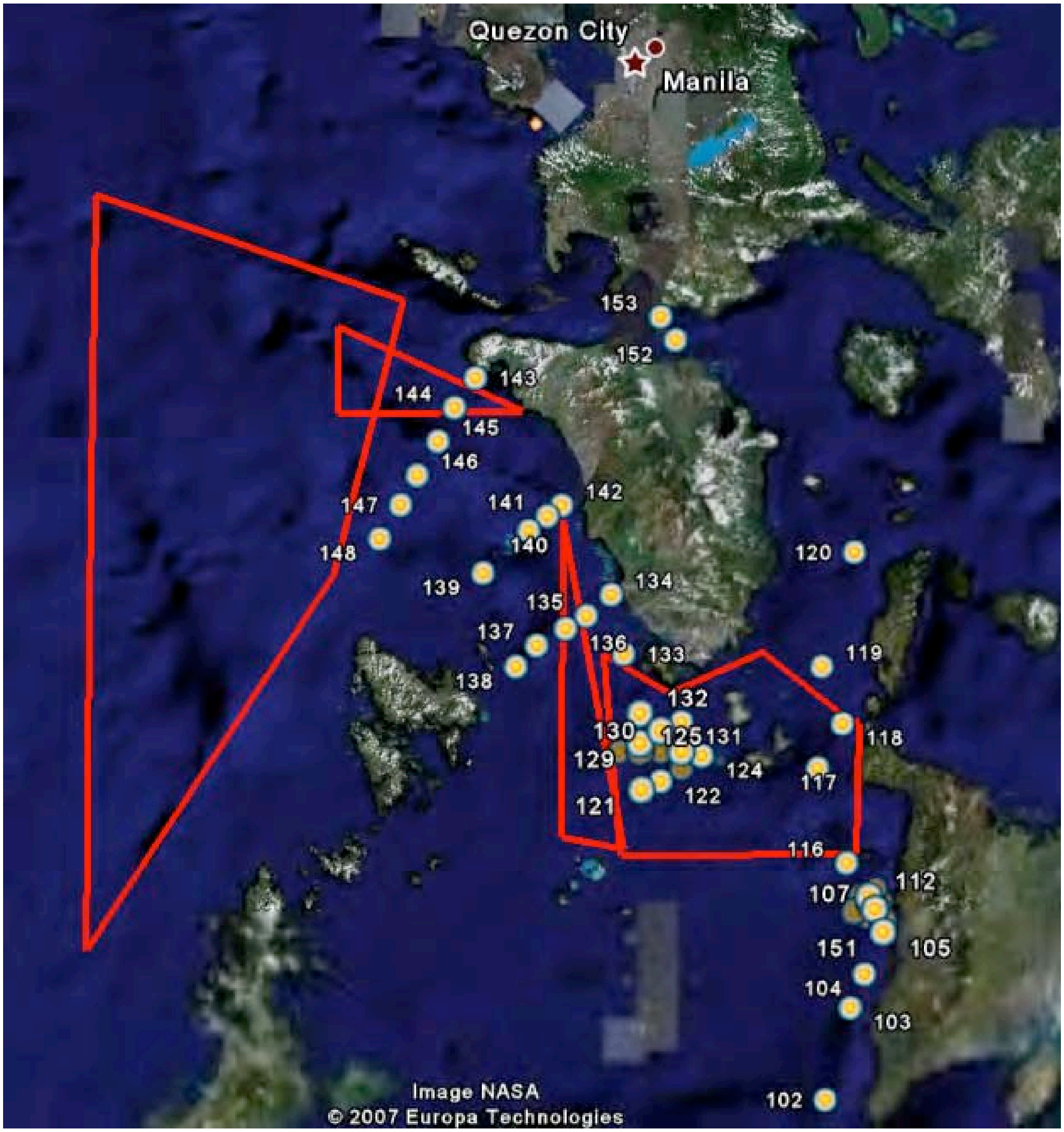

Figure 3. Location of stations 52 CTD Stations and the 4 repeat-hull ADCP surveys

PERMITS: Permit to conduct the Exploratory cruise was obtained from the Philippine Department of Foreign Affairs (DFA). Additional permits were obtained from LGUs where intensive ships activities were deemed intensive so as to ensure local fishers and coastal managers were made aware of the scientific nature of the expedition.

Total Steaming Time (TST)

Total Miles Covered (TMC)

USA participants:

Dr. Arnold Gordon
Phil Mele, Claudia Giulivi, Debra Tillinger,
Zachary Tessler, David Sprecher
Lamont-Doherty Earth Observatory, Columbia University

Dr. Julie Pullen
Naval Research Laboratory

Michael Gilligan
Naval Oceanographic Office

Jacob Greenberg, Drew Cole
Res Tech

Frank Delahoyde
Computer Technician

Philippine participants:

Dr. David Laura, Dr. Aletta Yniguez
Joseph Dominic Palermo, Roselle Borja, Rommel Maneja,
Bernadette de Venecia, Victor Ticzon, Kristina Cordero
Marine Science Institute, UP Diliman

LTJG Loyd Ayonayon
OLAG, Philippine Navy

LTJG Lawrence Tamayo
Philippine Coast Guard

Appendix 1: DETAILS for CTD casts and SUMMARY TABLE for samples taken at each station

A total of 52 stations were occupied. A summary of the sampling stations and parameters taken at each depth per station is given in Table 1.

Station	Lat	Lon	Depth	Start Date	UTC	Bottle1	B2	B3	B4	B5	B6	B7
102	10 30.005	121 45.094	1385	08/01/22	18:01	1377 (Oxy,Sal)	1017.7 (Oxy,Sal)	611.0 (Oxy,Sal)	55 (Pln)	30 (Pln)	13.0 (Oxy,Sal)	NC
103	10 52.004	121 50.989	1205	08/01/22	21:26	NC	NC	NC	60 (Pln)	55 (Pln)	50 (Pln)	45 (Pln)
104	11 0.120	121 54.550	1204	08/01/22	23:15	1197.6 (Oxy,Sal)	813.2 (Oxy,Sal)	509.2 (Oxy,Sal)		60 (Pln)	55 (Pln)	10.2 (Oxy,Sal)
105	11 10.144	121 59.082	1223	08/01/23	01:28	NC	NC	NC	60 (Pln)	55 (Pln)	50 (Pln)	45 (Pln)
106	11 17.165	121 58.616	670	08/01/23	03:26	NC	NC	NC	60 (Pln)	55 (Pln)	50 (Pln)	40 (Pln)
107	11 15.540	121 57.023	682	08/01/23	04:24	688 (Oxy,Sal)	303 (Oxy,Sal)	65 (Pln)	60 (Pln)	55 (Pln)	50 (Pln)	12 (Oxy,Sal)
108	11 14.016	121 55.452	617	08/01/23	05:27	615 (Oxy)	300 (NC)	55 (Pln)	50 (Pln)	45 (Pln)	40 (Pln)	12 (Oxy)
109	11 15.021	121 52.052	430	08/01/23	07:36	420 (Oxy)	300 (NC)	55 (Pln)	50 (Pln)	45 (Pln)	40 (Pln)	12 (Oxy)
110	11 16.739	121 55.788	595	08/01/23	08:38	579 (Oxy,Sal)	302 (Oxy,Sal)	60 (Pln)	55 (Pln)	50 (Pln)	45 (Pln)	12.7 (Oxy,Sal)
111	11 20.196	121 57.170	332	08/01/23	09:56	323 (Oxy)	200 (NC)	65 (Pln)	60 (Pln)	55 (Pln)	50 (Pln)	12 (Oxy)
112	11 18.559	121 55.469	515	08/01/23	10:46	509 (Oxy)	300 (NC)	55 (Pln)	50 (Pln)	45 (Pln)	40 (Pln)	13 (Oxy)
113	11 17.729	121 54.691	569	08/01/23	11:36	566 (Oxy,Sal)	335 (Oxy,Sal)	45 (Pln)	40 (Pln)	35 (Pln)	30 (Pln)	12 (Oxy,Sal)
114	11 16.897	121 53.812	509	08/01/23	12:31	508 (Oxy)	300 (NC)	50 (Pln)	45 (Pln)	40 (Pln)	35 (Pln)	12 (Oxy)
115	11 18.430	121 53.370	596	08/01/23	14:14	596 (Oxy)	300 (NC)	55 (Pln)	50 (Pln)	45 (Pln)	40 (Pln)	12 (Oxy)
116	11 26.543	121 49.908	1094	08/01/23	17:18	1071.3 (Oxy,Sal)	761.2 (Oxy,Sal)	406.4 (Oxy,Sal)	50 (Pln)	45 (Pln)	12.8 (Oxy,Sal)	NC
117	11 49.066	121 42.884	849	08/01/23	20:20	833.1 (Oxy,Sal)	509.5 (Oxy,Sal)	NC	55 (Pln)	30 (Pln)	12.9 (Oxy,Sal)	NC
118	11 59.532	121 48.923	400	08/01/23	22:23	380 (Oxy,Sal)	154 (Oxy,Sal)	NC	NC	NC	12.6 (Oxy,Sal)	NC
119	12 12.936	121 43.974	668	08/01/24	00:12	NC	NC	NC	45 (Pln)	40 (Pln)	35 (Pln)	30 (Pln)
120	12 39.956	121 51.964	600	08/01/24	03:30	586.1 (Oxy,Sal)	307.4 (Oxy,Sal)	NC	NC	30 (Pln)	25 (Pln)	13.4 (Oxy,Sal)
121	11 43.919	120 59.903	346	08/01/25	02:58	NC	NC	NC	50 (Pln)	45 (Pln)	40 (Pln)	35 (Pln)
122	11 45.992	121 4.976	624	08/01/25	03:59	617 (Oxy,Sal)	306 (Oxy,Sal)	50 (Pln)	45 (Pln)	40 (Pln)	35 (Pln)	12 (Oxy,Sal)
123	11 48.997	121 10.006	210	08/01/25	05:20	204 (Oxy)	100 (NC)	35 (Pln)	30 (Pln)	25 (Pln)	20 (Pln)	12 (Oxy)
124	11 51.966	121 14.989	271	08/01/25	06:23	260 (Oxy)	200 (NC)	45 (Pln)	40 (Pln)	35 (Pln)	30 (Pln)	12.5 (Oxy)
125	11 53.002	121 9.985	390	08/01/25	07:21	379 (Oxy)	250 (NC)	50 (Pln)	45 (Pln)	25 (Pln)	20 (Pln)	12 (Oxy)
126	11 53.072	121 4.879	427	08/01/25	08:27	416 (Oxy,Sal)	255 (Oxy,Sal)	65 (Pln)	60 (Pln)	45 (Pln)	40 (Pln)	12 (Oxy,Sal)
127	11 52.961	120 59.936	466	08/01/25	09:32	462 (Oxy)	300 (NC)	45 (Pln)	40 (Pln)	20 (Pln)	15 (Pln)	12 (Oxy)
128	11 52.980	120 54.923	471	08/01/25	10:37	463	300	35	30	25	20	11

						(Oxy)	(NC)	(Pln)	(Pln)	(Pln)	(Pln)	(Oxy)
129	11 54.884	120 59.860	460	08/01/25	11:49	458 (Oxy,Sal)	302 (Oxy,Sal)	50 (Pln)	45 (Pln)	40 (Pln)	35 (Pln)	12 (Oxy,Sal)
130	11 57.998	121 5.083	461	08/01/25	13:02	449 (Oxy)	300 (NC)	55 (Pln)	50 (Pln)	45 (Pln)	40 (Pln)	12 (Oxy)

Station	Lat	Lon	Depth	Start Date	UTC	Bottle1	B2	B3	B4	B5	B6	B7
131	11 59.930	121 9.886	164	08/01/25	14:05	158 (Oxy)	100 (NC)	55 (Pln)	50 (Pln)	45 (Pln)	40 (Pln)	12 (Oxy)
132	12 1.965	120 59.993	420	08/01/25	15:25	405 (Oxy,Sal)	253 (Oxy,Sal)	50 (Pln)	45 (Pln)	40 (Pln)	35 (Pln)	12 (Oxy,Sal)
133	12 15.959	120 56.005	753	08/01/25	17:31	NC	NC	NC	50 (Pln)	45 (Pln)	40 (Pln)	35 (Pln)
134	12 29.994	120 52.968	609	08/01/25	19:43	NC	NC	NC	50 (Pln)	45 (Pln)	40 (Pln)	35 (Pln)
135	12 24.929	120 46.909	646	08/01/25	21:09	646.1 (Oxy,Sal)	509.2 (Oxy,Sal)	NC	NC	70 (Pln)	55 (Pln)	13.2 (Oxy,Sal)
136	12 21.983	120 41.978	1138	08/01/25	22:27	NC	NC	NC	55 (Pln)	50 (Pln)	45 (Pln)	40 (Pln)
137	12 17.926	120 35.076	785	08/01/26	00:08	NC	NC	NC	70 (Pln)	65 (Pln)	60 (Pln)	55 (Pln)
138	12 13.082	120 29.892	507	08/01/26	01:34	493.7 (Oxy,Sal)	326.9 (Oxy,Sal)	NC	75 (Pln)	70 (Pln)	12.9 (Oxy,Sal)	NC
139	12 35.018	120 22.032	1187	08/01/26	04:17	1180 (Oxy)	1000 (NC)	70 (Pln)	65 (Pln)	60 (Pln)	55 (Pln)	12 (Oxy)
140	12 44.988	120 33.082	991	08/01/26	07:30	985 (Oxy)	600 (NC)	55 (Pln)	50 (Pln)	45 (Pln)	40 (Pln)	13 (Oxy)
141	12 48.504	120 37.524	1604	08/01/26	08:27	1574 (Oxy,Sal)	1120 (Oxy,Sal)	612.2 (Oxy,Sal)	55 (Pln)	50 (Pln)	40 (Pln)	13.4 (Oxy,Sal)
142	12 51.030	120 41.064	998	08/01/26	10:11	988 (Oxy)	600 (NC)	55 (Pln)	50 (Pln)	45 (Pln)	40 (Pln)	13 (Oxy)
143	13 21.029	120 19.876	356	08/01/26	23:48	348.5 (Oxy,Sal)	NC	245.5 (Oxy,Sal)	55 (Pln)	50 (Pln)	12.6 (Oxy,Sal)	NC
144	13 14.023	120 15.013	2416	08/01/27	01:21	NC	NC	NC	75 (Pln)	70 (Pln)	65 (Pln)	60 (Pln)
145	13 06.002	120 11.046	2930	08/01/27	03:58	2897 (Oxy)	2000 (NC)	70 (Pln)	65 (Pln)	60 (Pln)	55 (Pln)	13 (Oxy)
146	12 57.998	120 6.036	2949	08/01/27	06:44	2901 (Oxy,Sal)	2038 (Oxy,Sal)	1016 (Oxy,Sal)	65 (Pln)	60 (Pln)	55 (Pln)	13 (Oxy,Sal)
147	12 51.025	120 1.978	1489	08/01/27	09:29	1487 (Oxy)	1000 (NC)	65 (Pln)	60 (Pln)	55 (Pln)	50 (Pln)	13 (Oxy)
148	12 43.037	119 56.980	281	08/01/27	11:31	270 (Oxy,Sal)	200 (NC)	60 (Pln)	55 (Pln)	50 (Pln)	45 (Pln)	12 (Oxy,Sal)
149	11 14.996	121 58.036	892	08/01/28	06:23	890 (Oxy,Sal)	500 (NC)	65 (Pln)	60 (Pln)	55 (Pln)	50 (Pln)	10 (Oxy,Sal)
150	11 12.295	121 59.280	1059	08/01/28	07:34	1061 (Oxy)	500 (NC)	70 (Pln)	65 (Pln)	60 (Pln)	50 (Pln)	12.7 (Oxy)
151	11 10.037	121 58.966	1218	08/01/28	09:01	1224 (Oxy,Sal)	608 (Oxy,Sal)	65 (Pln)	55 (Pln)	50 (Pln)	Did not trip	13 (Oxy,Sal)
152	13 30.095	121 8.756	337	08/01/29	10:41	315 (Oxy,Sal)	45 (Pln)	35 (Pln)	30 (Pln)	25 (Pln)	12.8 (NC)	12.8 (Oxy,Sal)
153	13 35.748	121 4.972	324	08/01/29	11:54	299 (Oxy,Sal)	75 (Pln)	60 (Pln)	55 (Pln)	30 (Pln)	12.7 (NC)	12.7 (Oxy,Sal)

***Oxy – Oxygen; Sal – Salinity; Pln – Plankton; NC – No collection**

Appendix 2: DETAILS for WATER SAMPLING

The objective of the water sampling is to calibrate the dissolved oxygen (DO), and salinity measurement of the CTD measurements. Typically water samples are taken at bottom and at 10m with additional samples taken in between depending on depth of station and CTD profile.

On board ship determination was done for DO and salinity. The procedure used for DO was the modified Winkler method adapted for the spectrophotometer. Results of the calibration is shown in Figure 4 (Actual measurements in Table 2). A composite of vertical profiles of DO values for all the stations in the Bohol Sea is shown in Figure 5.

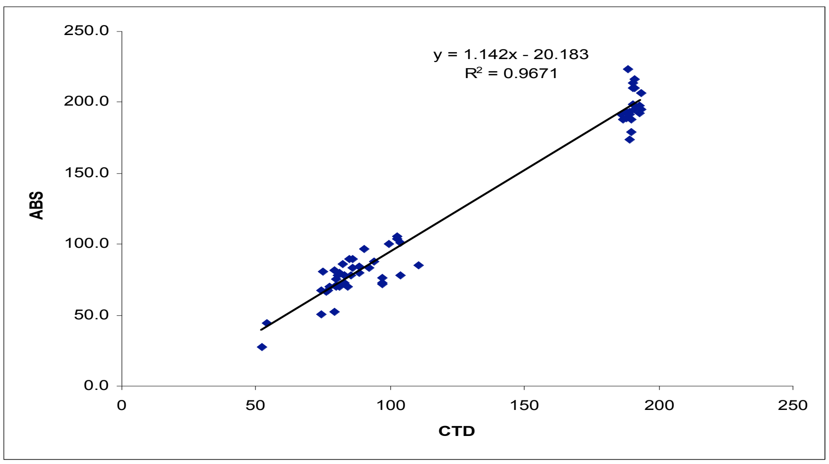

Figure 4. Calibration curve for DO using CTD and Winkler-spectrophotometric method

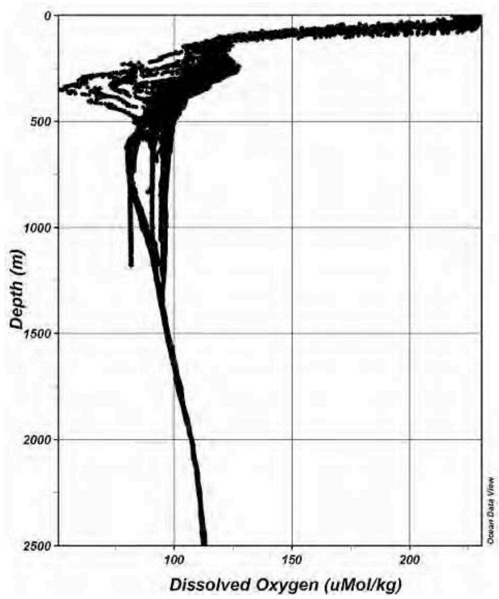

Figure 5. Composite of vertical profiles of DO from the CTD casts

Table 2. CTD and Spectrophotometric reading of Oxygen

Station	Pressure	CTD	Spectro	Comments
102	1377	84.53	91.6	addition of potassium
	1017.7	85.67	122.8	iodate did not produce
	611	85.22	89.7	precipitate
	13	190.65	227.3	opened new bottle
104	1197	85.2	78.3	
	813.2	85.84	83.2	
	509.2	88.35	83.9	
	10	189.36	193.7	
107	688	82.73	78.0	bubbles observed
	303	94.39	346.7	upon scheduled
	12	190.9	476.1	shaking of bottles
110	579	83.38	334.7	bubbles observed
	302	94.39	347.5	upon scheduled
	12.7	190.9	455.4	shaking of bottles
113	566	82.81	77.9	
	335	83.18	78.2	
	12	190.93	195.1	
116	1098	84.44	69.8	
	750	81.3	70.4	
	400	88.58	79.4	
	10	188.33	223.8	
117	833	79.62	71.0	
	509.5	82.82	73.1	
	10	189.16	191.6	
118	380	76.45	66.9	
	154	94.26	87.6	
	10	186.84	187.9	
120	586	76.83	67.3	

	307.4	54.18	43.9	
	13.4	192.8	197.9	
122	617	80.72	78.1	
	306	99.57	100.0	
	12	190.83	209.7	
126	416	81.3	79.6	
	255	102.37	103.6	
	12	193.47	206.5	
129	458	79.19	81.2	
	302	102.6	105.2	
	12	190.23	198.3	
132	405	79.8	75.0	
	253	103.54	101.4	
	12	185.98	191.3	
135	646.7	74.56	67.3	
	505.9	77.54	70.0	
	13.2	188.15	193.7	
Station	Pressure	CTD	Spectro	Comments
138	493.7	79.76	70.3	
	326.9	92.35	83.7	
	12.9	188.01	188.7	
141	1574	90.04	96.6	
	1120	82.06	86.2	
	612.2	74.76	80.8	
	13.4	190.97	216.5	
143	348.5	96.84	71.6	
	245.5	110.84	85.4	
	12.6	190.04	188.3	
146	2901	104.04	77.6	
	2038	96.92	72.6	
	1016	79.06	52.2	
	13	190.02	179.0	
148	270	97.31	76.5	
	12	189.31	173.7	
149	890		88.6	missing data
	10	190.5	213.6	
151	1224	84.61	89.3	
	608	86.03	89.8	
	13	190.38	209.8	
152	315	52.03	27.5	
	12.8	193.14	192.2	
153	299	74.24	50.8	
	12.7	193.53	194.9	

Note that we did not use the bottles from stations 102, 107 and 110 for the calibration curve. For the very first station, station 102, addition of the left-over potassium iodate from the previous leg did not produce any precipitate (we think that the bottle might just have been mislabeled). We opened a new bottle of potassium iodate and added 1ml to each sample bottle again. Samples were read as usual but we believe the integrity of the reading is compromised. Succeeding samples were pickled with the new potassium iodate.

We also did not use bottles from stations 107 and 110 since during shaking (done sometime after pickling and before reading the samples) we observed that there were bubbles in the bottles. We still read the samples as usual and the values are reported in Table 2 but we did not include there in the calibration curve.

Results of the salinity calibration is shown in Figure 6 (ask Dave)

Figure 6. Calibration curve for salinity using CTD and

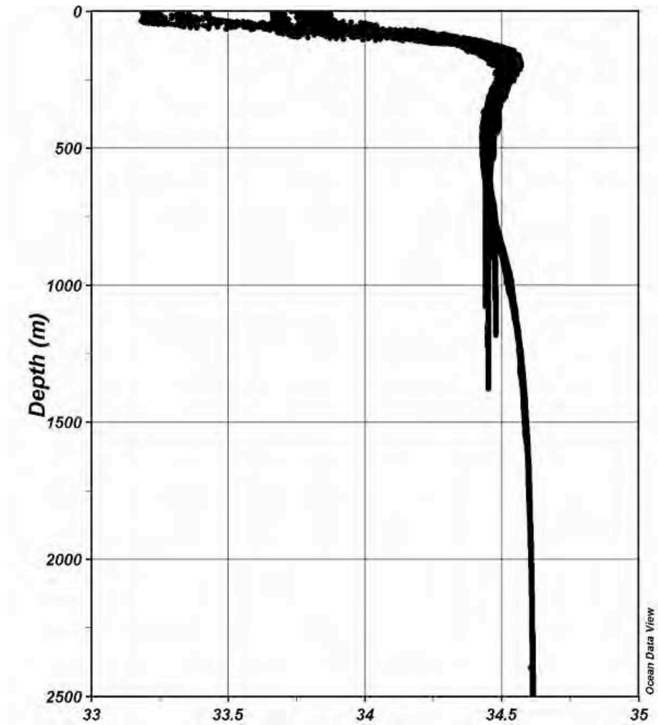

Figure 7. Composite of vertical profiles of salinity

Appendix 3: DETAILS for VERTICAL PLANKTON sampling

Samples for plankton were collected all 52 CTD Stations. Samples were taken using Niskin bottles mounted on a Rosette sampler system. Sampling depths were identified based on DCM profiles generated per station.

Average DCM depth was found to be within 40 - 60m with Chl maximum concentration ranging from 1.60 – 1.82 mg m^{-3}. Besides the normal Gaussian distribution (Figure 8a), the DCM profiles displayed four other different types which could be associated to physical factors :

(1) Stations between the Mindoro and Panay (Stns. 122 – 132) did not exhibit a deep chlorophyll maximum due to strong winds, causing the upper layer to be well mixed (Figure 8b).
(2) Stations in the northern Mindoro transect and most stations in the Panay showed higher phytoplankton biomass below the DCM (Figure 8c), indicating probable higher nutrients from deeper waters.
(3) Stations near the coast (Stns. 132, 133, 134 and 105) seem to indicate freshwater influence as the profiles showed higher biomass above the DCM (Figure 8d).

(4) Stations located in the middle of both the Mindoro and Tablas Straits (Stn 106, 119, 147, 148) showed a sharp decrease in phytoplankton biomass below the DCM (Figure 8e), suggesting an abrupt depletion in nutrients.

10 L water samples were collected from 2-4 depths (above DCM, DCM, below DCM)); filtered through 64 µm mesh and then preserved in 10% formalin. Additional samples were taken from the re-occupied station in the Sulu Sea. Plankton identification and estimation of relative abundances will be performed at the University of the Philippines Marine Science Institute.

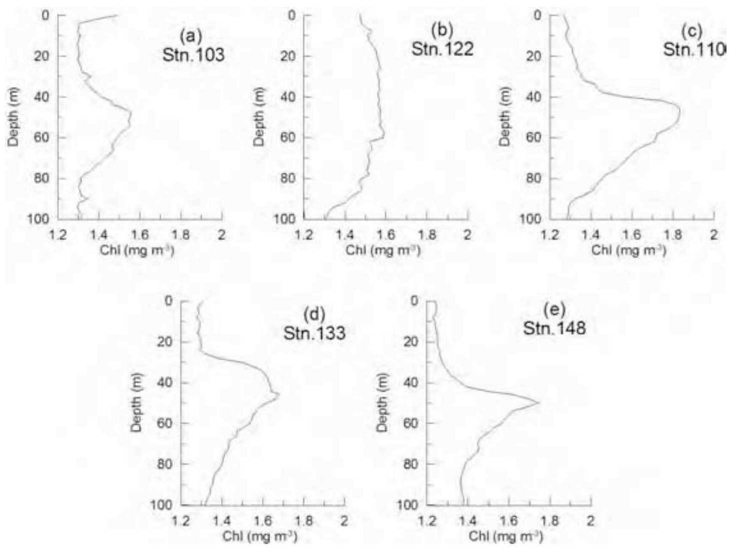

Figure 8. Typology of vertical profiles of the Deep Chlorophyll Maximum (DCM): (a) Normal distribution (b) Well mixed layer (c) High biomass below DCM (d) High biomass above DCM (e) Well-definedDCM.

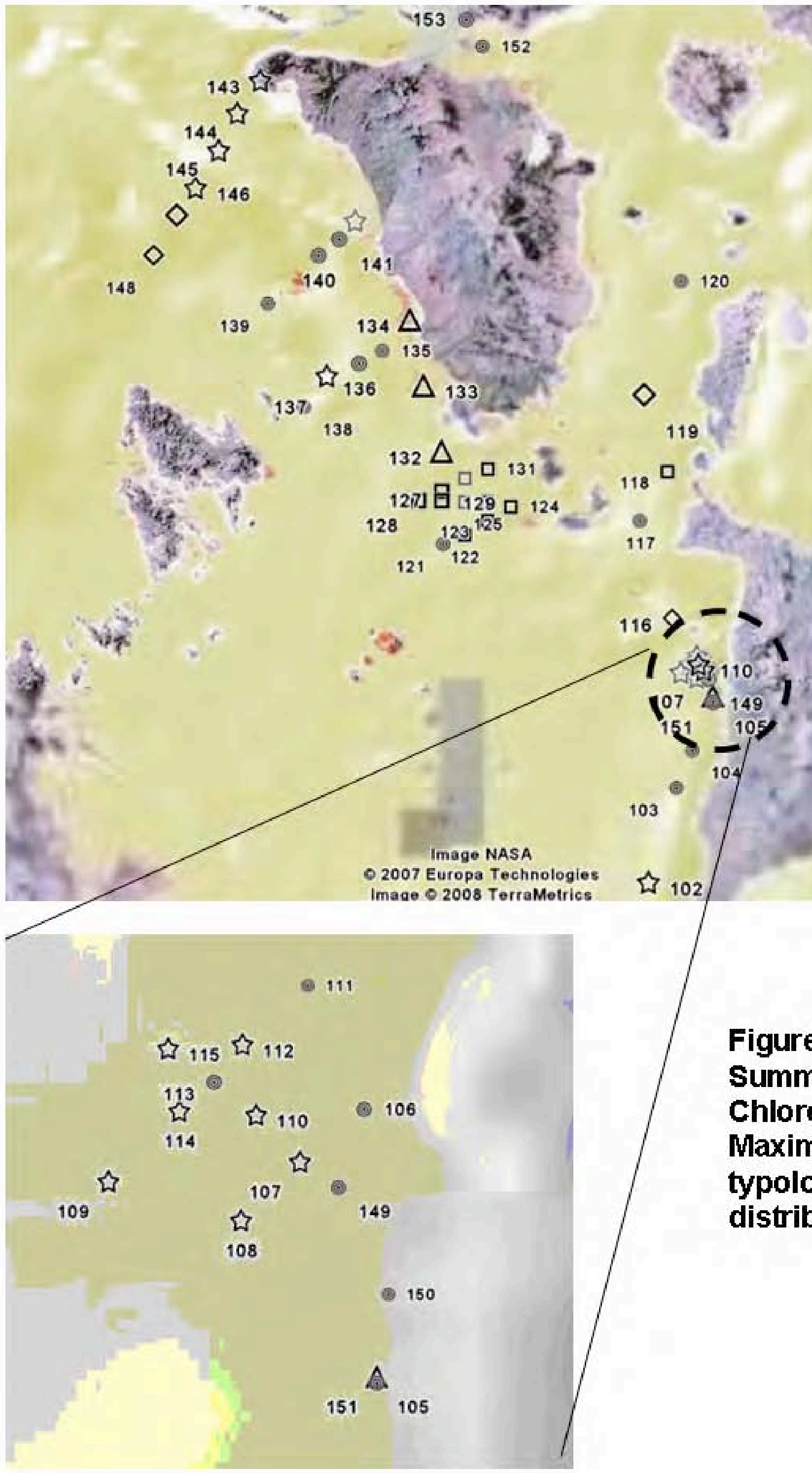

Figure 9. Summary of Deep Chlorophyll Maximum (DCM) typology distribution

Appendix 4: DETAILS for LIVE PLANKTON sampling

About 23 zooplankton samples were collected from the surface waters through the underway flow through sample system (UTSS) that was equipped with ctd, flourometer, flowmeter, and DO meter. A 64 um sieve was placed at the outflow of UTSS and live zooplankton samples were instantly transferred into a plastic disposable Petri dish and observed under a dissecting-darkfield microscope. Live images, mating and feeding behavior , and the different aspects of zooplankton motility were recorded with the use of a video system attached to the microscope.

Figure 9. Sample photos from plankton sampling

Appendix 5: Pictures of each sampling study

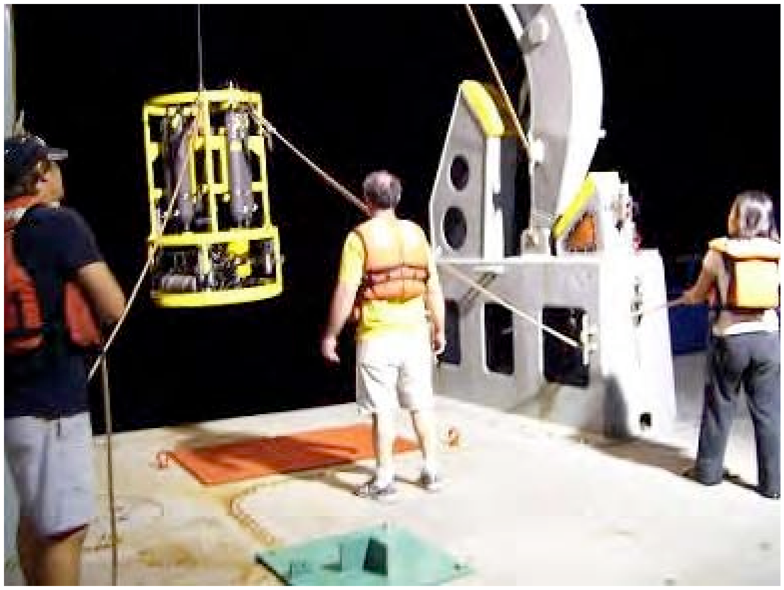

Figure 10. CTD with the 7 bottle rosette. Activities 1,3 and 4 were done using this instrument. Deployment and retrieval takes a minimum of 4 people aside from the Res. Tech. and the winch operator. Trigger of the bottles was done inside the laboratory in what is called the CTD control station (see below right) CTD sampling was done anytime the boat was on station, day or night. Approximate sampling time 30 minutes to 2 hours. (pictures taken by R. Maneja)

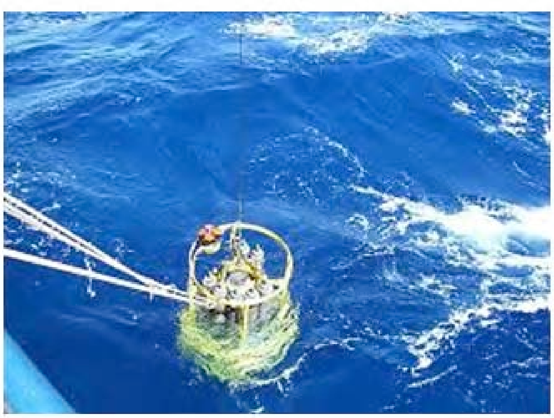

Figure 11. Sampling for water analysis was done in 2-4 of the 7 immediately after the CTD is brought up to the deck. Oxygen samples are taken first and pickled immediately before water samples for salinity were taken. Analysis for both oxygen and salinity were done in the laboratory on board R/V Melville (pictures taken by R. Maneja)

Figure 12. Sampling for plankton from DCM and near-DCM depth was done in 2-4 of the 7 bottles immediately after oxygen and salinity sampling is completed. Samples were either collected in buckets and sieved later in the laboratory or sieved immediately on deck. Samples were then pickled with formalin for later analysis. Sampling for surface live plankton (shown below) was done from the through flow system in the lab and then observed under a dissecting-darkfield microscope (pictures taken by R. Maneja)

Figure 13. Wind data (strength and direction) is recorded every 15-minutes. The boat heading and direction is likewise recorded to correct the recorded wind data.