R/V MIRAI

Final Cruise Report

BEAGLE (Blue EArth GLobal Expedition) 2003

MR03-K04

Leg 1, Brisbane (Australia) – Papeete (Tahiti)

August 3rd - September 5th , 2003

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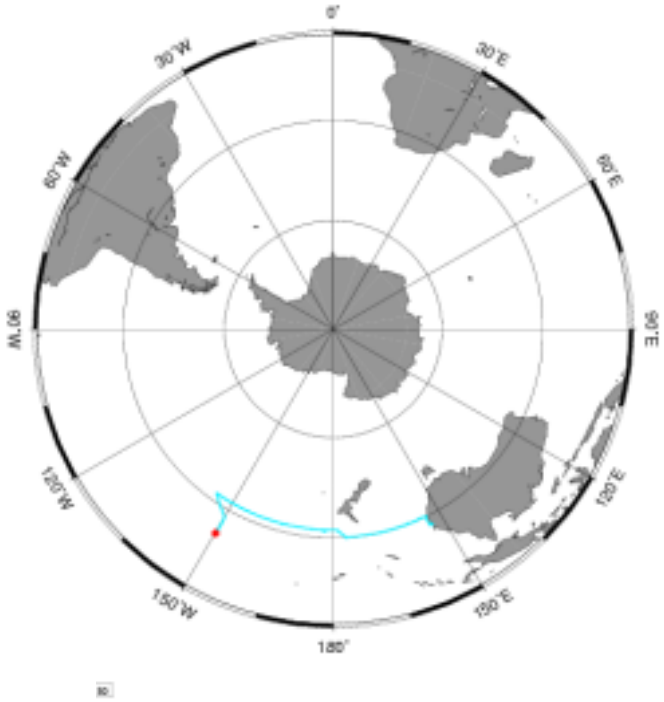

2003

1. Preface

This scientific international circumpolar cruise is organized by The Japan Marine Science and Technology Center (JAMSTEC) on board the Research Vessel (R/V) Mirai. The research project, termed BEAGLE 2003 (Blue EArth GLobal Experiment), is comprised of six legs and will be carried out along the WHP lines (WOCE Hydrographic Programme). The first leg of BEAGLE 2003 cruise was started at Brisbane, Australia on 3rd August 2003 and ended in Papeete, Tahiti on 5th September 2003 (Figure.1). The main goal of this cruise was to enhance research activities in Southern hemisphere, since this part of the world's oceans are greatly under sampled. In this leg, the proposed scientific samplings were included: CTD-RMS transects, deployment of floats and bio-optical measurements. This report mainly focuses on bio-optical measurements as one of important measurements that have been done during this leg. The bio-optical data will be used for validation of ocean-colour data from various ocean-colour sensors and to improve satellite-derived estimates of phytoplankton standing stocks and primary production.

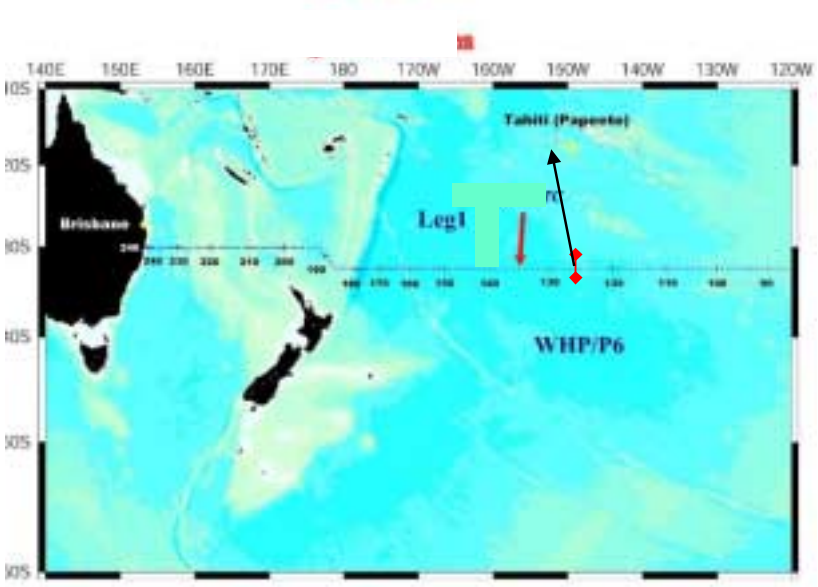

Fig.1. Sampling Stations of Leg 1, from Brisbane (Australia) to Papeete (Tahiti).

OCEANOGRAPHIC RESEARCH VESSEL "MIRAI"

The Oceanographic Research Vessel (R/V) "MIRAI" is one of the JAMSTEC's research vessels, which has been completed in August 1997. As one of the largest research vessels in the world, this vessel has equipment which designed to reduce vibrations of the hull, so that it can make possible observation under stormy weather, and has capacity of about 8.672 tons. Moreover, many buoys equipped with sensors for oceanographic and meteorological observation can be carried on board for efficient deployment and work. R/V Mirai has length, cruising speed and range is 128,58 meters, 16 knots and 12.000 nautical miles (about 22.000 km), respectively. This vessel can be extensively used year around in the Pacific Ocean and in high latitude sea areas where the weather is harsh (Figure 2).

Fig. 2. Research Vessel (R/V) Mirai.

2. Outline of the first leg of BEAGLE 2003

In this leg, there were several scientists of different countries had been working and participating beside Japanese scientists. They were from Indonesia, Canada, Argentina, Sri Lanka and Australia (Figure 3). The objectives of this cruise were 1) To detect and quantify temporal changes in the Antarctic Overturn System corresponding to the global ocean and the southern Ocean warming during this century through high quality and spatially dense observation along old WHP (World Ocean Circulation Experiment Hydrographic Program 1991-2002) lines. 2.) To estimate the amount of anthropogenic carbon up taken by the Antarctic Ocean. 3.) To provide a training environment in which trainees could get a hand-on experience in collecting biological, optical samples and optical data. In other to achieve the objectives, on this leg, there were several measurements or samples collection have been done as follow:

1. Measurements of temperature, salinity, oxygen, current profile, fluorescence and transmission by using CTD/O_2 with LADCP. Fluorescence meter and transmission meter.
2. RMS (Rosette Multi Sampler) water sampling and analysis of salinity, oxygen, nutrients, CFC11, 12, 113, SF_6, total alkalinity, DIC, DOC and pH.
3. Water samples collection for ^{14}C, ^{13}C and $^{3}He/^{4}He$.
4. Measurements of autotropics biomass (epifluorescence and chlorophyll a) by using surface LV.
5. Bio-Optical measurements.
6. ARGO floats deployment.

This particular report will focus on Bio-Optical measurements that have been conducted during this leg. These measurements will be used for validation of ocean-colour data from ocean-colour sensors. So that, the data will be used to improve satellite-derived estimates of phytoplankton standing stocks and primary production. Besides that, some of the measurements or analysis will be done on land by using HPLC or other instruments.

On this leg, generally all the experiments and measurements that have been well done based on the schedule and protocols. But in some cases, when the weather was very bad, the sampling and field measurements had been canceled until the weather got better. Besides that, on station 166^{th} one of the instruments (fluorescence meter) which attached to RMS was

broken and there was no spear available for this particular instrument. Thus, for the next stations no fluorescence measurement data had been collected. In order to solve this problem, we decided to change our sampling strategy by taking water samples with RMS at 5 different water depths (at 10, 50, 100, 150 and 200 meters) and analyzed them by Turner Chlorophyll.

Fig. 3. Scientists and Technicians on BEAGLE 2003- Leg 1.

3. Bio-Optical Measurements

There were several measurements, experiments and samples collection have been done during this leg. These measurements were carried out mostly two times each day and in some cases one time or even none especially when on board holiday or bed's weather. Most the water samples have been collected at around 9-10 am and 2-3 pm (local time) and for light measurement were done in parallel with sampling times. All measurements that have been done are listed below:

a. Photosynthesis-Irradiance experiments (PI's).
b. Phytoplankton absorption measurements.
c. Coloured Dissolved Organic Matter (CDOM) measurements.
d. Sampled collection for HPLC pigment determinations.
e. Turner fluorometry Measurements.
f. Samples collection for flow cyctometry (picoplankton).
g. SIMBAD radiometer measurements.
h. SIMBADA radiometer measurements.
i. Ocean Optics Hyperspectral Radiometer measurements.
j. Continuous measurements with the PAR sensor.

The seawater sub samples for phytoplankton pigments or primary production experiments were collected from surface water (± 5 meter depth) by niskin bottle samplers attached to CTD-RMS (Figure 4). In some cases, when the water depth was deeper than 5500 m, hand-held niskin bottle or bucket have been used, for the detail sampling collection please see table 1. But after station 166th, since the Fluorescence meter was broken, additional water samples have been collected at 5 different depths which were 10, 50, 100, 150, 200 meters to figure out the fluorescence profiles. The CTD-RMS consists of 36 niskin bottles and each has volume of 12 liters. Concerning the measurements or samples collection that have mentioned above, the methodology and some analyses will be described briefly below.

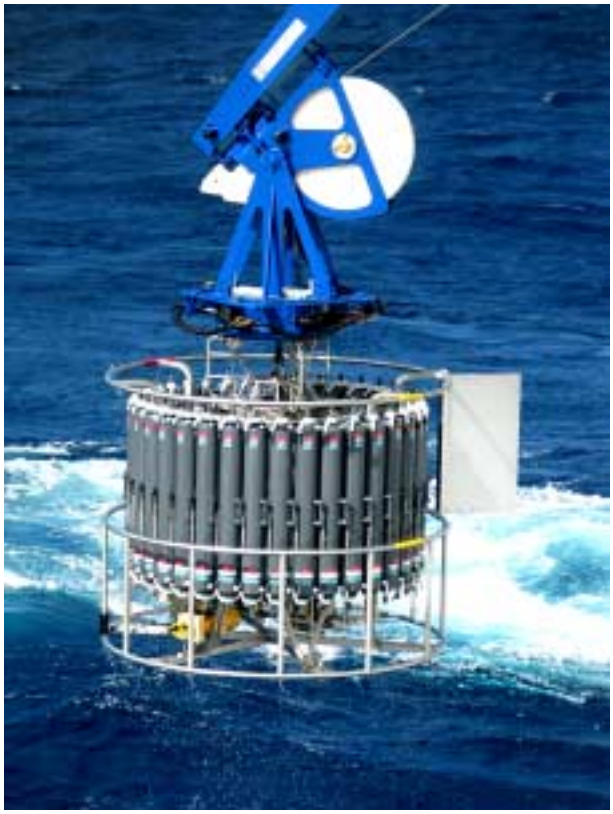

Fig. 4. CTD-RMS (Rosette Multi Sampler)

Table 1. Sampling stations and the equipment have been used for the sampling.

DATE	TIME GMT	STATION #	LATITUDE	LONGITUDE	ID#	RMS	NISKIN	BUCKET
4-Aug	01 00	PO6W-244	30 05.05S	153 35.90E	264001	X		
4-Aug	23 10	PO6W-238	30 05.13S	154 29.80E	264003		X	
5-Aug	22 00	PO6W-234	30 04.97S	156 31.78E	264005	X		
6-Aug	03 15	PO6W-232	30 04.94S	156 55.26E	264006	X		
6-Aug	22 10	PO6W-227	30 04.64S	158 40.96E	264008	X		
7-Aug	02 30	PO6W-226	30 19.93S	159 04.98E	264009	X		
7-Aug	20 50	PO6W-221	30 04.99S	161 30.26E	264011	X		
8-Aug	00 30	PO6W-220	30 05.30S	162 10.00E	264012	X		
8-Aug	21 10	PO6W-215	30 05.06S	164 49.90E	254014	X		
9-Aug	01 45	PO6W-214	30 04.62S	165 24.50E	264015	X		
9-Aug	24 00	PO6W-212**	30 04.65S	166 29.48E	264017		X	
10-Aug	21 30	PO6W-210	30 04.92S	167 29.90E	264019	X		
11-Aug	04 00	PO6W-209	30 04.92S	167 59.90E	264020	X		
11-Aug	20 30	PO6W-205	30 04.82S	169 59.82E	264022	X		
12-Aug	01 00	PO6W-204	30 05.70S	170 29.94E	264023	X		
12-Aug	20 30	PO6W-199	30 04.98S	172 29.92E	264025	X		
13-Aug	00 30	PO6W-198	30 05.06S	172 59.95E	264026	X		
13-Aug	18 10	PO6W-194	30 04.86S	175 10.08E	264028			X
14-Aug	01 00	PO6W-X14	30 00.50S	176 00.60E	264029	X		
14-Aug	19 30	PO6W-190	31 05.06S	177 32.25E	264031	X		

15-Aug	01 30	PO6C-186	31 34.99S	177 59.20E	264032	X		
15-Aug	19 30	PO6C-182	32 30.00S	179 55.06E	264034	X		
15-Aug	23 20	PO6C-181	32 30.15S	179 34.98W	264035	X		
16-Aug	18 00	XXXXXXXX	31 56.04S	177 19.05W	264037			X
17-Aug	18 00	PO6C-177	32 30.00S	178 17.02W	264039	X		
17-Aug	22 30	PO6C-176	32 30.05S	178 00.03W	264040			X
18-Aug	18 30	XXXXXXXX	31 59.81S	177 19.76W	264042			X
19-Aug	00 30	PO6C-173	32 29.96S	176 45.08W	264043			X
19-Aug	18 10	PO6C-170	32 28.87S	175 15.29W	264045			X
19-Aug	24 00	PO6C-169	32 30.10S	174 50.13W	264046			X
20-Aug	18 40	PO6C-166	32 30.25S	173 39.97W	264048			X
21-Aug	01 10	PO6C-165	32 29.95S	173 10.39W	264049			X
21-Aug	17 40	PO6C-162	32 29.95S	171 55.03W	264056	X		
21-Aug	22 00	PO6C-161	32 30.11S	171 35.07W	264062	X		
22-Aug	19 10	PO6C-X15	32 30.15S	170 00.13W	264069			X
23-Aug	00 45	PO6C-156	32 30.02S	169 30.23W	264075			X
23-Aug	17 15	PO6C-153	32 30.11S	168 00.92W	264082			X
23-Aug	23 00	PO6C-152	32 30.15S	167 29.97W	264088			X
24-Aug	16 20	PO6C-149	32 29.87S	165 49.93W	264095	X		
25-Aug	20 00	PO6C-148**	32 29.98S	165 09.97W	264101			X
26-Aug	02 00	PO6C-148**	32 29.98S	165 09.97W	264108			X
26-Aug	17 45	PO6C-146	32 30.05S	163 50.12W	264110			X
26-Aug	24 00	PO6C-145	32 29.94S	163 10.03W	264116			X
27-Aug	18 00	PO6C-142	32 29.94S	161 09.91W	264123			X
27-Aug	23 40	PO6C-140	32 29.72W	160 29.62W	264129			X
28-Aug	18 20	PO6C-137	32 30.04S	158 09.95W	264136			X
29-Aug	00 50	PO6C-136	32 29.73S	157 19.98W	264142			X
29-Aug	19 40	PO6C-133	32 30.17S	154 50.49W	264149	X		
30-Aug	01 35	PO6C-132	32 30.00S	153 59.69W	264155			X
30-Aug	16 40	PO6C-130	32 29.95S	152 20.05W	264162			X
30-Aug	22 20	PO6C-129	32 29.92S	151 29.62W	264168			X
31-Aug	18 00	PO6C-126	32 29.98S	148 59.94W	264176	X		
1-Sep	00 05	PO6C-125	32 30.13S	148 09.99W	264182			X
1-Sep	18 40	PO6C-122	32 29.97S	145 39.81W	264189	X		
2-Sep	00 50	PO6C-121	32 30.35S	144 49.87	264195			X

1. Photosynthesis-Irradiance (PI) measurements.

The amount of 9 liters surface water samples that have been collected by RMS, hand-held niskin bottle or bucket, filled into a carboy with a spigot. Added 9 ml of ^{13}C solution to the water sample and mixed them. Then, filled each of 45x125 ml polycarbonate bottles to the rim with this new solution and closed it with the cap. Placed 42 bottles into the PI light box (Figure 5) and space bars between each row and 3 dark bottles placed to the water bath. Put the pieces of rubber hose supplied on top of the bottle caps before the lid is closed to prevent

the bottles from moving and floating during the incubation. Turn on the light sources and incubate for three hours.

Fig.5. Photosynthesis-Irradiance (PI) light box.

The light source was turned off after three hours and filtered the bottles trough 25mm GF/F filter. Each filter was filtered through with combination of three bottles of samples, based on the order in the PI light box. These filtering have been repeated until the last three dark bottles. Each filter were folded in half and put in a glassine envelope. All of the envelopes with filter in it were dried before storage. Afterward all filters were stored at room temperature for later analysis on a mass spectrometer on land.

At the end of each day, the light intensities at each of the bottle position were measured by using a QSL 100 light meter as follows: 41 bottles have been filled with seawater, closed and put them in the incubator. Then, the 125 ml QSL bottle were filled with distilled water and insert probe and split stopper into the bottle. QSL probe plus bottle at position #1 were inserted and noted the reading as well as the range. The next were shuffled bottle 2 to position 1 and placed QSL probe plus bottle in position #2 and read the light measurement and so on until all the 42 light measurements have been done. The mean of three light readings will be used in the calculations.

2. Samples collected for HPLC pigment determination.

Duplicate samples for determination of phytoplankton pigment composition by HPLC have been collected every day and kept them frozen at $-80^{o}C$ for later analysis in the laboratory on land (Hobart and Cape Town). These samples were prepared by placing

duplicate 25 mm GF/F filters onto filtration rig and filtered 2 liters of water samples by using a low vacuum. After finishing the filtered, removed the filter, folded in half and wrapped in tin foil. Then, the filters were put in the liquid nitrogen freezer at –80 ^{o}C immediately after the filtering was finished.

3. Measurements of Turner Fluorometry.

Fluorometric measurements of Chlorophyll-a have been analyzed by using Turner fluorometer. The samples were prepared by filtering 3x100 ml water samples on to 25 mm GF/F glass fiber filters. Each filter was put in to a 20 ml glass scintillation vial containing 10 ml of 90% acetone. Then, all samples were stored in a freezer for around 24 hours for chlorophyll extraction. Prior to analysis, all the vial samples have removed from freezer and warmed at room temperature in the dark.

4. Measurements of Phytoplankton Absorption

In this particular measurement, samples were taken directly from carboy in duplicate at each station. These samples were filtered onto precombusted 25 mm GF/F glass fiber filter with the volume of 2 liters. One sample was analyzed on board by a Carey Model 50 BIO UV/VIS Spectrophotometer (Figure 6) and another one was frozen in liquid nitrogen then stored at –80 ^{0}C. Frozen samples will be sent to Canada for later analysis.

Fig. 6. Carey Model 50 BIO UV/VIS spectrophotometer

5. Measurements of Coloured Dissolved Organic Matter (CDOM)

Water samples were filtered trough 47 mm 0.2 μm Nucleopore membrane filters. Filtered about 30-50 ml of superQ water through the filter, swirled in filter flask and discarded the water. Then, about 10 ml of samples were poured in to funnel for filtering. Swirl in filter flask and discard the water, this step have been repeated three times. The next step was filtered about 200 ml of sample, rinsed the beaker and pour the sample into the filtration apparatus with superQ water three times. Afterward, the beaker was rinsed 3 times with the filtered sample from the filter flask and filled it with the remaining filtered sample in the filter flask. Filtered flask was covered by aluminum foil. The samples were measured by a Carey Model 50 BIO UV/VIS spectrophotometer on board.

6. Samples collected for flow cytometry (Picoplankton)

Duplicate water samples with a volume of 1.8 ml were mixed with paraformaldehyde (1%) in a 2 ml capacity cryogenic vial. The samples were kept at room temperature for around 15 minutes before freezing in liquid nitrogen. Later they were stored at – 80 ^{0}C. All of the samples will be analyzed in the laboratory on land.

7. Flow through water samples.

Water samples from the flow through system were collected once per day and the fluorosence was recorded, in the afternoon at around 18.30 (local time). This water sample were filtered in triplicate and analyzed by Turner fluorometer on board.

8. Chlorophyll profiles

The fluorometer, which is attached on CTD-RMS, was used to measure chlorophyll profiles at each station. At station PO6C-166 the fluorometer was broken, and since this station, there were no chlorophyll profile measurements. In order to overcome this problem, the sampling strategy had been changed. Water Samples, at subsequent Bio Optical stations were collected from CTD-RMS at live different depths 10, 50, 100, 150 and 200 meters. All samples were filtered in triplicate and analyzed for Turner chlorophylls.

9. Light measurements.

At every station where the water samples were collected, sea surface, solar and sky measurements of radiation were measured by using three different instruments. These instruments were SIMBAD-07. SIMBADA-21 and Ocean Optics Hyperspectral Radiometer. The measurements have been done during day time.

The SIMBAD-07 radiometer (Figure.7-A) have been used for measuring direct sunlight intensity by viewing the sun and water leaving radiance by viewing the ocean surface at 45^{o} from nadir and 135^{o} from the sun's vertical plane. This instrument has an external GPS (Global Positioning System) and five spectral bands. These spectral bands are centered at 443, 490, 560 670 and 870 nm.

The SIMBADA-21 instrument (Figure 7-B) is an above-water radiometer as well. This instrument have been used for measurement of water leaving radiance and aerosol optical thickness in 11 spectral bands by viewing the sun and the ocean surface. These spectral bands are centered at 350, 380, 421, 443, 490, 510, 565, 620, 670, 750 and 870 nm. On SIMBADA, a GPS antenna is attached in the front of instrument and a display provides various types of information.

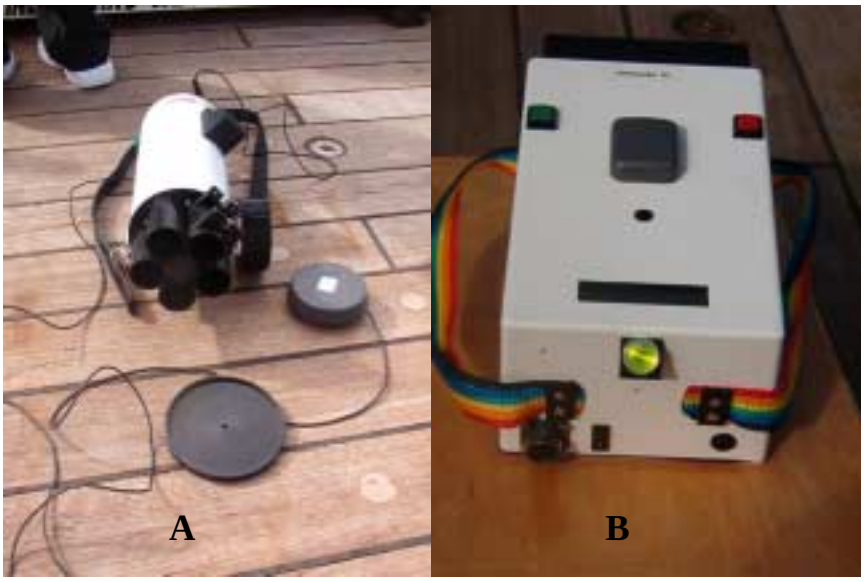

Fig. 7. The SIMBAD (A) and SIMBADA (B)

Ocean Optics Hyperspectral Radiometer have been used for detemining water leaving remote sensing reflectance which is defined as the water leaving radiance over the downwelling irradiance. The downwelling irradiance was measured using a Spectralon (Figure 8). Three types of measurements were done to calculate remote sensing reflectance. They were: a sea measurement, a spectralon measurement and a sky measurement. This instrument measures a complete spectrum from 350-1000 nm at 0.5 nm intervals.

Fig. 8. The Spectralon measurement.

The data from SIMBAD – 07 and Ocean Optics Hyperspectral Radiometer were analyzed to verify that valid information had been collected and for detail analysis will be done later in the laboratory. There was no software available to analyzed SIMBADA-21 data so that the analysis will be done on laboratory.

10. Photosynthetically Active Radiation (PAR) sensor.

A Photosynthetically Active Radiation have been used to measure photosysnthetically active radiation. This sensor had been attached on atmospheric laboratory (facing atmosphere directly) on the vessel and run during the cruise continuously. At every hour, an hourly average was logged on a Licor Li 1400 data logger.

Acknowledgment

After more than a month of struggle for collecting and analyses of samples, and handling data in Western Pacific Ocean, we ended this leg at Papeete (Tahiti) with a lot of stories, experiences and information. This cruise was a great experience and memorable one!!!. Therefore, I would like to thank **POGO (Partnerships for Observation of the Global Oceans)** and **IOCCG (International Ocean Colour Coordinating Group)** for the scholarships enabling me to participate in this research cruise and to **JAMSTEC (Japan Marine Science and Technology Center)** for this opportunity and well organized cruise. My heartfelt thanks to Captain Takaaki Hashimoto, crew and technicians of the R/V Mirai, they worked devotedly and satisfied our request. The last, most of all I would like to express my thanks to Dr. Masao Fukasawa (Chief Scientist), Mr. Brian Irwin, Dr. Kanthi Yapa, Elena S. Barbieri, Dr. Takeshi Kawano, Dr. Yuichiro Kumamoto and all scientists on this cruise for the cooperation, without them any works were not possible.