Biogeochemical database in the north Pacific

by

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The northwestern North Pacific is the terminal of the Great Conveyer Belt. Owing to the upwelling of aged and nutrients-rich deepwater, concentrations of surface nutrients are much higher than other oceans resulting high biological activity. It has been reported that the capability of biological activity to uptake atmospheric CO_2 and transport it vertically into the ocean interior (namely “the biological pump”) in this area works very efficiently to uptake atmospheric CO_2 based on large seasonal amplitude of nutrients and pCO_2. However comprehensive study and seasonal study for the biological pump had not been conducted. MIO and MBCRT of RIGC have been conducting the time-series study for the biological pump with research vessels, mainly R/V MIRAI, and mooring systems with automatic sampler and sensors since the late 1990’s. Using these data, characteristics of the biological pump in the northwestern North Pacific have been reported. However used data in previous reports is a handful of data collected. We compiled biogeochemical data relating the biological pump that have been collected by our group as much as possible.
This database consists of the following data sets associated deeply with biological pump:

1. Time-series moored Sediment Trap data set
2. Primary Productivity data set
3. Phytoplankton Pigments data set
4. Natural Radio Nuclides data set

On the other hand, we have also measured dissolved chemical species with high quality. These data are compiled in the K2 and KNOT hydrogaraphic data sets (to see http://www.godac.jamstec.go.jp/k2/index.html).

We hope these data sets are helpful and / or useful for many scientists all over the world.

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2. Primary productivity

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1. Introduction

In order to study the ocean's capability to uptake atmospheric CO_2 (namely, the biological pump), measurement of primary productivity is the one of essential factors. JAMSTEC has been conducting the study of the biological pump in the northwestern North Pacific. Measurement of primary productivity in this area was initiated in 2003.

2. Methods

Primary productivity was measured at major stations centering station K2 onboard by using the ^{13}C method developed by Hama et al. (1983) instead of the ^{14}C method (Steeman Nielsen, 1952: Marra and Barber, 2004). Incubation for PP measurement were conducted by *in situ* incubation method using the drifting system (*e.g.* Fig. 1) and, sometimes, incubation was conducted by simulated *in situ* incubation method using the light-controlled water bath on deck (*e.g.*Fig. 2).

(1) *in-situ* or simulated *in situ* incubation

1) Bottles for incubation and filters

Bottles for incubation are *ca.* 1 liter Nalgen polycarbonate bottles with screw caps. Grass fiber filters (Wattman GF/F 25mm) pre-combusted with temperature of 450°C for at least 2 hours were used for a filtration of phytoplankton after incubation.

2) Incubation

Water samples were collected at 8 layers between the surface and seven pre-determined depths with a bucket (for surface water) or CTD/Carousel Water Sampling System (CTD: Sea-Bird 9plus, and 12-litter Niskin Bottles x 36). These depths corresponded to nominal specific optical depths, that is, approximately 50%, 25%, 10%, 5%, 2.5%, 1%, and 0.5% of surface PAR determined from the optical profiles obtained by "Free Fall sensor". All samples were spiked with 0.2 μ moles/mL of $NaH^{13}CO_3$ solution. After spike, bottles were installed at respective depths on the drifter and *in situ* incubated (*e.g.* Fig. 1) or bottles were incubated in the onboard water baths (*e.g.* Fig. 2). Natural light was adjusted to the light level for each depth with blue film. After 24 hours incubation, samples were filtrated through grass fiber filters (Wattman GF/F 25mm). GF/F filters were kept in a freezer on board until analysis.

(2) Measurement

^{13}C of samples were measured by using a mass spectrometer ANCA-SL system (PDZ Europe) on board.

Before analysis, inorganic carbon of samples was removed by an acid treatment in a HCl vapor bath for 4 - 5 h.

Based on the balance of ^{13}C, assimilated organic carbon ($\triangle$POC) is expressed as follows (Hama *et al*., 1983):

$$^{13}C_{(POC)} \text{ x POC} = {}^{13}C_{(sw)} \text{ x } \triangle POC + (POC - \triangle POC) \text{ x } {}^{13}C_{(0)}$$

This equation is converted to the following equation;

$$\triangle POC = POC \text{ x } ({}^{13}C_{(POC)} - {}^{13}C_{(0)}) / ({}^{13}C_{(sw)} - {}^{13}C_{(0)})$$

where $^{13}C_{(POC)}$ is concentration of ^{13}C of particulate organic carbon after incubation, *i.e.*, measured value (%). $^{13}C_{(0)}$ is that of particulate organic carbon before incubation, *i.e.*, that for sample as a blank (measured value for each cruise or 1.084, that is average of all data). $^{13}C_{(sw)}$ is concentration of ^{13}C of ambient seawater with a tracer. This value was determined based on the following calculation;

$$^{13}C_{(sw)} (\%) = [(TDIC * 0.011) + 0.0002] / (TDIC + 0.0002) \text{ x } 100$$

where TDIC is concentration of total dissolved inorganic carbon at respective bottle depths (mol l^{-1}) and 0.011 is concentration of ^{13}C of natural seawater (1.1 %). 0.0002 is added ^{13}C (mol) as a tracer. Taking into account for the discrimination factor between ^{13}C and ^{12}C (1.025), primary productivity (PP) was, finally, estimated by

$$PP = 1.025 \text{ x } \triangle POC$$

The precision (repeatability: standard deviation / average) was less than 5% on average (n = 105, Honda et al., 2009).

Table 1 and Table 2 are the explanation of data file and Data list, respectively.

Note: Environment during incubation (such as water temperature and light intensity) conducted on R/V MIRAI is usually described in respective cruise reports. Please visit following JAMSTEC MIRAI database site:

http://www.godac.jamstec.go.jp/cruisedata/mirai/j/index.html

References

Hama, T., Miyazaki, T., Ogawa, Y., Iwakuma, T., Takahashi, M., Otsuki, A., Ichimura, S., 1983. Measurement of photosynthetic production of a marine phytoplankton population using a stable ^{13}C isotope. Marine Biology 73, 31-36.

Honda, M. C., Sasaoka, K., Kawakami, H., Matsumoto, K., Watanabe, S., Dickey, T., 2009. Application of underwater optical data to estimation of primary productivity. Deep-Sea Research I 56, 2281-2292.

Marra, J., Barber, R.T., 2004. Phytoplankton and heterotrophic respiration in the surface layer of the ocean. Geophysical Research Letters, 31, L09314, doi:10.1029/2004GL019664.

Steemann Nielsen E., 1952. The use of radio-active carbon (^{14}C) for measuring organic production in the sea. Journal du Conseil International pour Exploration de la Mer 18, 117-140.

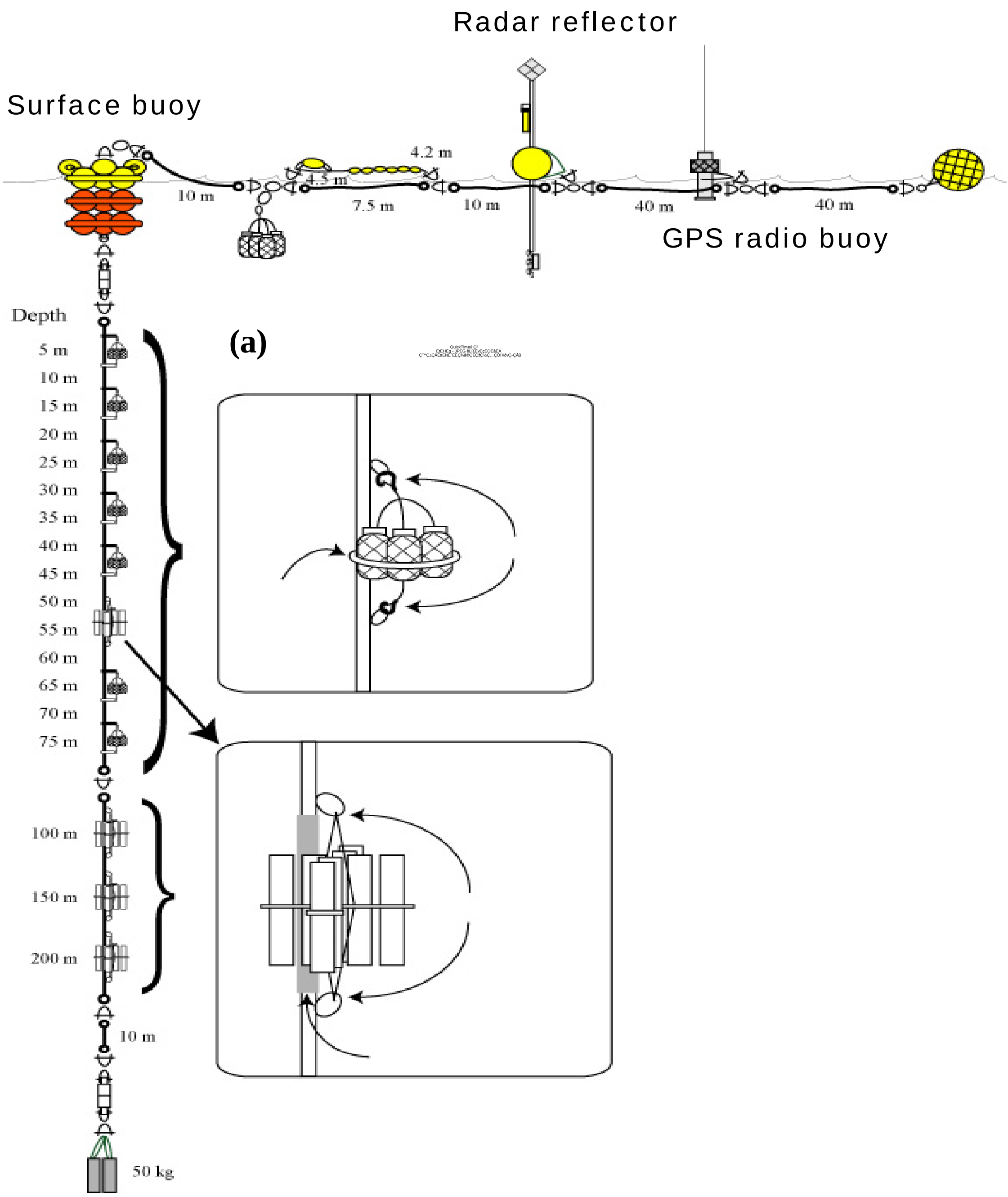

Fig.1 Drifter for in situ incubation (IS)

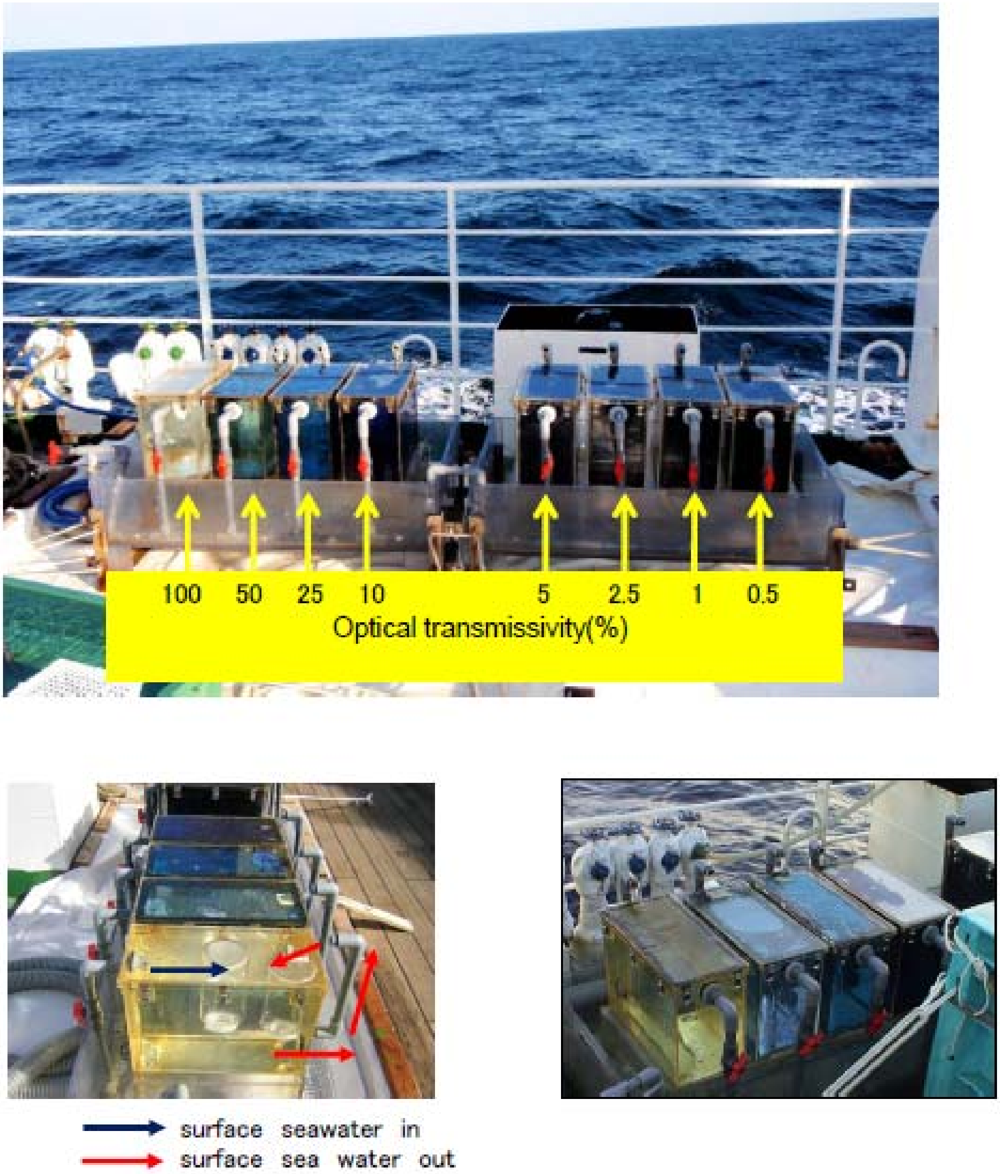

Fig.2 On-deck aquarium for simulated in situ incubation (SIS)

Table 1 Explanation of data file

items	
Cruise	Cruise Name
Stn.	Station Name
Cast	Hydrocast Noumber
Incubate Type	IS:in situ (using drifter) SIS: simulated in situ (on-deck water tank)
UTC Date	Start day (UTC) yyyymmdd
UTC Time	Start time (UTC) hhmm
Latitude	Latitude (when water sampling done)
Longitude	Longitude (when water sampling done)
Depth (m)	Water (sample) collecting depth
Light Intensity (%)	Relative light intensity (%)
PP (ave) (mgC m^{-3} day^{-1})	Primary production (average) (mgC m^{-3} day^{-1})
dev (mgC m^{-3} day^{-1})	Deviation (mgC m^{-3} day^{-1})

Table 2 Data list

Cruise	Stn.	Incubate Type	UTC Date	UTC Time	Latitude	Longitude	Cruise Report available
NT03-07	KNOT	SIS	20030708	-	43-59.99N	154-59.83E	
	K2	SIS	20030711	-	46-59.91N	160-00.14E	
	K3	SIS	20030713	-	39-00.03N	159-59.95E	
KR03-11	K1	SIS	20030927	23:00	51-18.18N	165-06.41E	
	K3	SIS	20031008	19:50	39-15.16N	160-03.59E	
MR04-02	K1	SIS	20040406	23:00	50-59.99N	164-59.95E	○
	K2	SIS	20040408	3:50	47-00.00N	160-00.22E	
	35N	SIS	20040412	4:00	34-59.89N	160-00.01E	
NT04-05	K2	SIS	20040527	-	46-59.90N	160-00.00E	
	K3	SIS	20040529	-	38-59.90N	160-00.00E	
MR04-06	K1	SIS	20041019	630	50-59.97N	164-59.75E	○
	K2	SIS	20041021	6:30	46-59.01N	159-58.92E	
	35N	SIS	20041024	6:30	35-00.02N	159-59.46E	
	K3	SIS	20041026	12:30	38-58.16N	160-01.36E	
	KNOT	SIS	20041029	7:00	44-00.18N	155-00.24E	
MR04-07	2	SIS	20011121	3:05	34-02.49N	155-07.42E	○
	6	SIS	20041123	2:45	29-59.01N	154-59.26E	
	10	SIS	20041125	2:43	24-29.41N	155-02.92E	
	13	SIS	20041127	4:05	19-59.95N	155-00.02E	
	17	SIS	20041129	4:25	16-00.10N	154-59.94E	
	21	SIS	20041201	4:30	12-00.09N	154-59.75E	
	26	SIS	20041203	2:02	06-59.87N	155-00.35E	
	31	SIS	20041205	3:00	02-00.19N	154-59.70E	
	33	SIS	20041206	4:40	00-00.10N	155-00.07E	
MR05-01	K2	SIS	20050305	7:00	46-57.90N	160-09.12E	○
	K1	SIS	20050307	6:30	51-00.06N	164-59.76E	
	35N	SIS	20050312	6:30	35-00.00N	160-00.06E	
MR05-04	KNOT	IS	20050917	2:30	43-58.88N	154-59.47E	○
	K3	IS	20050919	19:30	38-59.99N	160-00.03E	
	K2	IS/SIS	20050924	19:20	47-00.40N	159-58.17E	
	K1	IS	20050927	18:50	51-00.20N	165-00.02E	
	EW1	IS	20090930	18:20	47-38.98N	169-16.66E	
	EW4	IS	20051006	18:00	45-59.82N	174-59.93W	
	EW7	IS	20051013	0:20	49-30.05N	160-00.66W	
	OSP	IS	20051017	2320	49-56.41N	144-56.85W	
MR06-03	K2	IS	20060603	16:30	46-52.38N	159-59.10E	○
	K2	IS	20060612	16:30	46-51.96N	160-08.22E	
	K2	IS	20060621	16:30	46-56.40N	160-07.14E	
	K2	IS	20060629	16:30	46-56.34N	160-06.78E	
	K2	IS	20060708	16:30	46-56.28N	160-07.38E	
	K2	IS	20060716	16:30	46-52.08N	160-06.00E	
MR07-05	S02 (K1)	SIS	20070910	2:00	50-59.70N	165-00.24E	○
	S06 (K2)	IS	20070912	19:00	46-51.90N	160-00.24E	
	S20 (K2)	IS	20070920	19:00	46-55.26N	160-00.24E	
MR08-05	S1 (AB)	SIS	20081014	0:00	57-00.00N	175-59.26E	○
	S7 (K1)	IS	20081019	17:00	51-00.81N	164-59.55E	
	S11 (K2)	IS	20081026	23:02	46-59.89N	159-59.73E	
	S14 (KNOT)	SIS	20081031	0:00	44-00.09N	154-59.71E	