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4.5.12　2006 年 Lützow-Holm 湾沖における純基礎生産量と総基礎生産量

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Relationship between net and gross primary production off Lützow-Holm Bay in 2006

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Introduction

Carbon exchange by photosynthesis and respiration is the largest biogeochemical cycle in aquatic systems. In order to understand this cycle, it is necessary to investigate the primary production for oceanographers. Generally, the primary production is estimated from the rate of incorporation of inorganic carbon into particulate carbon and the rate of production of oxygen from water. In incubations during 24h, the former method is considered to provide the values close to a net primary production (NPP), while the latter is gross primary production (GPP) (Laws et al., 2000; Falkowski and Raven, 1997). It is important to estimate ratios of NPP/GPP for the understanding of ecosystem and carbon balance in the ocean. The ratios provide information on the ability of an ecosystem to retain production and set an upper limit on the amount of production that can be exported from the euphotic zone (Dickson et al., 2001). We measured the incorporation rate of ^{13}C into particulate material only and oxygen evolution rate using the light-dark bottle method.

Methods and Preliminary results

Sampling

Antarctic observations were carried out from 5th to 29th January 2006 by the RT/V Umitaka Maru IV of Tokyo University of Marine Science and Technology (Table 1). Hydrographic data (water temperature, salinity) and water samples were collected with a CTD (Falmouth Scientific, Inc.) rosette system fitted with Teflon-coated Niskin bottles of 20 L capacity. The vertical photosynthetically active radiation (PAR) profiles were measured using a quantum PAR sensor (Biospherical Instruments) that attached on the CTD. The samples for determination of Chlorophyll a, nutrients, TIC, ^{13}C uptake and GPP were collected from six or seven depths corresponding to 100, 50, 25, 12.5, 6, 3, and 1% of the surface irradiance with reference to the PAR profile (Table 1). The seawater samples for nutrient concentration analysis were collected from 8-11 depths above 200 m depth (Table 1). The incident solar radiation was monitored with a Li-Cor 2π sensor during the incubation experiments. The integrated values of a PAR on the deck and day length as an integrated time of more than 5 μE m^{-2} s^{-1} of PAR were calculated (Table 1).

Chlorophyll a

A total of 200 ml samples were filtered onto 25 mm Whatman GF/F filters under gentle aspiration (<250 mm Hg). Chlorophyll a was immediately extracted by immersing the filter in N,N-dimethylformamide (Suzuki and Ishimaru, 1990), and the samples were preserved at -20°C until on shore analysis. Chlorophyll a concentrations were determined using a Turner Designs Model 10-AU Fluorometer calibrated with commercial chlorophyll a (Wako Pure Chemical Industries), according to the method of Parsons et al. (1984 a). Euphotic zone integrated standing stocks were obtained by trapezoidal integration of the volumetric data down to the depth of 1% surface incident irradiance.

Nutrients

Samples were collected into polystyrene spits bottles, frozen immediately after collection and stored at -20°C until analysis. Nitrate, nitrite, ammonium, silicate, and phosphate concentrations will be measured

with a Bran and Luebbe AACS III autoanalyzer.

DIC

The water samples were drawn into clean, 15mL borosilicate glass bottles. Few drops of saturated mercuric chloride are then added to the sample bottle to prevent further biological activity. The bottle neck is dried with a Kim-Wipe stick and then the bottle is sealed with teflon membrane, ensuring that it remains gas-tight. The samples are then stored in a cool, dark location until laboratory analysis.

Photosynthetic ^{13}C incorporation

Seawater samples from each depth were immediately transferred into three transparent 250 ml polycarbonate bottles. Seawater in the bottle was spiked with a ^{13}C-$NaHCO_3$ (99 atom % ^{13}C, Shoko Corporation) solution. The ^{13}C enrichment was about 10% of the total inorganic carbon in the ambient water. Incubation experiments were begun within about 1 hour after sample collection. The samples were incubated for 24 h in an on-deck incubator bath that running surface water. Immediately following incubation, the samples were filtered directly through pre-combusted (450°C for 4 h) Whatman GF/F filter under gentle vacuum (<200mm Hg), and the particle matter on the Whatman GF/F filters was rinsed with pre-filtered seawater. The filtered samples were immediately frozen and stored at -20°C until isotope analysis on land. After the cruise, filters were treated with HCl fumes for 4 h to remove inorganic carbon, and were completely dried in a desiccator. The isotopic ratios of ^{13}C to ^{12}C and particulate organic carbon will determine by an infra-red spectrometer (JUSCO instruments, Japan). Primary productivity will calculate according to the equation described by Hama et al. (1983).

Oxygen production (GPP)

GPP was determined from in vitro changes in dissolved oxygen after 24 h light and dark bottle incubations. Seawater was carefully siphoned into nine 100-cm^3 gravimetrically calibrated borosilicate glass bottles from Niskin bottle by means of a silicone tube. From each depth, three dark bottles and three light bottles were placed in the same incubator as ^{13}C uptake experiments. The dark bottles were wrapped with aluminum foil and were kept within dark bags, and the light bottles were incubated under irradiance conditions that simulated those of the original sampling depth as ^{13}C uptake bottle. After incubation, the light and dark bottles were fixed immediately. Fixing and storage, reagents and standardization followed the recommendations of Carritt and Carpenter (1966). Dissolved oxygen concentration was measured by automated precision Winkler titration performed with a Metrohm Met-808DO Titrino, utilizing a potentiometric end point (Oudot et al., 1988). Euphotic zone integrated values were calculated as the standing stock of chlorophyll a. Laws (1991) reported a photosynthetic quotient between 1.1 and 1.4. For convenience, the photosynthetic quotient used this conversion was assumed to be 1.2 (Boyd et al., 1997; Smyth et al., 2004).

Table 1 Summary of observation stations regarding primary production

Station	GMT		Lat. (S)		Long. (E)		PAR(E/m2)	DAYLENGTH(h)	TRANSP(m)	PARrelative	DEPTH (m)	CHL(mg/m3)
S1	2006/1/5	8:37	39	39.9609	20	25.6470	45.9	-	25.0	100%	0	0.10
										50%	5	0.01
										25%	12	0.14
										12.5%	25	0.17
										6%	38	0.19
										3%	50	0.26
										1%	65	0.54
S2	2006/1/6	8:04	44	39.7988	22	31.0711	16.4	15.4	9.0	100%	0	0.16
										50%	5	0.16
										25%	10	0.16
										12.5%	15	0.16
										6%	20	0.18
										3%	26	0.18
										1%	35	0.21
L4	2006/1/12	3:49	66	11.4745	35	59.3474	16.3	21.2	23.0	100%	0	0.11
										50%	7	0.10
										25%	18	0.12
										12.5%	31	0.14
										6%	47	0.22
										3%	65	0.26
										1%	87	0.24
L1	2006/1/13	8:23	65	0.1278	35	59.6924	19.1	20.1	27.0	100%	0	-
										50%	9	0.12
										25%	20	0.09
										12.5%	37	0.09
										6%	55	0.14
										3%	80	0.14
										1%	95	0.22
L5	2006/1/14	9:13	65	0.1357	38	0.6460	20.0	19.8	35.0	100%	0	0.05
										50%	9	0.05
										25%	15	0.05
										12.5%	28	0.09
										6%	50	0.16
										3%	66	0.24
										1%	83	0.82
L8	2006/1/15	12:47	66	51.726	37	52.5934	12.6	20.2	13.0	100%	0	0.05
										50%	10	0.05
										25%	18	0.05
										12.5%	26	0.09
										6%	36	0.16
										3%	47	0.24
										1%	62	0.82
FG3	2006/1/19	3:45	65	51.4016	51	6.0318	12.4	19.1	15.5	100%	0	0.88
										50%	10	1.17
										25%	23	1.07
										12.5%	32	0.87
										6%	44	1.09
										3%	55	1.14
										1%	70	1.15
S4	2006/1/20	19:05	63	31.7115	66	0.8643	15.8	18.9	22.0	100%	0	0.24
										50%	13	0.36
										25%	25	0.38
										12.5%	40	0.36
										6%	60	0.37
										3%	75	0.38
										1%	100	0.41
S5	2006/1/21	6:03	62	29.6651	70	49.7684	29.2	17.9	12.0	100%	0	0.65
										50%	5	0.64
										25%	7	0.63
										12.5%	10	0.66
										6%	16	0.66
										3%	20	0.54
										1%	27	0.14
S6	2006/1/21	18:30	61	0.9608	75	57.5089			-	100%	0	0.20
										50%	7	0.20
										25%	12	0.20
										12.5%	20	0.23
										6%	28	0.16
										3%	37	0.25
										1%	50	0.26
S7	2006/1/22	5:27	59	54.0036	79	36.1668	23.6	17.3	13.5	100%	0	0.53
										50%	7	0.49
										25%	12	0.50
										12.5%	20	0.50
										6%	28	0.38
										3%	37	0.31
										1%	50	0.29
S8	2006/1/22	17:59	58	22.8197	84	19.8619			-	100%	0	0.58
										50%	8	0.60
										25%	13	0.58
										12.5%	21	0.74
										6%	30	0.86
										3%	43	0.79
										1%	60	0.49