Cruise Report

Blue Earth Global Expedition

(BEAGLE - 2003)

Leg 2, Papeete (Tahiti)- Valparaiso (Chile)

September 6th - October 16th, 2003

Bio-optics Group

IOCCG/POGO Students	:	Alexander Galan	(Colombia)
		Dante Matellini	(Peru)
		Serkan Sancack	(Turkey)
Specialist in charge :		Gadiel Alarcon	(Chile)

1. **Introduction**

The **B**lue **EA**rth **GL**obal **E**xpedition 2003, '**BEAGLE 2003**', is an oceanographic research program developed by Japan Marine Science and Technology Centre (JAMSTEC). The principal objective of this project is to enhance oceanographic research activities in the Southern Hemisphere, in accordance with the Sao Paulo Declaration (POGO, 2000). These are pointed out as follows: 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 uptaken 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.

1.1 The Ship

The Oceanographic Research Vessel (R/V) "MIRAI" belongs to JAMSTEC and was completed in August 1997. As one of the largest research vessels in the world, it has equipment that is designed to reduce vibrations of the hull, so that it can make possible observation under stormy weather, and has a 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's length, cruising speed and range are 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 weather is harsh.

2. Bio-optical Objectives

The general objectives of the biological optical experiments of the cruise were:

➢ To know the Pacific Ocean primary productivity and bio-physical relationship in order to provide an important data base of bio-optical measurements in the Southern Ocean.

To reach this objective, light measurements will be made and data will be collected to obtain concentrations and kinds of photosynthetic pigments, and primary production rates. These observations will provide an important database for the Southern Oceans. Besides, bio-optical measurements will contribute to develop and validate algorithms of satellite-derived chlorophyll and primary production rates by sensors such as SeaWiFS, MODIS, and MERIS.

➢ To provide a training environment in which trainees could get a hands-on experience in collecting biological-optical and optical data. In addition, to obtain a feeling with the magnitudes, analysing and processing of bio-optical data.

3. Sampling Strategy

In order to attain the bio-optics objectives, experiments, water sampling and optics instruments were used according to standard protocols (taken from URL), therefore no specification about these will be provided here. The former were carried out onboard, some of the second will be analysed in different research laboratories (see below), and computing of the later will be developed onboard as preliminary process. Most of the water samples were

collected around 8-10 a.m. and 2-4 p.m. (local time) and the light measurement were done close to the sampling times and when possible at midday. All measurements done are listed below:

I. BIOLOGICAL

Photosynthesis v/s Irradiance (PI) Experiments

Everyday 2 experiments were carried out onboard. The seawater was collected from surface using a bucket or the 12 litre Niskin bottles of the rosette (5-10 m.), depending on weather conditions. 42 bottles (+ 3 dark) were incubated with ^{13}C in a Larsen box for 3 hours, then filtered and dried in an oven.

Storing: filters were labelled and stored in sets of 15 envelopes.

CDOM

The **C**oloured **D**issolved **O**rganic **M**atter analysing was immediately scanned with 0.2 μm filtered seawater in a 10 cm quartz cuvette into a CARY spectrophotometer.

Storing: no samples were stored. Results are in folder JAMSTEC/CDOM/Leg2/dailyfolder

Photosynthetic Pigments

A profile for Chlorophyll-a and Phaeopigments concentration were done in every PI experiment. Six standard depths were selected: Surface, 10, 50, 100, 150 and 200 meters. The pigments estimates were done onboard using a digital Turner Designs fluorometer.

Storing: no samples were stored. Results are in folder JAMSTEC/Leg2/Chl/daily files

Particulate Absorption

Two samples were collected from same depth of PI experiment. One sample was scanned into CARY spectrophotometer and the other was stored to be analysed in Bedford Institute of Oceanography (Att: Dr. Venetia Stuart). Besides, a blank was scanned everyday and one blank was stored as same as particulate absorption sample.

Storing: First sample results are in folder JAMSTEC/Absorption/Leg2/dailyfolder. Second, were frozen in liquid nitrogen into a labelled cryogenic vial and then stored in a deep freezer (-80°C).

High Performance Liquid Chromatography

Two samples were collected from same depth of PI experiment. These samples will be analysed using High Performance Liquid Chromatography in 2 different laboratories: Cape Town and Hobart.

Storing: Both samples were frozen in liquid nitrogen and then stored in 2-separated labelled aluminium foil envelopes into a deep freezer (-80^oC).

II. OPTICS

The weather conditions were not good for collecting optics data due to high cloud cover most of the time. However, when there was no rain or drizzle to interfere with data collection, 2 rounds of measurements were carried out.

SIMBAD

The hand-held battery operated radiometer collects data in five spectral bands which are centred at 443, 490, 560, 670, 870 nm. This instrument has an external GPS antenna and measures direct sunlight intensity and water leaving radiance. The GPS must first find the instruments position before readings can be made. The sequence of measurements are 1 Dark, 3 Sun, 6 Sea, 3 Sun, and 1 Dark.

Storing: The files are in the folder

JAMSTEC/Leg2/simbad/dailyfolder.

SIMBADA

This instrument is an above-water radiometer and it measures water-leaving radiance and aerosol optical thickness in 11 spectral bands. The bands are centred at 350, 380, 412, 443, 490, 510, 565, 620, 670, 750 and 870 nm. The instrument has an internal GPS antenna that must home in on 3 or more satellites before readings can be taken. The sequence of measurements are 1 Dark, 3 Sun, 6 Sea, 3 Sun, and 1 Dark. Under rough sea conditions it is not easy to maintain the instrument at the right angle.

Storing: The files are in the folder

JAMSTEC/Leg2/simbada/dailyfolder.

Hyperspectral radiometer

This instrument has a large wavelength range. It measures the irradiance from 350 to 1000 nm at 0.5 nm intervals and has a special fibre optic that collects the irradiance from the sky and the sea surface. The downwelling irradiance is measured using a spectralon that diffuses the incident irradiance.

Storing: Files are in folder

JAMSTEC/Leg2/HyperSp/dailyfolder.

Photosynthetic Active Radiation (PAR)

The PAR sensor was mounted outside, above the Atmospheric Observation laboratory. The Licor 1400 data logger connected to the sensor reads measurements every 60 seconds and records hourly average on the hour.

4. IOCCG/Pogo Students Activities

The general activities involved the participation in activities of water sampling from the rosette and the gaining of experience in biological experiments and optical instruments handling.

4.1 Students Remarks

Alex

I would like to thank POGO for this great training opportunity and to all the JAMSTEC people for their collaboration.

The knowledge of the techniques used to validate the remote sensing information has an incalculable value for me and is the bases for the development of my thesis project, the likes of which is part of the compromise with the entity that I represent.

Likewise, the recording and management of information has allowed me to improve the applications of these tools and the viability to be able to develop them in different types of research in the eastern coastal boundaries, as is the Chilean upwelling system.

The handling of this information that has permitted some bio-optical characterizations (mainly absorption of photosynthetic pigments and reflectance data) in an oligotrophic system, as is the South Pacific Gyre and the highly productive coastal system, has generated questions which lead to the placement of my working hypothesis, which I hope to prove during the development of my thesis.

Dante

About ¾ of the way through, we experienced some problems with the SIMBAD 7 and the SIMBAD 1.1 software. Both malfunctioned at the same time. When turning on the SIMBAD 7 a continuous beep would be heard and all the lights would light up. When initialising the SIMBAD 1.1 software it would crash every time so we had to use the 1.0 version. However when using the latter version to download the data all at once, some of the files would be corrupt, so we had to download them one at a time.

Simbada worked well and was easy to use. It was a shame we could not process the data. It is more practical to use on a rocking ship than Simbad although the sun is harder to find.

The hyperspectral radiometer worked well although we couldn't work out why the instrument took longer to stabilize during some measurements. The data was processed as indicated in the protocol and we obtained remote sensing reflectance. 5 wavelengths were chosen that approximate to the SeaWiFS bands. We compared the ratios of 4 bands with the highest band and plotted this against chlorophyll. This information could be used to calculate a new algorithm for primary production.

When making a note of some meteorological parameters such as cloud cover and sea condition, there was a difference in the interpretation depending on the observer. It would be useful to have some guide or visual scale to make these observations more precise.

All the lab experiments went well although we made some small mistakes at the beginning. It will be interesting to see how our results compare with those to be obtained from the duplicate samples.

The rosette sampling with the people from JAMSTEC was a good experience and taught me the necessity for strict control. I am happy to know that I have participated in this project.

In general I was able to learn and experience what it is to work in a laboratory on a ship for such a long time and simultaneously process the data. The light measurements were also new to me and I will transmit this experience to the people at my home institute in Peru in the hope that we can begin recording this kind of data when at sea.

Serkan

The SIMBAD data is processed using *calc_marref_v16PC.exe* for the first 20 measurements. The output file (simbad.leg2) can be found under Leg2 data in SIMBAD section. The files processed with *calc_marref_v16PC* as follows: For the first sea measurement of a cast

first sun measurement is used, for the seconds the second sun measurements are used and so on up to sixth measurement. And first dark file is used for first three sea measurements and the second dark measurement used for last three sea measurements.

The absorption measurements were made with two different sessions with the software. Only for the last seven days of the sampling the same session was used for both measurement in a day. So the one blank measurement made in the morning has done with the same zero setting for two absorption measurements. In the beginning the second sampling of the day used a different zero setting than the zero setting for blank, due to exiting and opening of the program again.

The colour observations for sea also made by naked eye. It is observed that the colour changes dramatically near Tahiti and as getting far from Tahiti green colour changes to deep blue within tens of meters. During the cruise the colour of the sea remained same (deep blue) and changed to green again at the station one before the one where the land (Chilean coast) can be seen with naked eye.

It was really interesting for me to have the chance to compare the bio-optical data collected in this cruise from the Pacific Ocean and the data we had in my institute cruises from Black Sea and Mediterranean. I think it will be very interesting to compare Pacific data with Mediterranean data that looks to have both similarities and dissimilarities. If it will be possible for me to use the bio-optical data of Beagle 2003 I would like to collaborate with other scientists from this cruise and work on the comparison of two oligotrophic seas (Pacific and Mediterranean). This also would be a great topic for my PhD thesis, which I have to start to write in the next semester in my institute.

(Please contact from sancak@ims.metu.edu.tr).

5. Preliminary Results

This preliminary analysis of the results consists of data taken during 38 days of navigation on board the R/V Mirai, but needs to be reviewed later as no quality control has been carried out. Temperature, oxygen and salinity distributions were computed from CTD data, and correspond to downcast only. The photosynthetic pigments were analysed onboard, but they still have to be review too. The optical data for the hyperspectral radiometer and simbad have been processed but not the simbada data as this is an experimental instrument. The PI stations are shown in figure 1.
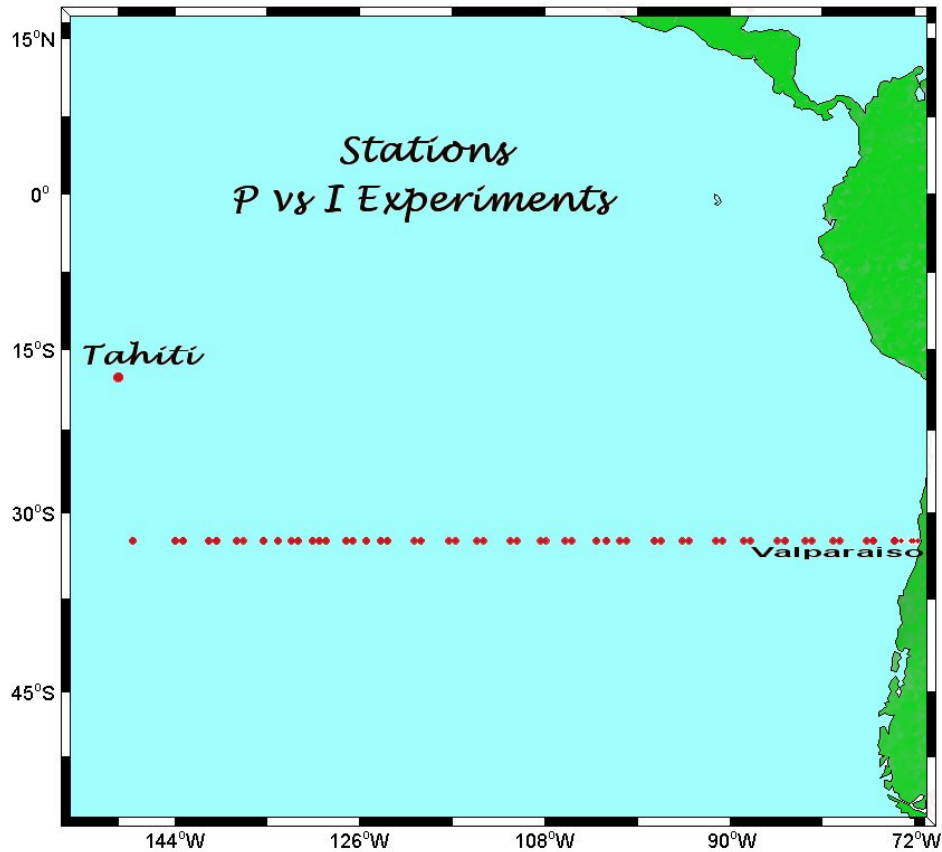
Figure 1. PI stations during Leg2

CTD data

Figure 2 shows the vertical structure of Temperature, Oxygen and Salinity between approximately 149°W and 71°W taken between the 12th September and 12th of October. The data corresponds to 114 CTD downcasts. Although in most stations the rosette reached the bottom of the ocean, we are only showing the top 500m that are to be used in the analysis of the bio-optical data. The temperature section seems to have a fairly even horizontal distribution with the thermocline appearing to be at a depth of around 150 to 200m between 149°W and 95°W. Approximately at 95°W it begins to rise and upwells near the coast proving to be a typical distribution for the South Eastern Pacific. Meanwhile the oxygen and salinity sections show decreases in values around 130°W and 124°W respectively possibly indicating the meeting of two different water masses. However further analysis possibly involving water currents are required. Finally near the coast we can observe the oxygen minimum at a depth of about 150m. Note: to convert μM to ml/L divide by 44.6.
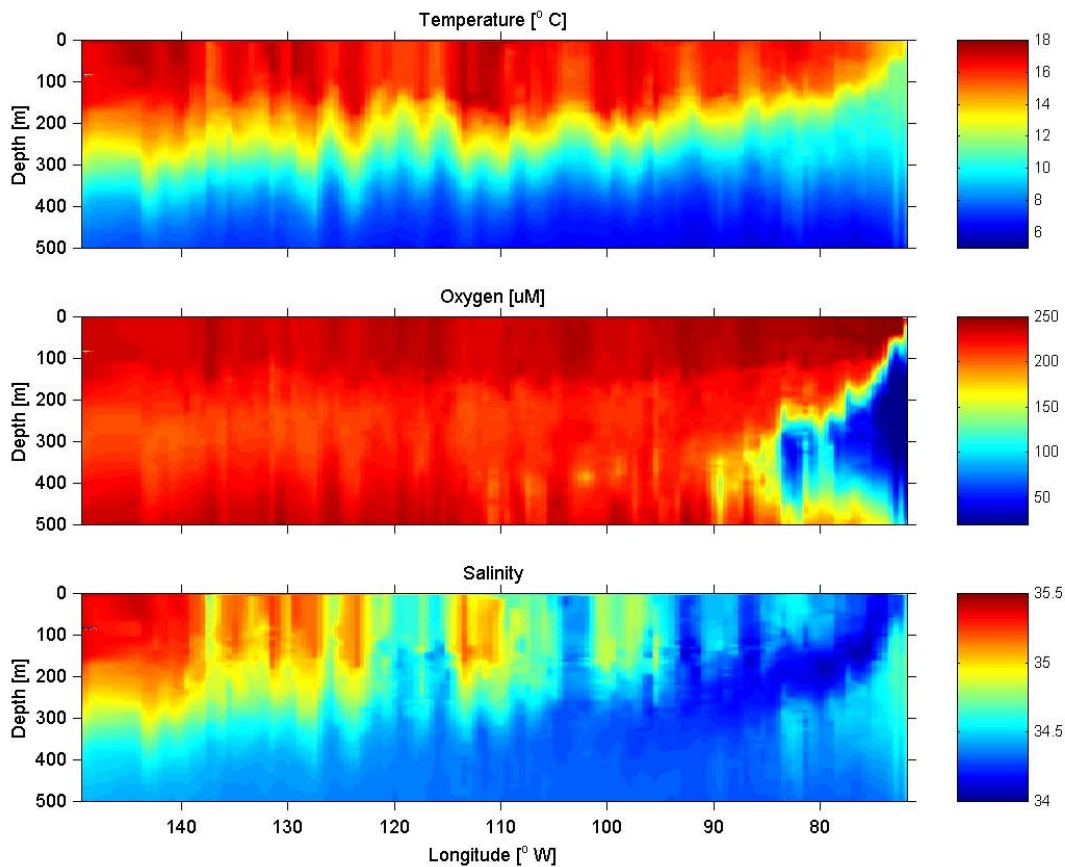
Figure 2. Temperature, oxygen, and salinity profiles.

Photosynthetic pigments

The chlorophyll-*a* and phaeopigments distribution from the surface to 200 meters depth of 56 profiles is shown in Figure 3. The highest concentrations were found near the coast and the maximum value was ca. 1.86 mg of Chl-*a* m^3 around 72°W. The lowest concentrations were located at 200m depth and several stations along the transect presented similar minimum values. At higher longitudes a daily shifting of chlorophyll-a between 100 and 150m was observed. The preliminary results suggest an important effect of the light penetration, depending on the sampling time (AM/PM). Between 120°W and 100°W the values became closer because of higher mixing of the water column mainly due to the high wind speed on those days. The phaeopigments were higher near to the coast too. The higher concentrations at 150 m along the transect probably are due to other kind of pigments (e.g. chlorophyll-b) and not as a degradation product. The HPLC analyses will give more details about what kind and how much pigments are presented in the water column.
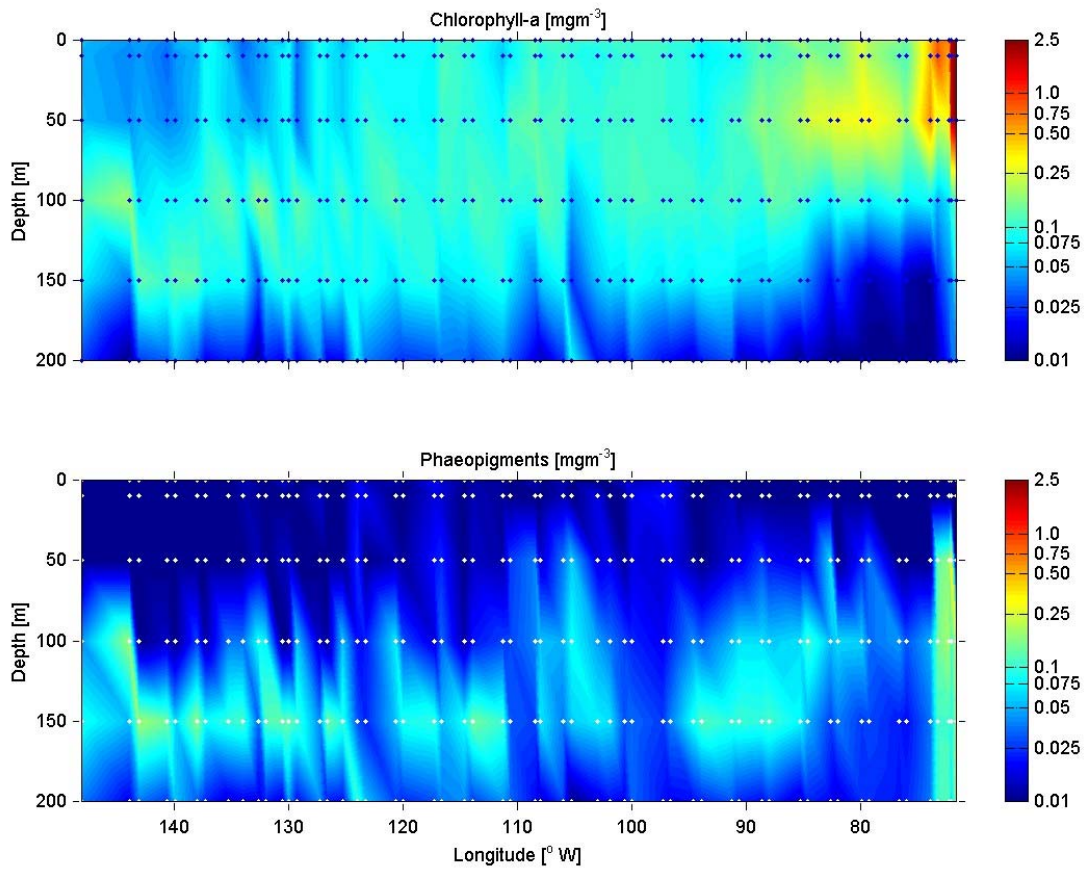
Figure 3. Chlorophyll and Phaeopigments section

Absorption

53 particulate and dissolved (CDOM) absorption scans were done onboard. The same amount of samples will be send to Bedford Institute of Oceanography to be scanned by Dr. Venetia Stuart. A matlab routine was developed to analyse data, as follows:

% Routine for absorption averages of Particulate Sample (PS)

% Detritus Sample (DS); Particulate Blank (PB); Detritus Blank (DB)

% --

% Condition 1: files should be belonging to the same scan

% Condition 2: files should have " ; " " - " and two lines of header

% Step 1: Make a list of kind of selected files

% Step 2: Make a change of signs by empty space and delete header

% Step 3: Store wavelength and average 10 scans of each one

% output: data of averaged values of absorption, data of spectral

%   absorption coefficients of phytoplankton and data of specific

%   absorption coefficient of phytoplanktonic pigments.

% Obs 1: Fluorometer Chl-a concentration must be download for

%   each scan

% Obs 2: A plot of specific absorption coefficient of phytoplanktonic

%   pigments for each analysis will be provide

% --

% Thanks to Victor Villagran for supporting in function and script

% development

% Gadiel Alarcon

% Bio-optics group

% JAMSTEC Oceanographic cruise 'BEAGLE 2003'. R/V Mirai.

% Leg 2. Papeete - Valparaiso

% September 9th to October 16th. 2003

 The data outputs will be provide in: JAMSTEC/Leg2/PreliminaryResult/Absorption.

Figure 4a and 4b, show the absorption averages spectrum for particulate (blue) and detritus (green) sample. The first scans should be checked.
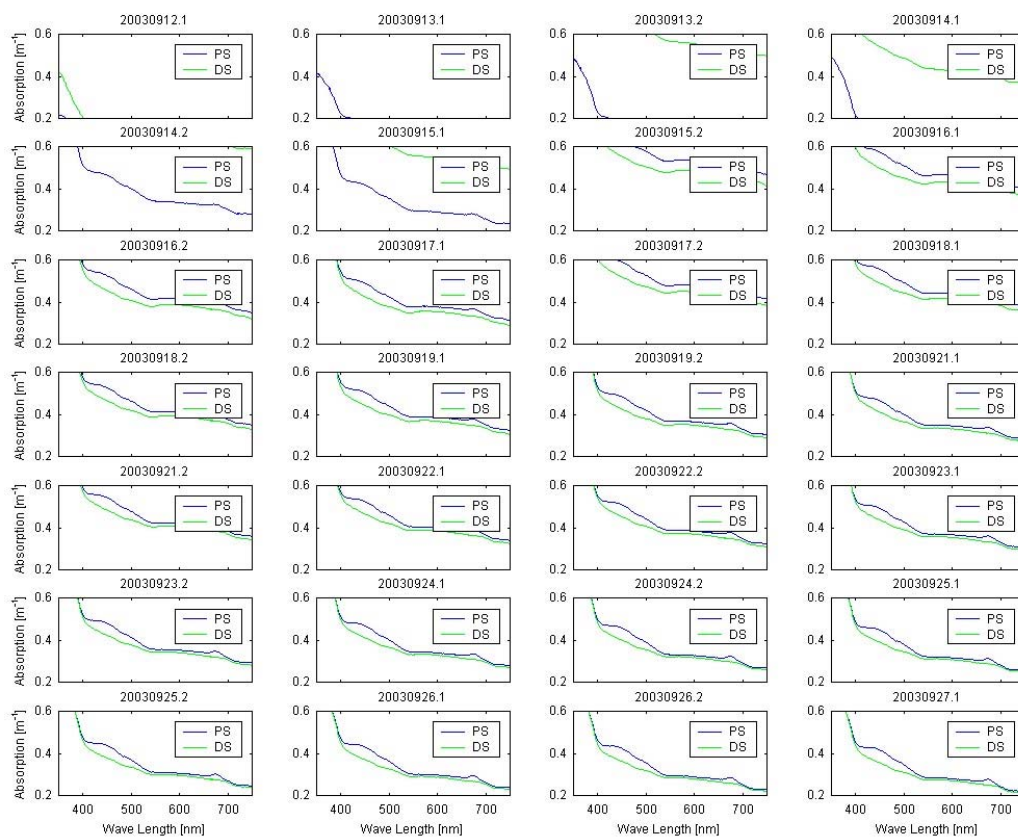
Figure 4a. Absorption averages spectrum particulate (blue) sample and detritus (green) sample
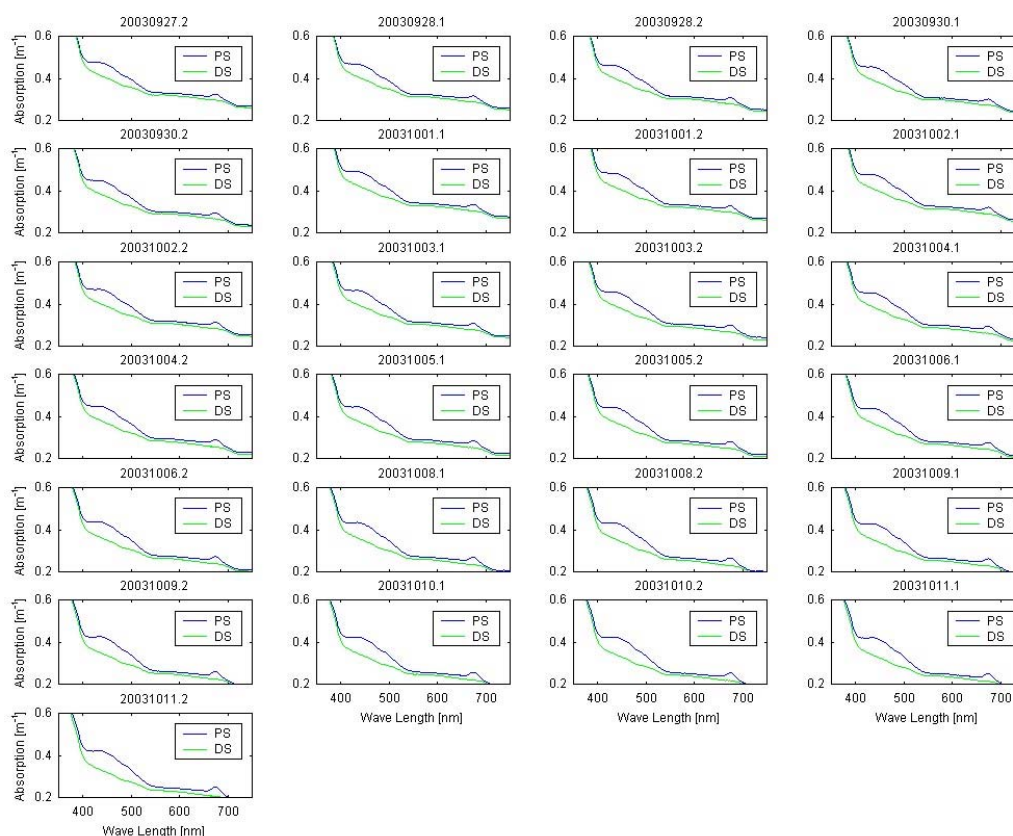
Figure 4b. Absorption averages spectrum particulate (blue) sample and detritus (green) sample

Figure 5a and 5b, show the absorption coefficient particles in suspension using two ***Beta*** values to correct for pathlength increase due to multiple scattering in the filter, according to:

Hoepffner and Sathyendranath (1992) (Beta 1)

$$\text{Beta } 1 = 0.31[OD_{pf}(\lambda)] + 0.57[OD_{pf}(\lambda)]^2$$

This *Beta* is used for most kind of phytoplankton cells.

Moore *et al.*(1995)

$$\text{Beta } 2 = 0.291[OD_{pf}(\lambda)] + 0.051[OD_{pf}(\lambda)]^2$$

13

This *Beta* is used when high numbers of small cells are presented.
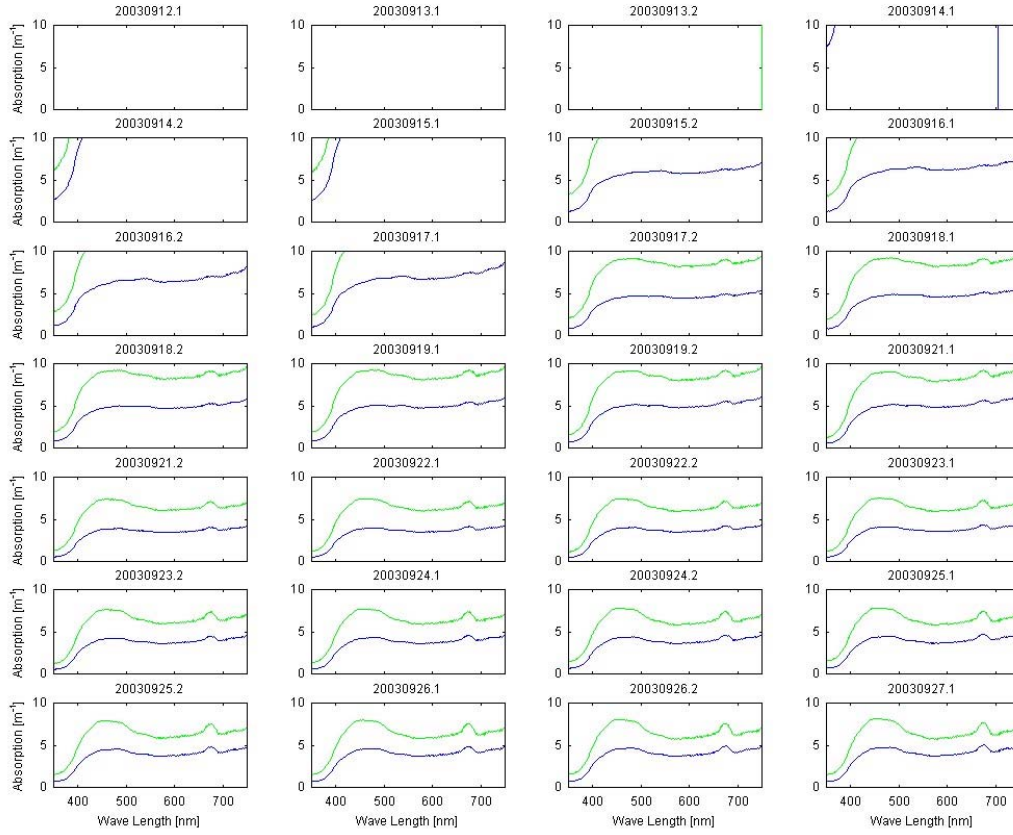
Figure 5a. Absorption coefficient particles in suspension (blue: using Beta 1; green using Beta 2)
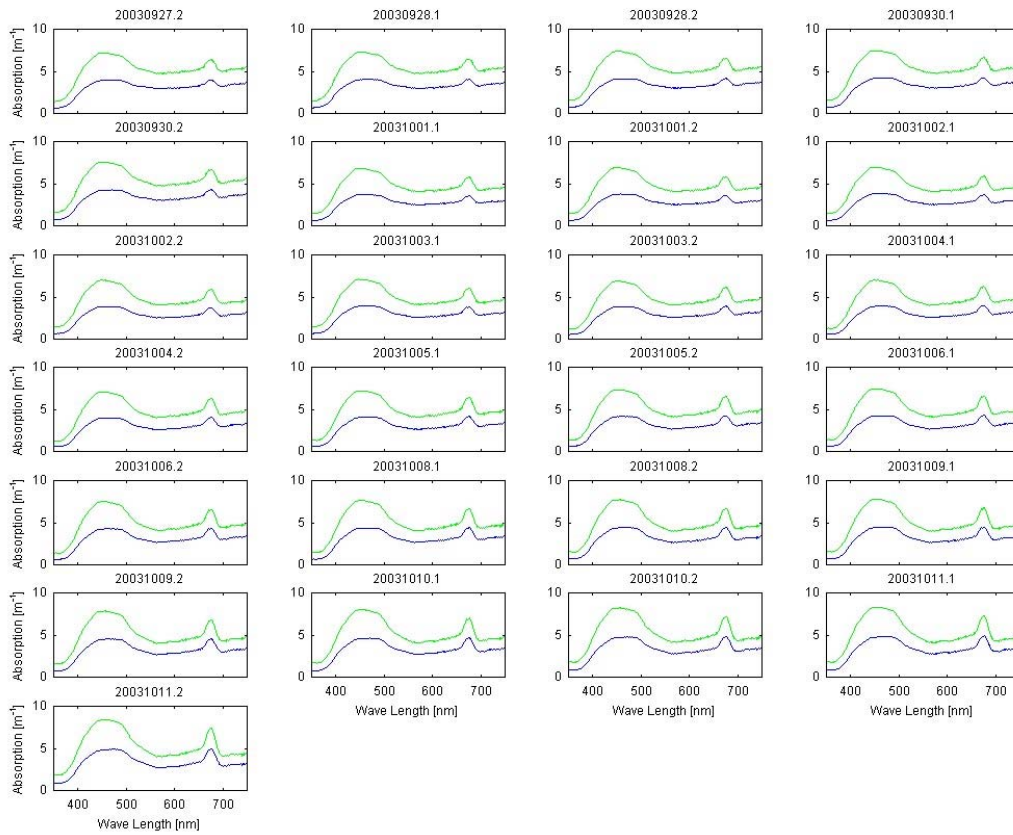
Figure 5b. Absorption coefficient particles in suspension (blue: using Beta 1; green using Beta 2)

Figure 6a and 6b, show the pigment specific absorption coefficient of phytoplankton (SAC), normalized by his corresponding chlorophyll-a concentration (fluorometry). SAC is computed using the *Beta* 1 and SAC$_2$ using *Beta* 2.
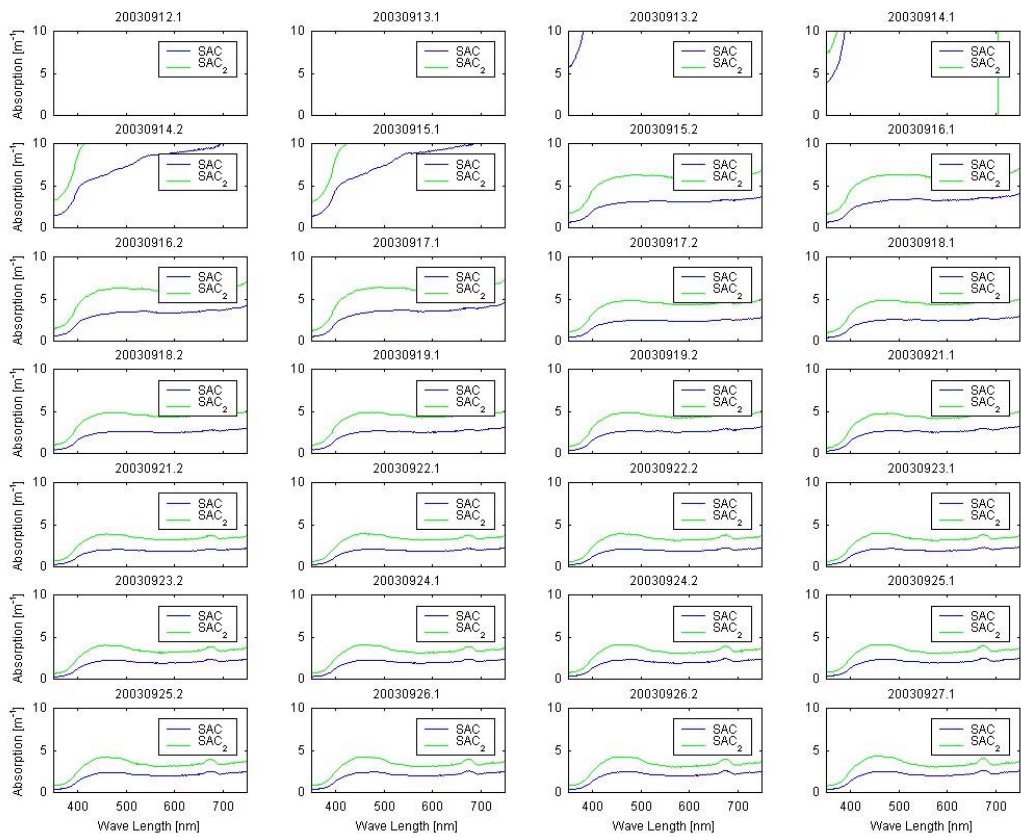
Figure 6a. Pigment specific absorption coefficient of phytoplankton
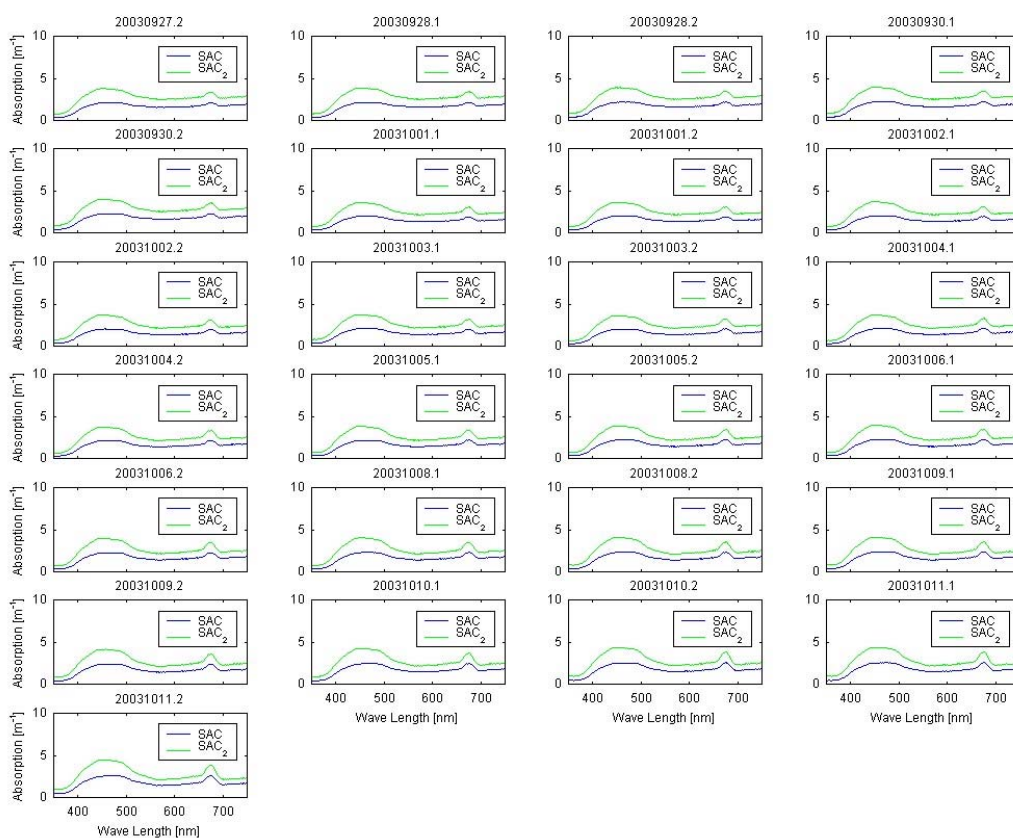
Figure 6b. Pigment specific absorption coefficient of phytoplankton

Figure 7a and 7b, show the CDOM absorption for the whole cruise. A routine similar to the absorption one was applied to process this data.
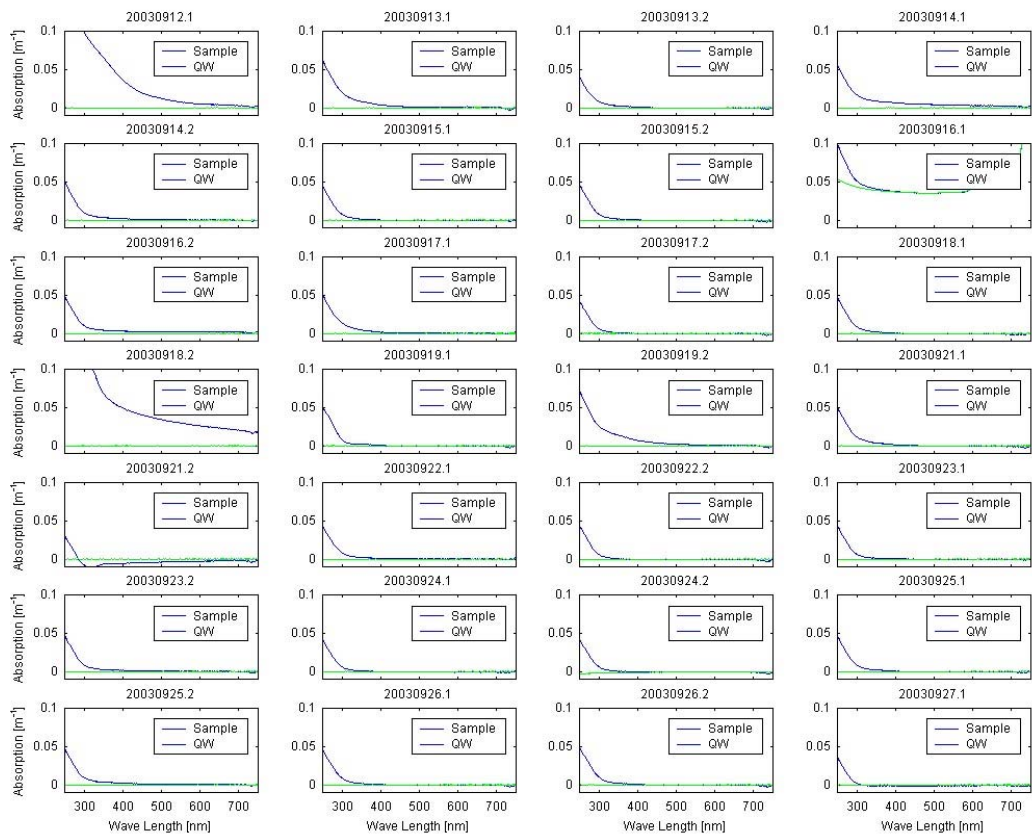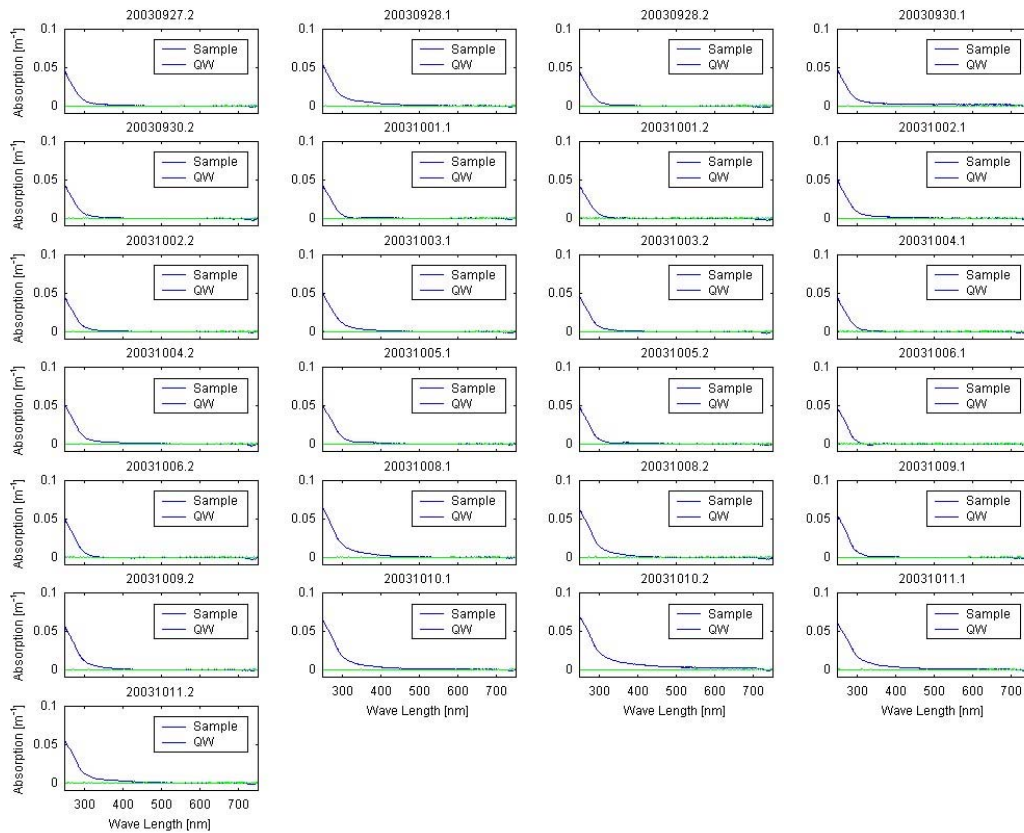
Figure 7a. CDOM absorption

Figure 7b. CDOM absorption (cont.)

Bio-optics

A total of 33 hyperspectral radiometer measurements were taken. The data was computed using a matlab routine, as follows:

% Routine for hyperspectral radiometer data average, which include

% spectralon, sky and sea measurements. Besides, Rrs computing

% ---

% Condition 1: files should be belonging to the same observation

% Condition 2: files should have header and footprint

% Step 1: Make a list of kind of selected files

% Step 2: Erase header and footprint and download data

% Step 3: Store wavelength and average each observation.

% Step 4: Store integration time for each measure

% output: Data of averaged values of espectralon, sky and sea

%   measurements. Besides, Remote Sensing Reflectance (Rrs) and

%   corrected Rrs are computed.

% Obs 1 : A spectralon calibration file should be download to

%   correct all computing.

% Obs 2 : 2 graphics are provided. The former include averages values

%   of espectralon, sky ans sea plots. The last include Rrs

%   and corrected Rrs plots.

% ---

% Thanks to Victor Villagran for supporting in function and script

% development

% Gadiel Alarcon

% Bio-optics group

% JAMSTEC Oceanographic cruise 'BEAGLE 2003'. R/V Mirai.

% Leg 2. Papeete - Valparaiso

% September 9th to October 16th. 2003

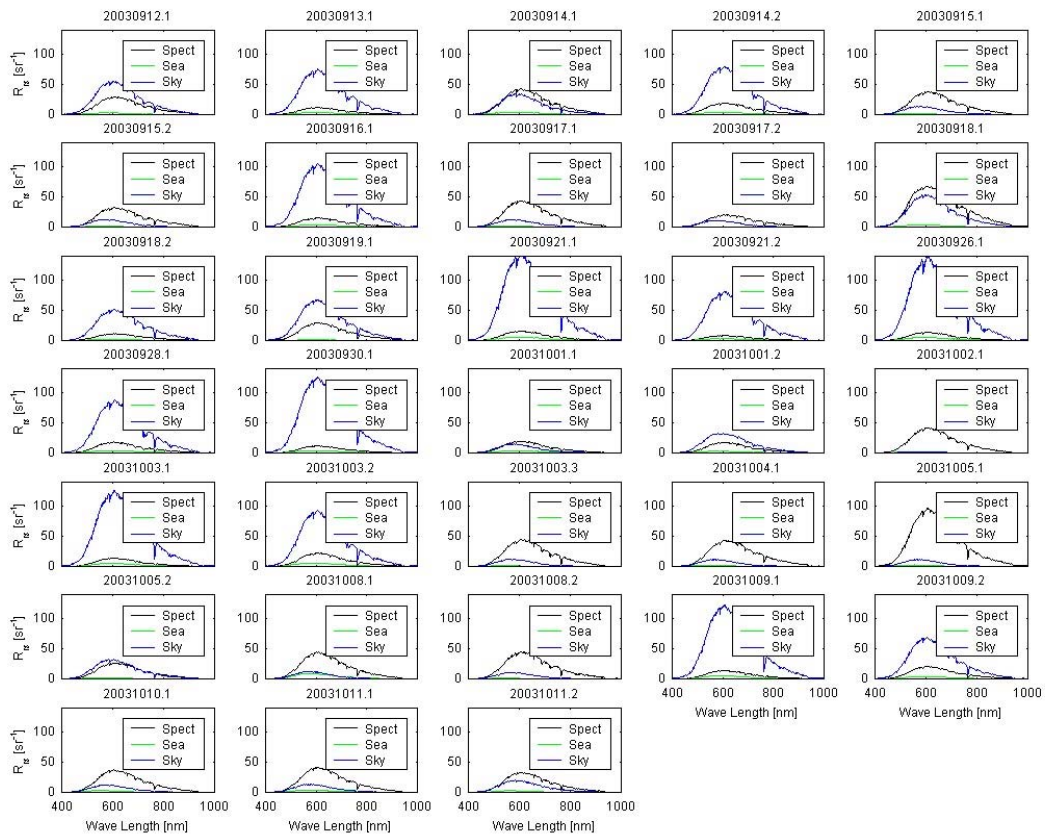Figure 8, shows the averaged spectrums of spectralon, sky and sea observations.

Figure 8. Averaged espectrums of spectralon, sky and sea observations

Figure 9 shows the computed remote sensing reflectance and corrected reflectance. This data was obtained from the hyperspectral radiometer.
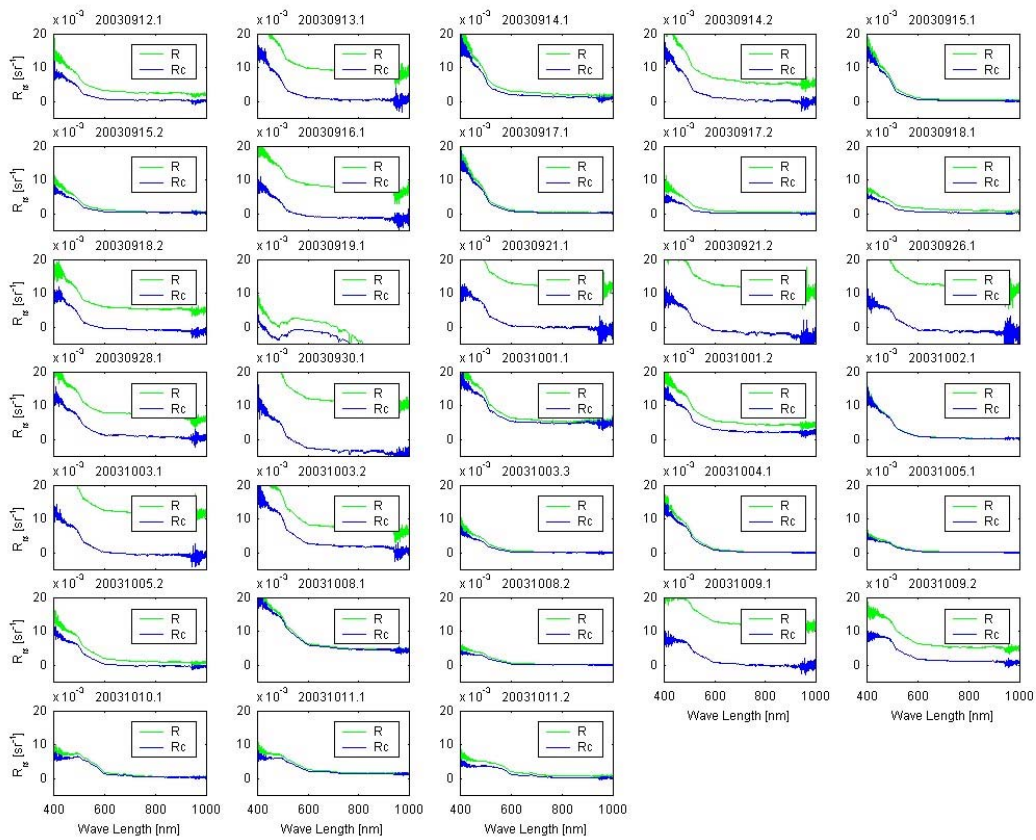
Figure 9. Remote sensing reflectance

The corrected reflectance (sr-1) was obtained between 350 and 1009.5 nm. 4 wavelengths ratio with 550 nm were chosen in order to see which ratio correlates better with the surface pigments variation. The ratios were 412/550, 440/550, 490/550, and 510/550. Pigments to ratios plots are shown in figures 10a, 10b, 10c, and 10d with the last 3 stations taken out as the pigment values shot up. In figures 9a and 9b there is more scatter in the points but in figures 9c and 9d the range of the ratios are lower.
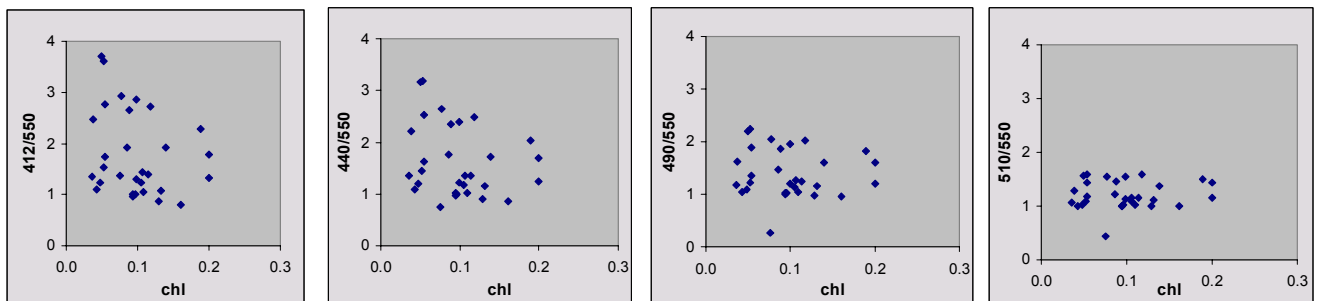
Figure 10a-d. Rrs ratios versus surface pigments

The ratios were then plotted together for each of the 33 measurements using a bar chart and the pigment concentration was plotted as a line on the same graph (figure 11). It is clearly visible that the lowest wavelength ratio (412/550) has the highest value most of the time. The white circles indicate regions where the 412/550 ratio is no longer dominant and coincides with variations of pigment concentration, hence to understand this graph we need to use other parameters that have been collected during the cruise. Only then can we explain why the ratio are changing with respect to each other at some parts of the Pacific.
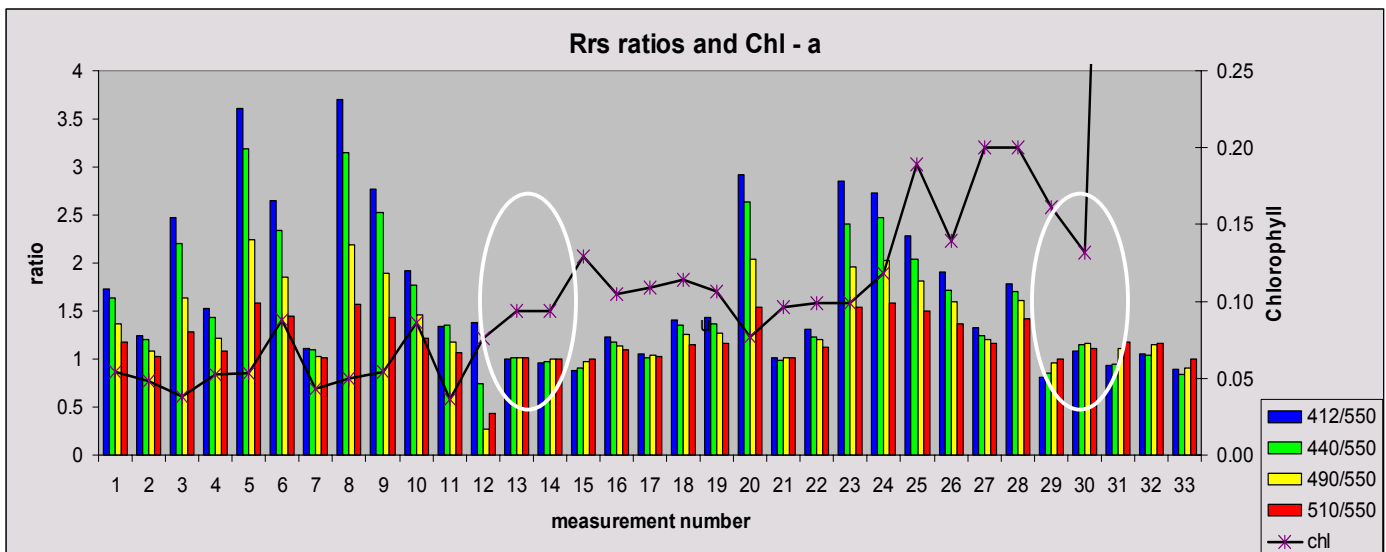

Figure 11. Rrs ratios variation and surface pigment

6. Acknowledgement

Appendix A

Readme file

Jamstec Cruise Leg 2

Participants:

Gadiel Alarcon   [bio-optics specialist]

Alexander Galan   [trainee]

Dante Matellini   [trainee]

Serkan Sancak   [trainee]

This is a guide to find the data collected into directories and files, as follows:

Absorption   : C:/Jamstec/Leg2/Absorption

CDOM   : C:/Jamstec/Leg2/CDOM

Chlorophyll   : C:/Jamstec/Leg2/Chlorophyll

CTD   : C:/Jamstec/Leg2/CTD

Ocean Optics : C:/Jamstec/Leg2/HyperSp

Meteorology   : C:/Jamstec/Leg2/Meteorology

PAR   : C:/Jamstec/Leg2/PAR_sensor_data

Simbad   : C:/Jamstec/Leg2/Simbad

Simbada   : C:/Jamstec/Leg2/Simbada

Preliminary results   : C:/Jamstec/Leg2/PreliminaryResults

Report   : C:/Jamstec/Leg2/Report

Besides, in the main folder there is a summary_leg2.xls file where you can have a quick look to the biological collected data.

Absorption:

The same directory system is used with CDOM. (Check for CDOM section).

For each station there is 80 files in the directory. In each directory generally there is 160 files for two stations visited in the morning and in the afternoon. The file names contains six digit sample label number. If there is two sampling files in a directory (120 in total, not 160 because one blank for a day; however for the first two days we made two blanks for a day and had 160 files), please check the Log Book, for which one is sampled in the morning and which one is sampled in the afternoon.

CDOM:

The directory names are given as 8 digit numers. First four digit represent the year; 5th and 6th represent month and the last two represent the day af the sampling time.

eg.

20030912 : 12th September 2003

In each directory the data taken on that day can be found. Generally two different sampling was made at two different times of the day. The two different sampling can be seperated by their file names.

Files for air, q-water, q-water after setting the q-water as the baseline, and sample are named as follow:

xxxxxxair.csv

xxxxxxair.DSW

These two files are for air measurements. xxxxxx represent the number on the label used for the sample taken at the station. eg. 264214. The same number is used also for HPLC, absorption and flow cytometry (picoplankton) samples.

xxxxxxqw.csv

xxxxxxqw.DSW

These two files are for q-water measurements.

xxxxxxqw1.csv

xxxxxxqw1.DSW

These two files are for q-water measurements after setting the q-water as the baseline.

xxxxxx.csv

xxxxxx.DSW

These two files are for sample measurements.

In total 8 files for each sampling.

If there is two different set of files with two different label number (eg. 264213 and 264214; in total 16 files), that means two sampling made in that day. One in the morning and one in the afternoon. (Check the Log Book for which one is which).

Chlorophyll:

Here you can find each day photosynthetic pigments readings. They are named as xxxyyz.xls (e.g. oct04a.xls).

xxx   = month

yy   = day

z   = a or b. (a morning extraction; b evening extraction)

The flow system pigments are found in these files too. Besides, there is a compilation for profile measurements (chl_leg2.xls).

CTD::

Here you can find down cast information of the CTD data.

HyperSp:

The data is organized in directories by day, as follows:

yyyymmdd.n

yyyy = year

mm   = month

dd   = dd

n   = 1 or 2 (1, morning round; 2, evening round)

Inside of each directory, three kind of files can be found:

- For spectralon measurements: e.g.

      sept122003espect.time.00000.Master.scope

- For sky measurements: e.g.

      sept122003sky.time.00000.Master.scope

- For sea measurements: e.g.

      sept122003sea.time.00000.Master.scope

Meteorology:

Here you can find daily meteorology information. A 'SOJ_readme.txt' and 'SOJ_format' files are provided in order to undestand the information.

PAR_sensor_data:

Here you can find the PAR data collected during Leg 2.

SIMBAD and SIMBADA:

The data is organized in directories, as follows:

yyyymmdd, where

yyyy   = year

mm   = month

dd   = day

Inside youll find sub-directories, named as am or pm.

am   = morning rounds

pm   = evening rounds

Preliminary Results:

Here you can find preliminary processed data, organized in directories, as follows:

Absorption. Each file has a header with the scan day (e.g. 20030913.1 for morning and 20030913.2 for evening).

    ps.dat   : averaged data for particulate sample

ds.dat   : averaged data for detritus sample

pb.dat   : averaged data for particulate blank

ds.dat   : averaged data for detritus blank

wavelength.dat   : averaged wavelength

aphi_1.dat   : phytoplankton absorption using Beta 1

aphi_2.dat   : phytoplankton absorption using Beta 2

csp.dat   : specific abs coefficient using Beta 1

csp2.dat   : specific abs coefficient using Beta 2

chl_abs.dat   : chl-a concentration for each scan

xx.jpg   : output figures for each analysis

CDOM. Each file has a header with the scan day (e.g. 20030913.1 for morning and 20030913.2 for evening).

s_cdom.dat   : sample data of each scan

qw_cdom.dat : Q water of each scan

wavelength_q.dat   : wavelengths for Q water

wavelength_s.dat   : wavelengths for sample

xx.jpg   : output figures for each analysis

Chl. Contains a file with photosynthetic file for leg 2 (chl_leg2.xls)and plot contour of pigments distribution.

ctd_leg2. Contains a plot contour for temperature, oxygen and salinity distribution.

HyperSRad. Each file has a header with the scan day (e.g. 20030913.1 for morning and 20030913.2 for evening).

espectralon.dat   : averaged data for espectralon observations

Cal_espect.dat   : calibration file for espectralon

sea.dat   : averaged data for sea observations

sky.dat   : averaged data for sky observations

Reflectance.dat   : computed Reflectance data

Reflectance_c.dat: computed corrected Reflectance data

integ_espect.dat : integration times of espectralon for each measure

integ_sea.dat : integration times of sea for each measure

integ_sky.dat : integration times of sky for each measure

w_length.dat : wavelengths

surface_chl.txt : surface pigments values (Chl+Phaeopigments)

comparison.xls : comparison for Rrs vs surface chl

xx.jpg   : output figures for each analysis

Simbad/Simabada. both directories have ancillary information for each observation.

Simbad07_03_report.xls

simbad.leg2   : analyzed files for all leg 2

Simbada21_report.xls

<div align="right">Bio-optic Group</div>

<div align="right">Leg 2</div>

Appendix B

We also participated in the sampling of the rosette. The parameters sampled were:

- Salinity

- Oxygen

- SiO4

- NO3

- NO2

- PO4

- CFC11

- CFC12

- H-3

- He-3/He-4

- C14

- C13

- Ar

- Cs-137

- DIC

- Alkalinity

- pH

- CFC113

- Nitrous Oxide

- Chlorophyll a

- Phaeophytin

- Nitrogen(gas)

- Total Organic Carbon (TOC)

- Pu(238,239,240,241)

- Primary Production

- Total Inorganic Carbon (TIC)

Continuous recordings were made of meteorological data, sea current and bathymetry.