The 6th China-Japan-Korea IMBER Symposium

Ocean Ecosystem Dynamics and Integrated Marine Biogeochemistry and Ecosystem Research

3-4 October 2013

Tokyo, Japan

NEOPS

New Ocean Paradigm
on Its Biogeochemistry, Ecosystem and Sustainable Use

WELCOME AND ACKNOWLEDGEMENTS

Welcome to the University of Tokyo!

Dear Colleagues,

It is our honour to host the 6th China-Japan-Korea (CJK) IMBER Symposium. It is also our pleasure to welcome you, our colleagues from China, Korea, Japan and other Asian countries, to the University of Tokyo, Japan.

The CJK IMBER symposia are held in order to provide marine scientists from these three countries with the opportunity to meet each other, collaborate, and share and exchange research achievements and ideas. The 6th CJK IMBER Symposium will deal with four main topics:

1. The impact of climate change on biogeochemical cycles in the marginal seas and adjacent open oceans.
2. Marine ecosystem responses to anthropogenic activities and natural stressors.
3. Modelling the interaction between marine biogeochemistry and food web dynamics.
4. Towards the sustainable use of marine resources and services at the interface of marine and human systems.

We sincerely hope that the 6th CJK IMBER Symposium will present many new findings and ideas about the impact of climate change and anthropogenic activity on marine biogeochemical cycles, ecosystems and their feedbacks that will help us understand better the interaction between marine and human systems.

I wish you all a very successful symposium, and I hope that you enjoy your time at the University of Tokyo and in Tokyo.

Professor, Ken Furuya

Director
Graduate School of Agricultural and Life Sciences / Faculty of Agriculture
The University of Tokyo

Acknowledgements

The Symposium Organizing Committee wishes to acknowledge the generous support provided by the sponsors of the research project “NEOPS” - New Ocean Paradigm on Its Biogeochemistry, Ecosystem and Sustainable Use (Project leader: Prof. Ken Furuya.). NEOPS is funded by the ’Grant-in Aid for Scientific Research on Innovative Areas’ made available by the Ministry of Education, Culture, Sports, Science and Technology, Japan. Detail information about the NEOPS project are available at: http://ocean.fs.a.u-tokyo.ac.jp/index-e.htm

We greatly appreciate their help.

Local Organizing Committee &

IMBER Regional Project Office*

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GOALS OF THE SYMPOSIUM

During the past decade, marine scientists from China, Japan and Korea have worked actively in the research areas of Global Ocean Ecosystem Dynamics (GLOBEC) and Integrated Marine Biogeochemistry and Ecosystem Research (IMBER). Since GLOBEC era, a series of scientific meetings have been organised every two years. The China-Japan-Korea (CJK) IMBER Symposium series provides the countries' scientists with the opportunity to collaborate, and share and exchange research achievements and ideas.

The goals of the 6th China-Japan-Korea IMBER Symposium are:

- to advance our understanding of marine biogeochemistry and ecosystem dynamics for the sustainable use of ecosystem services
- to understand the response of various marine ecosystems to multi-stressors and drivers, from climate change to anthropogenic forcing.

TOPICS & SESSIONS

Oral presentation topics

1. The impact of climate change on biogeochemical cycles (e.g. nutrients, organic matter, trace metals) in the marginal seas and adjacent open oceans.
2. Marine ecosystem responses to anthropogenic activities and natural stressors.
3. Modeling the interaction between marine biogeochemistry and food web dynamics.
4. Towards the sustainable use of marine resources and services at the interface of marine and human systems.

Poster presentations:

Posters are invited for the same themes as the oral presentations and will be displayed for the duration of the symposium. The size of all posters must be 80cm (width) by 120cm (height).

Discussion session:

1. National and regional activities of IMBER-related research in East Asia
2. Comparison of ecosystem functions at the regional scale

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New Ocean Paradigm on Its Biogeochemistry, Ecosystem and Sustainable Use (NEOPS) project, Japan

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GENERAL INFORMATION

Venue

Nakashima Hall, Food Science Building, Yayoi Section / Hongo Campus, The Uiversity of Tokyo, Tokyo, Japan

The university website: www.u-tokyo.ac.jp/en/

Campus map

- http://www.a.u-tokyo.ac.jp/english/campus/map-e.html
- http://www.u-tokyo.ac.jp/en/about/documents/Hongo_CampusMap_E.pdf

How to get to The University of Tokyo

The University of Tokyo (Hongo Campus) is located at Bunkyo-ku in Tokyo. The subway stations for the university are Ueno and Okachimachi on the JR Yamanote line, Ochanomizu on the JR Chuo line, and Keisei-Ueno on the Keisei line.

From Narita Airport

Take the Keisei line from Narita airport to the Keisei-Ueno station (about 1.5 hours). Or, you can take the Skyliner, where you could use some extra facilities, for example baggage rooms. You need an additional ticket to take the Skyliner. More information about the Keisei line is available on the Internet.

From Tokyo Train Station

Take the JR Yamanote line to Ueno or Okachimachi: about 10 minutes Take the JR Chuo line to Ochanomizu: about 5 minutes Take theMarunouchi subway line to Hongo-sanchome: about 10 minutes

General information

Access from the nearest station (walking)

Nearest Stations	Distance from Sta.
Hongo-sanchome Station. (Subway Marunouchi Line)	12 min. walk
Hongo-sanchome Station. (Subway Oedo Line)	10 min. walk
Yushima Station or Nezu Station. (Subway Chiyoda Line)	8 min. walk
Todaimae Station. (Subway Namboku Line)	1 min. walk

Access from the nearest station (by Bus, Subway)

Stations	Transportation	Route
From Ochanomizu Station. (JR Chuo Line, JR Sobu Line)	Subway	Take Subway Marunouchi Line direction Ikebukuro and get off at Hongo-sanchome Station. 8 minutes walk
	Subway	Take Subway Chiyoda Line direction Toride and get off at Yushima Station or Nezu Station. 8 minutes walk
	Bus	Take Toei Bus 茶 51 direction Komagome Station South. Exit or 東 43 for Arakawa-dote-soshajo and get off at Todai (Akamon-mae, Seimon-mae, Nogakubu-mae)
	Bus	Take Toei Bus 学 07 for Tokyo Univ. and get off at Todai (Tatsuokamon, Byoin-mae, Konai Bus Stop)
Okachimachi Station. (JR Yamanote Line, etc.)	Bus	Take Toei Bus 都 02 for Otsuka Sta. or 上 69 for Otakibashi-shako-mae and get off at Yushima-yon-chome or Hongo-sanchome.
Ueno Station (JR Yamanote Line, etc.)	Bus	Take Toei Bus 学 01 for Todai-konai and get off at Todai (Tatsuokamon, Byoin-mae Konai Bus Stop)

Source: www.a.u-tokyo.ac.jp/english/campus/keiro-e.html

Registration

The registration desk in the lobby of the Food Science Building, Yayoi Section / Hongo Campus, The University of Tokyo will be open from 08:30-09:00 on 3 October 2013.

AGENDA

Day One: 3rd October, Thursday Morning

Time	Speaker	Oral Presentation Title
Opening		
09:00-09:10	Ken Furuya	Opening remarks
09:10-09:20	Hiroshi Ogawa	
09:20-09:40	Liuming Hu	IMBER recent activities, achievements and future development
Oral session 1: The impact of climate change on biogeochemical cycles (e.g. nutrients, organic matter, trace metals) in the marginal seas and adjacent open oceans. Convener: Hiroshi Ogawa		
09:40-10:00	Xinyu Guo	Budget calculation for the Kuroshio nutrient transport from the East China Sea to south of Japan
10:00-10:20	Yu Umezawa	Seasonal and spatial variations in the contribution of the Changjiang River and the Kuroshio to nitrate dynamics at the continental shelf of the East China Sea
10:20-10:40	Yutaka Hiroe	3D structure and interannual variation of nutrient in the Kuroshio region
10:40-11:00	Coffee break and Group photo	
11:00-11:20	Xiuqing Ge	Nitrogen uptake and primary production in Tokyo Bay
11:20-11:40	Guodong Song	Anammox, denitrification and dissimilatory nitrate reduction to ammonium in the East China Sea sediment
11:40-12:00	Fuminori Hashihama	Sensitive determination of enzymatically labile dissolved organic phosphorus and its vertical profiles in the oligotrophic western North Pacific and East China Sea
12:00-13:30	Lunch	

Day One: 3rd October, Thursday Afternoon

Time	Speaker	Oral Presentation Title
Oral session 2: The impact of climate change on biogeochemical cycles (e.g. nutrients, organic matter, trace metals) in the marginal seas and adjacent open oceans. (Continued) **Convener: Hiroshi Ogawa**		
13:30-13:50	Masao Ishii	Trend of ocean acidification in the western Pacific tropical and subtropical zones
13:50-14:10	Zhongqiao Li	The source of organic carbon in the Changjiang sediments, based on the distribution of GDGTs and lignin-derived phenols
14:10-14:30	Youhei Yamashita	Accumulation of humic-like fluorescent dissolved organic matter in the Japan Sea Proper Water
14:30-14:50	Chia-Jung Lu	The distribution of dissolved lignin as a tracer of terrigenous dissolved organic matter in Otsuchi Bay, Japan
14:50-15:10	Juan Du	Seasonal various of ^{7}Be, ^{210}Pb, ^{234}Th and ^{137}Cs in the surface sediments of the Changjiang Estuary and its adjacent sea and their implications
15:10-15:30	Coffee break	
Oral session 3: Modeling the interaction between marine biogeochemistry and food web dynamics. **Convener: Hiroaki Saito**		
15:30-15:50	Ian Jenkinson	Measurements of rheology and surface properties for models of plankton ecology and biogeochemistry
15:50-16:10	Eiji Masunaga	Resuspension and lateral dispersal of sediments due to shoaling internal waves
16:10-16:30	Yoichi Ishikawa	Forecasting ocean circulation and fishery-resource variabilities for operational use
16:30-16:50	Hiromichi Igarashi	Modeling of habitat suitability index for neon flying squid in the North Pacific by using 3-dimensional ocean data assimilation product
16:50-17:10	Jun Sun	Living coccolithophores in China Sea waters: Role in carbon cycle
17:10-18:00	Poster session	

Day Two: 4th October, Friday Morning

Time	Speaker	Oral Presentation Title
Oral session 4: Marine ecosystem responses to anthropogenic activities and natural stressors. Convener: Se-Jong Ju		
09:00-09:20	Koji Suzuki	Responses of spring diatom assemblages in Oyashio waters of the western subArctic Pacific to CO_2 availability as estimated from molecular markers
09:20-09:40	Yuan Zhao	Temporal variation of picoplankton in the spring bloom of Yellow Sea, China
09:40-10:00	Li Zhao	Picoplankton distribution in different water masses of the East China Sea in autumn and winter
10:00-10:20	Eunho Ko	Comparison of the two methods for primary production measurement
10:20-10:40	Coffee break	
Oral session 5: Marine ecosystem responses to anthropogenic activities and natural stressors. (Continued) Convener: Se-Jong Ju		
10:40-11:00	Yasunori Sakurai	May the warm sea surface water of spawning areas of Japanese common squid in autumn contribute to the decreased survival of paralarvae and annual catch after 2000s?
11:00-11:20	Lingfeng Huang	Chain response of microbial loop to the decay of a diatom bloom in the East China Sea
11:20-11:40	Hongbin Liu	Predator – prey interactions in planktonic food web under changing environment
11:40-12:00	Ying Cui	Variation in the $\delta^{13}C$ of specific fatty acids in *Coilia mystus* during migration
12:00-13:30	Lunch	

Day Two: 4th October, Friday Afternoon

Time	Speaker	Oral Presentation Title
Oral session 6: Marine ecosystem responses to anthropogenic activities and natural stressors. (Continued) **Convener: Se-Jong Ju**		
13:30-13:50	Se-Jong Ju	Understanding the food web dynamics of Yellow Sea ecosystem: the role of *Euphausia pacifica* using multi-approaches
13:50-14:10	Joji Ishizaka	Influence of river discharge on phytoplankton absorption properties: A case study in the East China Sea and Tsushima Strait
14:10-14:30	Aida Sartimbul	Diet composition dynamics in relation to the Omega-3 fatty acid of Bali Sardine (*Sardinella lemuru*) in Bali Strait
14:30-14:50	Meixun Zhao	Ecosystem responses to anthropogenic and natural forcings over the past 100 years in the coastal areas of the East China Sea elucidated from biomarkers
Oral session 7: Towards the sustainable use of marine resources and services at the interface of marine and human systems. **Convener: Hiroaki Saito**		
14:50-15:10	Hiroaki Saito	The role of Kuroshio on the food-web structure and fisheries production off Japan: Introduction of SKED project
15:10-15:30	Sei-Ichi Saitoh	Dissemination of potential fishing zone prediction map of Japanese common squid in the coastal water, southwestern Hokkaido, Japan
15:30-15:50	Yang Liu	Impacts of climate change on suitable region for Japanese scallop aquaculture in Dalian, China and Funka Bay, Japan, using GIS-Based model and satellite remote sensing.
15:50-16:10	Takaomi Kaneko	Fisheries management under species alternation from the aspect of regional economy and food security
16:10-16:30	Coffee break	
16:30-17:00	Discussion session: **National and regional IMBER-related research and activities and the possibility for future collaboration in east Asia** Conveners: **Hiroaki Saito; Hiroshi Ogawa; Se-Jong Ju**	
17:00-17:30	Meeting wrap up and closing	

POSTER LIST

Authors	Poster Title
Adi Nugraha	The internal tides and ecosystem dynamics around Oshima Island: A preliminary study
Adrean Webb	A first step towards modeling the impact of the 2011 Tōhoku earthquake and tsunami on estuary dynamics in Ōtsuchi Bay, Japan
Atsushi Kojima	Rapid acidification rates in the western North Pacific subarctic region, offshore Sanriku area
Herminio Foloni-Neto	Quasi-horizontal observations of biophysical phenomena in the base of the mixed layer
Jun Nishioka	Intensive mixing along an island chain controls oceanic biogeochemical cycles
Mofizur Rahman	Plant-herbivore interaction under acidified ocean
Sandip Mandal	A novel approach for modeling spatial variability of phytoplankton in oceanic ecosystem
Shengkang Liang	Distribution of neutral sugar and its compositions as indicators of matter degradation state in the East China Sea surface sediments
Shigenobu Takeda	Distribution of dissolved iron in the East China Sea during summer
Sulin Sim	Alkaline phosphatase activity in Tokyo Bay
Xiaofan Luo	Numerical simulation of giant jellyfish *Nemopilema nomurai* population dynamics in East China Sea
Yang Liu	The impacts of climate events on aquaculture site-selection model for Japanese kelp (*Saccharina japonica*) in southern Hokkaido, Japan
Yanhui Yang	Grazing and viral lysis on autotrophic nano- and picoplankton and heterotrophic bacteria in the Otsuchi Bay
Yongjiu Xu	Relationships of interannual variability in SST and phytoplankton blooms with giant jellyfish (*Nemopilema nomurai*) outbreaks in the Yellow Sea and East China Sea

PRESENTATION ABSTRACTS

ORAL PRESENTATIONS

Budget calculation for the Kuroshio nutrient transport from the East China Sea to south of Japan

Xinyu Guo[1,2,*], Xiaohua Zhu[2,3], Yu Long[2], Daji Huang[2,3]

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Abstract
Based on absolute geostrophic velocity calculated from repeated hydrographic data of 39 cruises from 2000 to 2009 and nitrate concentrations measured at the same sections from 1964 to 2009, we obtained temporally averaged nitrate flux (the product of velocity and nitrate concentration) and nitrate transport (integration of flux over a section) through 4 sections across the Kuroshio from the East China Sea (sections PN and TK) to south of Japan (sections ASUKA and 137E). In addition, we examined section OK east of the Ryukyu Islands in order to understand the contribution of Ryukyu Current to the Kuroshio nutrient transport south of Japan. The mean nitrate flux shows a subsurface maximum core with a value of 9, 10, 11, 9, and 5 mol $m^{-2}s^{-1}$ at sections PN, TK, ASUKA, 137E, and OK, respectively. The depth of subsurface maximum core changes among five sections and is approximately 400, 500, 500, 400, and 800 m at sections PN, TK, ASUKA, 137E, and OK respectively. The mean downstream nitrate transport is 204.8, 165.8, 879.3, 1230.4, and 338.6 kmol s^{-1} at sections PN, TK, ASUKA, 137E, and OK respectively. The nutrient transports at these sections suggest the presence of Kuroshio nutrient stream from its upstream region to downstream. The deep current structure of Ryukyu Current (section OK) makes it contribute the same order of nitrate transport as the Kuroshio in the East China Sea (section TK) to the Kuroshio south of Japan although the former has only one fifth of volume transport of latter. A budget calculation suggests that the downstream increase of nitrate transport along the Kuroshio is mainly caused by the join of Kuroshio recirculation into the Kuroshio. This conclusion, however, depends on water depth. In the upper layers ($<26.5\sigma_\theta$), the downstream change of nitrate concentration along the Kuroshio and that from the Kuroshio recirculation to the Kuroshio has a significant contribution to the downstream increase of nitrate transport along the Kuroshio. In the deep layers ($>26.5\sigma_\theta$), the change in nitrate concentration is small and the Kuroshio recirculation dominates the downstream increase of nitrate transport.

Keywords: Kuroshio, Kuroshio recirculation, Ryukyu Current, diapycnal mixing

Seasonal and spatial variations in the contribution of the Changjiang River and the Kuroshio to nitrate dynamics at the continental shelf of the East China Sea

Yu Umezawa[1,*], Ryu Nozaki[1], Akira Yamaguchi[1], Joji Ishizaka[2], Toru Hasegawa[3], Kou Nishiuchi[3,4], Chiyuki Sassa[3], Chikage Yoshimizu[5], Ichiro Tayasu[5]

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Abstract
East China Sea (ECS) serves as a spawning and nursery ground for many species of fish and squid. Therefore, it is important to clarify the dynamics of the nutrients supporting the growths of phytoplankton and subsequent zooplankton, which become the food sources of the juveniles. Nitrate (NO_3^-) is dominant component of new dissolved inorganic nitrogen (DIN) and ECS has multiple NO_3^- sources, but it is not clear which NO_3^- is really used for phytoplankton growth. To clarify the basis of the food web in the ECS, we examined the NO_3^- dynamics based on stable nitrogen and oxygen isotopes of NO_3^- ($\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$) and temperature-salinity dynamics in winter (February 2009), early spring (March 2012) and summer (July 2009, 2011 and 2012). Despite the use of snapshot sampling, multiple isotopes of NO_3^- provided information about the NO_3^- dynamics, including its sources and the biological reactions occurring during transportation. Although both Kuroshio Subsurface Water (KSSW) and the Yellow Sea Mixed Water (YSMW) predominantly contributed to NO_3^- distributed in the shelf water at northern ECS in winter, KSSW-derived NO_3^- seemed to stimulate phytoplankton growth, along with a temperature increase caused by an intrusion of Kuroshio Surface Water (KSW). In summer, Changjiang Diluted Water (CDW), Yellow Sea Cold Water Mass (YSCWM), and KSSW affected the distribution and abundance of NO_3^- in the northern ECS, depending on precipitation in the Changjiang drainage basin and the development of the YSCWM in the shelf bottom water. Isotopic fractionation during NO_3^- uptake by phytoplankton seemed to drastically change $\delta^{15}N_{NO3}$ and $\delta^{18}O_{NO3}$, and $\delta^{15}N_{NO3}$–ln([NO_3]) dynamics suggested that nitrification may have contributed to NO_3^- dynamics, too, especially in the NO_3^--depleted layer during summer, suggesting a tightly coupled N cycle in the shelf water of the ECS.

Keywords: nitrate, multi-isotopes, Kuroshio, Changjiang River, East China Sea

3D structure and interannual variation of nutrients in the Kuroshio region

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Abstract
The transport of heat and nutrient by the Kuroshio and its impacts on the ecosystem in the adjacent regions is an important issues to clarify the mechanism of the decadal change of the productivity in the western North Pacific. Focused on the nutrient and chlorophyll in the Kuroshio region, historical hydrographic data were analyzed to clarify their 3D structure and seasonal and interannual variabilities. The nutrient maximum was detected on the isopycnal surface of 24.5-25.5 sigma-theta along the jet in the whole region of the Kuroshio. The structure was analogous to the characteristic one well-known as Nutrient Stream found in the Gulf Stream region. It should be emphasized that the nutrient concentration on the 24.5-25.5 sigma-theta surface gradually decreases along the Kuroshio toward the downstream region. It implies that the high nutrient water is originated from the upstream and its adjacent coastal regions and transported downstream epipycnally along the Kuroshio as is the case with the Gulf Stream. Moreover, the along-jet maximum was detected only in spring, which is attributed to more active consumption by the phytoplankton on the inshore side of the jet under the adequate irradiance because the strong baroclinicity inclines isobathes on the isopycnal surfaces and the water depth on the inshore side is much shalower. The decadal change of the nutrient concentration on the subsurface isopycnal surfaces was synchronized with the cyclic climate change in the Pacific, suggesting the effect of the induction process on the nutrient supply to the euphotic layer in the Kuroshio region.

Keywords: Kuroshio, nutrient structure, interannual variation

Nitrogen uptake and primary production in Tokyo Bay

Xiuqing Ge[1,*], Takahisa Mifune[1], Atsushi Kubo[1], Fuminori Hashihama[1], Michiyo Kawai[1], Naho Miyazaki[1] and Jota Kanda[1]

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Abstract
Tokyo Bay is one of the most eutrophic waters in Japan. The water discharge from rivers and sewage treatment plants, which is affected by human activities, deteriorates water quality of the bay. Despite recent reduction of nutrients in surface water of Tokyo Bay, phytoplankton blooms still happen frequently. Since organic matter produced by phytoplankton mainly determines water quality, nitrogen uptake and primary production by phytoplankton are both important. This study is to investigate temporal patterns in nitrogen uptake and primary production in Tokyo Bay, and to analyze their relationships to environmental factors.

In every month from May to December 2012, incubation experiments with ^{15}N labeled nitrate and ammonium and ^{13}C labeled bicarbonate were conducted at station F3 (35°30′42″N, 139°49′48″E) in the inner part of Tokyo Bay. Seawater samples for the experiments were collected at 0 and 20 m depths using Niskin samplers mounted on a CTD rosette. Samples for nutrients, dissolved inorganic carbon, and chlorophyll *a* (Chl *a*) were also collected. Photosynthetically active radiation (PAR) was measured by a PAR sensor which was set in CTD system. Samples treated with ^{15}N and ^{13}C tracers were incubated for 3 h in an on-deck incubation tank under ambient PAR levels at 0 and 20 m. Uptake rates of nitrate and ammonium, and primary production rates were calculated from ^{15}N and ^{13}C incorporation into the particulate matter which was determined by mass spectrometer. Nitrogen uptake and primary production rates were subject to bivariate correlation and multiple linear regression analysis with environmental parameters using SPSS 16.0.

Chl *a* concentrations, nitrogen uptake and primary production rates at 0 m were 1 to 5 orders of magnitude higher than those at 20 m throughout the study period. Chl *a* concentration at 0 m was the highest in June (85.0 μg l^{-1}), and that in July was the second highest (51.7 μg l^{-1}). The higher phytoplankton biomass at 0 m was associated with higher temperature, lower salinity, and higher nitrate and silicic acid concentrations. Maximum nitrate uptake rate of 1.10 μmol-N l^{-1} h^{-1}, maximum ammonium uptake rate of 1.28 μmol-N l^{-1} h^{-1}, and maximum primary production rate of 26.6 μmol-C l^{-1} h^{-1} were commonly observed at 0 m in July. Uptake rates of ammonium were always higher than those of nitrate both at 0 and 20 m and nitrate contribution to the total (nitrate and ammonium) uptake ranged from 0 to 46% throughout the study period, indicating that ammonium was preferred to be taken up in the water column. Chl *a*-specific uptake rates of nitrate and ammonium commonly showed positive correlations with temperature and PAR. In addition, Chl *a*-specific ammonium uptake rates showed negative correlations with nitrate and nitrite concentrations. Chl *a*-specific primary production rates showed a positive correlation with PAR. None of them showed positive correlations with concentrations of nutrients. These results suggest that high production regime in summer was attributed to the high biomass, and high biomass-specific nitrogen uptake and primary production, which were mainly controlled by temperature and PAR rather than nutrients.

Keywords: nitrogen uptake, primary production, environmental factors

Anammox, denitrification and dissimilatory nitrate reduction to ammonium in the East China Sea sediment

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Abstract

Benthic nitrogen transformation pathways were investigated in the sediment of the East China Sea (ECS) in June of 2010 using the ^{15}N isotope pairing technique. Slurry incubations indicated that denitrification, anammox and dissimilatory nitrate reduction to ammonium (DNRA) as well as intracellular nitrate release occurred in the ECS sediments. These four processes did not exist independently, the nitrate release therefore diluted the ^{15}N labeling fraction of NO_3^-, a part of the $^{15}NH_4^+$ derived from DNRA also formed $^{30}N_2$ via anammox. Therefore current methods of rate calculations led to over and underestimations of anammox and denitrification respectively. Following the procedure outlined in Thampdrup and Dalsgaard (2002), denitrification rates were slightly underestimated by on average 6% without regard to the effect of nitrate release, while this underestimation could be counteracted by the presence of DNRA. On the contrary, anammox rates calculated from $^{15}NO_3^-$ experiment were significantly overestimated by 42% without considering nitrate release. In our study this overestimation could only be compensated 14% by taking DNRA into consideration. In a parallel experiment amended with $^{15}NH_4^+$+$^{14}NO_3^-$, anammox rates were not significantly influenced by DNRA due to the high background of $^{15}NH_4^+$ addition. The significant correlation between potential denitrification rate and sediment organic matter content (r=0.68, P<0.001) indicated that denitrification was regulated by organic matter, while, no such correlations were found for anammox and DNRA, respectively. The relative contribution of anammox to the total N-loss increased from 13% at the shallowest site near the Changjiang estuary to 50% at the deepest site on the outer shelf (Fig. 1), implying the significant role of anammox in benthic nitrogen cycling in the ECS sediment, especially on the outer shelf. N-loss as N_2 was the main pathway, while DNRA was also an important pathway

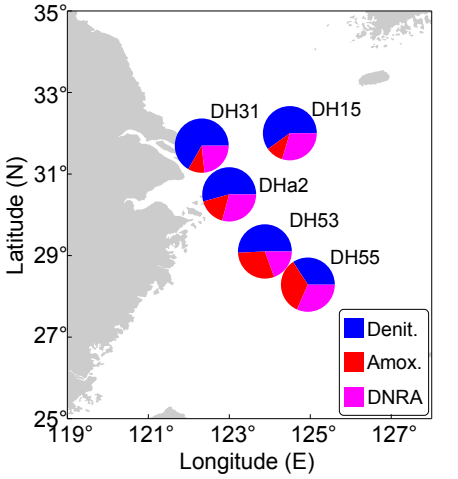

Fig. 1 relative contribution of anammox, denitrification and DNRA to total nitrate reduction in the ECS sediment.

accounting for 20-31% of benthic nitrate reduction in the ECS (Fig. 1). Our study demonstrates the complicated interactions among different benthic nitrogen transformations and the importance of considering denitrification, DNRA, anammox and nitrate release together when designing and interpreting future studies.

Keywords: anammox, denitrification, DNRA, East China Sea, sediment

Sensitive determination of enzymatically labile dissolved organic phosphorus and its vertical profiles in the oligotrophic western North Pacific and East China Sea

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Abstract
Trace concentrations of labile dissolved organic phosphorus (LDOP) in oligotrophic seawater were measured using an enzymatic procedure and a nanomolar phosphate analytical system consisting of a gas-segmented continuous flow analyzer with a liquid waveguide capillary cell. LDOP, defined as DOP hydrolyzed by alkaline phosphatase (AP) from *Escherichia coli*, was quantified by the difference between the phosphate concentrations of the seawater sample with and without AP treatment. For the sensitive measurement of LDOP, we found that phosphate contamination derived from the commercially available AP must be corrected, and azide treatment before AP treatment proved effective in removing biological influence that occur during DOP hydrolysis. Field observations at six stations of the western North Pacific and the East China Sea during the boreal summer revealed that, in the upper 200 m of the water column, LDOP concentrations ranged from the detection limit of 3 nM to 243 nM and phosphate concentrations ranged from 5 to 374 nM. The spatial distribution patterns of LDOP were similar to those of phosphate. Most of the depth profiles for LDOP and phosphate showed extremely low concentrations of <25 nM between the surface and the deep chlorophyll maximum layer (DCML) and an increase below the DCML. Strongly depleted LDOP and phosphate above the DCML suggest that LDOP is actively hydrolyzed under phosphate-depleted conditions and utilized by microbes.

Keywords: labile dissolved organic phosphorus, phosphate, liquid waveguide capillary cell, alkaline phosphatase, Western North Pacific, East China Sea

Trend of ocean acidification in the western Pacific tropical and subtropical zones

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Abstract

With three decades of ocean CO_2 system measurements, we demonstrate the occurrence of ocean acidification in the western Pacific tropical and subtropical zones.

In the warm pool of the tropical Pacific near Coral Triangle (5°S - 5°N), partial pressure of CO_2 in surface water has been increasing at a mean rate of +1.31 ±0.14 µatm yr^{-1} since mid-1980s while salinity-normalized total alkalinity show no significant variability both in space and time. The results are indicative of the increase in salinity-normalized dissolved inorganic carbon at +0.77 ±0.14 µmol kg^{-1} yr^{-1}, a lowering of pH at -0.0013 ±0.0001 yr^{-1} and a reduction of the saturation indices of the carbonate minerals aragonite (Ω_{arag}) and calcite (Ω_{calc}) at -0.008 ±0.001 yr^{-1} and -0.012 ±0.001 yr^{-1}, respectively. Similar trends of CO_2 increase and acidification have also been observed over the subtropical zone (5°N - 34°N) at 137°E to the south of Japan. In the northern subtropics, the trend of CO_2 increase is superposed on remarkable seasonal and interannual variations (Fig. 2). The increase of CO_2 has also been observed since mid-1990s

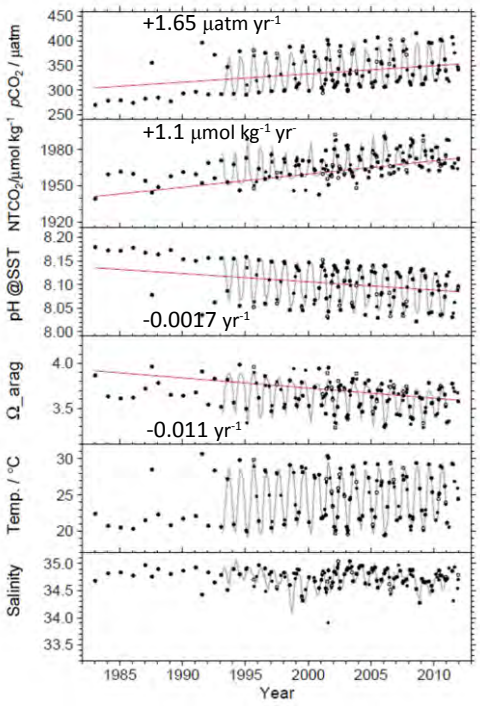

Fig 2. Trend of ocean CO_2 parameters in surface water at 137ºE, 27ºN.

in the interior of the subtropical gyre at 137°E above the density class of North Pacific Intermediate Water (σ_θ >26.8) and in the Equatorial Undercurrent (σ_θ > 25.5). These results of measurements and ocean biogeochemistry / general circulation models suggest that the shallow meridional overturning circulations in the North and South Pacific are playing an important role for the uptake and storage of anthropogenic CO_2 in the subtropical gyre and its transport into the tropical zone.

Keywords: ocean acidification, Pacific Ocean

The source of organic carbon in the Changjiang sediments, based on the distribution of GDGTs and lignin-derived phenols

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Abstract
We use the organic matter composition of river sediments from the Changjiang basin to study the distribution and source of organic cabon in the Changjiang systerm. Elemental constrains (TOC and TN), total organic carbon isotopes ($\delta^{13}C_{org}$) and lignin-derived phenols as well as glycerol dialkyl glycerol tetraethers (GDGTs) have been measured for the sediments from Changjiang basin collected during the wet season (from September to October) of 2009. $\delta^{13}C_{oc}$ indicates that the isotopic carbon in Jinsha river reaches is heavier than that in main of Changjiang River reaches. This can be attributed to a much higher altitude of Jinsha river reaches than the main of reaches of Changjiang River. Compared to the $\delta^{13}C_{oc}$ of organic matter souce along Changjiang, the $\delta^{13}C_{oc}$ of sediments are close to the isotopic signature of soils in this regin which indicate that the sedimentary organic carbon in these samples is mainly from C3 plant-derived soils.

Three main branched GDGTs (bGDGTs) (Ⅰ+Ⅱ+Ⅲ) *vs.*isoprenoid GDGT cren ratio varies between 2.26 and 10.29, and the lowest appears at ***HH*** station near the DT lake which imple the lake supply extra iGDGTs to the sediments. The BIT (branched and isoprenoid) index variation also show the same trend in present study. The MAT (ºC) derived from bGDGTs range from 1.94 to 15.95 ℃, and there is a negative correlation between MAT and altitude of the site (r=-0.83, p=0.05) . The iGDGTs-derived pH vary between 7.20 and 8.71, with an average value 7.91. Considering the uncertainty of the equation, the pH_{CBT} is close to the actual pH of the bottom water.

Key Words: the Changjiang, GDGTs, lignin-derived phenols

Accumulation of humic-like fluorescent dissolved organic matter in the Japan Sea Proper Water

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Abstract
Marine dissolved organic matter (DOM) is the largest reduced carbon reservoir in ocean. Most marine DOM is produced by marine biota and is resistant to rapid microbial degradation. Thus, it is crucial to know the dynamics of recalcitrant DOM for determining whether the marine DOM reservoir is stable or not. Even though there have been several hypotheses regarding with the recalcitrant mechanism of marine DOM, the microbial production of recalcitrant DOM (defined as microbial carbon pump) has been considered as the main

process. Humic-like fluorescent DOM ($FDOM_H$) has found to produce during microbial incubation. Even though $FDOM_H$ has known to easily degrade by sunlight, linear relationships between fluorescence intensity of $FDOM_H$ and indicators of microbial remineralization, e.g., apparent oxygen utilization (AOU), have been observed throughout the ocean. These experimental and observational results imply that $FDOM_H$ is a product of microbial carbon pump. Another important source of $FDOM_H$, especially in coastal environments and marginal seas, is riverine supply. Even though the major fractions of $FDOM_H$ have been considered to be photo-degraded in coastal environments, substantial contribution of terrestrial $FDOM_H$ into ocean interior has been suggested. Thus, in addition to accumulation of *in situ* produced $FDOM_H$, recalcitrant terrestrial $FDOM_H$ might occur in deep ocean, especially in marginal seas. However, it is not clear whether recalcitrant autochthonous and/or terrestrial $FDOM_H$ is accumulated in deep ocean of marginal seas or not. We determined spatial distribution of $FDOM_H$ in the Japan Sea using excitation emission matrix fluorescence with parallel factor analysis. Levels of $FDOM_H$ were lowest in surface waters, gradually increased with depth below surface waters, and were highest in the Japan Sea Proper Water (JSPW). Levels of $FDOM_H$ were linearly correlated with AOU in the JSPW, suggesting that $FDOM_H$ were produced *in situ* in the JSPW. Interestingly, levels of FDOM in JSPW were similar or slightly higher compared with those in deep waters of the western North Pacific, even though AOU in the JSPW were significantly lower than those in deep waters of the western North Pacific. Such distributional characteristics of $FDOM_H$ in the JSPW imply that $FDOM_H$ is accumulated in the JSPW. We will discuss possible origin and accumulation mechanism of $FDOM_H$ in the JSPW.

Keywords: dissolved organic matter, recalcitrant, FDOM, Japan Sea

The distribution of dissolved lignin as a tracer of terrigenous dissolved organic matter in Otsuchi Bay, Japan

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Abstract
Lignin phenol is one of the most clear-cut patterns to indicate the source and the diagenesis process of organic matter in the ocean. It only occurs in vascular plants, thus has potential for indicating the land-derived and the degradation of the organic matter in aquatic environment. Terrigenous dissolved organic matter (DOM) is transported from the land to the ocean by river input

and the amount is minor than marine DOM in open ocean, therefore coastal environment should be the major place to remove or consume terrigenous DOM in seawater. Pervious investigations show terrigenous DOM is more sensitive to photochemical than microbial process in coastal seawater, but the factor to control terrigenous DOM is still not understood very well.

Otsuchi Bay offers an ideal field to study the removal mechanism of terrigenous DOM in seawater because of the simple terrigenous matter sources and little human impact. In this study, we can have a better understand about the degradation of terrigenous matter in coastal environment by lignin analysis.

Samples were collected in September and November in 2012. Seawater was collected at a depth of 1m with a Niskin bottle and the sample sites were from inner to outer of the bay. River water samples were also collected in this watershed, including Otsuchi River, Kotsuchi River and Unosumai River. Both seawater and river samples were filtered through Whatman polycarbonate filter (1 μm pore size) and then acidified to ca. pH 2.5. Dissolved lignin phenols were isolated from 10 L seawater or 5 L river samples by solid phase extraction using C18 cartridges (Varian MegaBond Elut) and oxidized by CuO oxidation method.

Concentration of lignin phenols were measured with Agilent 7890 gas chromatograph equipped with a Varian DB5-MS capillary column and an Agilent 5975 mass selective detector. Nine lignin phenols were measured in this study, including vanillyl phenols (vanillin, vanillic acid and acetovanillone), syringyl phenols (syringaldehyde, syringic acid and acetosyringone) and *p*-hydroxy phenols (*p*-hydroxybenzaldehyde, *p*-hydroxyacetophenone and *p*-hydroxybenzoic acid).

The maximum value of the total dissolved lignin phenols concentrations ($TDLP_9$) was at the Unosumai River site and the $TDLP_9$ decreased from inner to outer of the bay (Fig. 3). The S/V (syringyl:vanillyl ratios) was also decreased from the land to the ocean, and the ratio of river sites (~ 0.8) reflected the predominance of angiosperms in this area. (Ad/Al)v (acid:aldehyde ratios of vanillyl) was

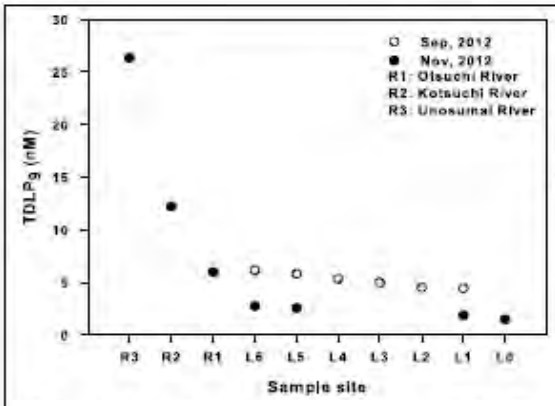

Fig. 3 Lingin concentrations ($TDLP_9$) in Otsuchi Bay and the inflow rivers.

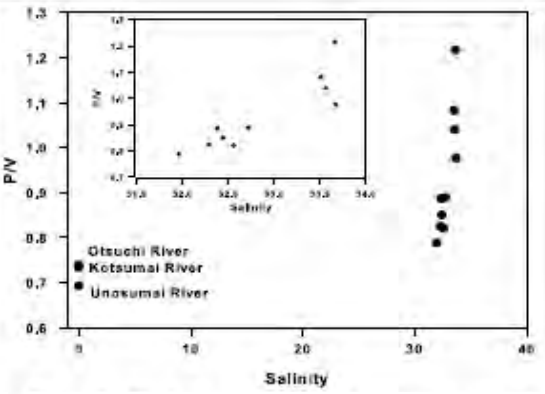

Fig. 4 Relationship between salinity and P/V.

increased nearly 2 fold from the river sites to the ocean. Both of above two results indicated the terrigenous DOM in seawater was degraded by photooxidation. Another evident to support photodegradation in this area was the P/V (*p*-hydroxy:vanillyl ratios), that ratio increased from river sites toward the ocean (Fig. 4) and it was conformed with previous study about P/V increased with irradiation exposure.

This study was conducted as part of the project "TEAMS" (Tohoku Ecosystem-Associated Marine Science) sponsored by MEXT.

Keywords: dissolved organic matter, terrigenous influx, Lignin phenols, coastal environment

Seasonal variations of ^{7}Be, ^{210}Pb and ^{137}Cs in the surface sediments of the Changjiang Estuary and its adjacent sea and their implications

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Abstract

Particle-reactive nuclides such as ^{7}Be, ^{210}Pb, and ^{137}Cs, as particle-reactive nuclides, have been broadly used to trace settling and reworking processes of suspended particle/sediment in marine environment. Based on the sampling surface sediment of the East China Sea in June and November of 2010, the distribution patterns of activities of ^{7}Be, ^{210}Pb and ^{137}Cs in the surface sediments were determined. The results showed that the ranges of activities of ^{7}Be, $^{210}Pb_{ex}$ and ^{137}Cs were 0.0–34.6, 8.0–214.0 Bq kg^{-1}, and 0.39–2.90, with averages of 9.8, 43.5 and 1.56 Bq kg^{-1}, respectively. Mass balance calculations suggested that the main source of ^{7}Be was atmospheric deposition flux and most of ^{7}Be in the estuary and the inner shelf was decayed and exported to offshore. The East China Sea was the sink for particle-reactive ^{210}Pb and ^{137}Cs, about 70% of ^{210}Pb and 95% of ^{137}Cs were transported from outer shelf to the estuary and inner shelf.

Keywords: sediment transport processes, $^{210}Pb_{ex}$, ^{7}Be, ^{137}Cs, radioactive tracers, Changjiang Estuary

Measurements of rheology and surface properties for models of plankton ecology and biogeochemistry

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Abstract

Natural waters (here called "the ocean")

and their biogeochemical system represent an inherited investment of immense capital value. Our lives depend on them, but they are being degraded and threatened by present and future global environmental and anthropic changes. More research-driven innovation is needed to understand, model, value and pro-actively maintain and repair this inheritance.

To model, predict and understand processes in plankton ecology and biogeochemistry as a function of environmental changes, including in extreme events, we need to use physical and chemical parameters known as accurately as possible across as wide a range of scales (space, time, mechanical stress, temperature, pH, and so on) as possible.

This talk will concentrate on rheology, resistance to flow, exopolymeric substances (EPS) as well as nano- and microfluidics. Ocean water has long been known to resist flow proportionally to a viscosity that is a function of temperature and salinity. Using rheological measurements, we have already shown in phytoplankton cultures and even oligotrophic seawater (Jenkinson & Sun, 2010, *J. mar. Syst.*, 83: 287-297) that extra resistance to flow is caused by additional viscosity as well as elasticity caused by EPS flowing and stretching. Mostly algae and bacteria produce this EPS. Because EPS is lumpy, its viscosity and elasticity are likely length-scale-dependent.

To model how extra viscosity may reinforce pycnocline stability, (Jenkinson & Sun, 2010, *J. Plankton Res.*, 33: 373-383) we (Jenkinson & Sun, 2013, *Deep-Sea Res. II,* in press) measured flow rate vs. flow pressure (and hence wall stress) in cultures (relative to that in EPS-free reference water) in capillaries of 5 radii, 0.35 to 1.5 mm, close to ocean-turbulence Kolmogorov length. We compared cultures of five potentially harmful algae and a bacterium. Drag increase (DI), ascribed to increased viscosity by EPS, occurred in the smallest capillaries, but, surprisingly, drag reduction (DR) occurred in the largest ones. Since this occurred at Reynolds numbers *Re* too small for turbulence (or turbulent DR) to occur, this was laminar-flow DR. It may have been superhydrophobic DR (SDR), causing wall slip (Fig. 5) at the surfaces of the

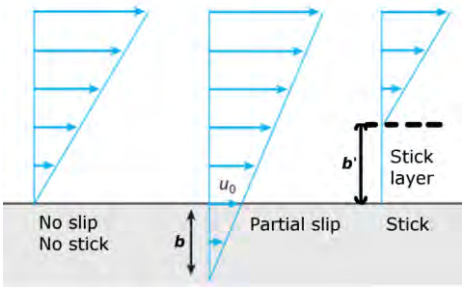

Fig. 5 Schematic diagram of slipping and sticking at a fluid-solid interface by a fluid subject to simple shearing. b is slip length; b' is sticking length; u0 is slip velocity. Adapted from Rothstein (2010, Ann. Rev. Fluid. Mech., 42: 89-209).

plankton and bacteria. SDR is associated with the self-cleaning Lotus-leaf Effect, in which water and dirt are repelled from surfaces bearing nm- to µm-sized irregularities coated with hydrophobic polymers. Conversely wall sticking, due to various mechanisms, can add a layer of no deformation at the wall. Along with rheological thickening,

laminar-flow DR and DI may represent hitherto unknown tools for plankton to manage adhesion, anti-fouling and ambient flow fields.

Advances in nano- and microfluidics since about 1990 give biogeochemists as well as microbial and plankton ecologists new engineering tools to understand many of the phenomena such phenomena at the surfaces of living and non-living particles. For the surfaces of pico- to mesoplankton (0.2 to 200 µm), we expose some recent advances in nano- and microfluidics, focussing on trophic ecology, particularly encounter dynamics and food sensing and handling.

Keywords: rheology, nano- and microfluidics, plankton ecology, biogeochemistry, modeling, material properties,

Resuspension and lateral dispersal of sediments due to shoaling internal waves

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Abstract

Cross-margin transport of suspended sediments containing nutrients from near shore areas is important for biological production in offshore sites. The breaking of internal waves contributes to resuspension and lateral transport of sediments in sloping areas. However, the details of these processes are not well understood. This study presents data from high-resolution *in-situ* surveys and a numerical model (SUNTANS) as they relate to resuspension and lateral dispersal of sediments in a sloping area due to internal waves. Observed data from tow-yo and mooring surveys show the strong sediment resuspension and the strong turbulent mixing along the sloping bottom induced by internal waves (Fig.6). Sediment resuspension reached 8 m vertically at the head of the bore wave, and suspended sediments intruded into the offshore layer, known as an intermediate nepheloid layer. Results from the numerical model forced by a first-mode internal wave show bore waves propagating along the slope similar to observed results and a vortex structure accompanied by the strong current at the head of the bore waves. This study suggests that the vortex structure generated by the breaking of

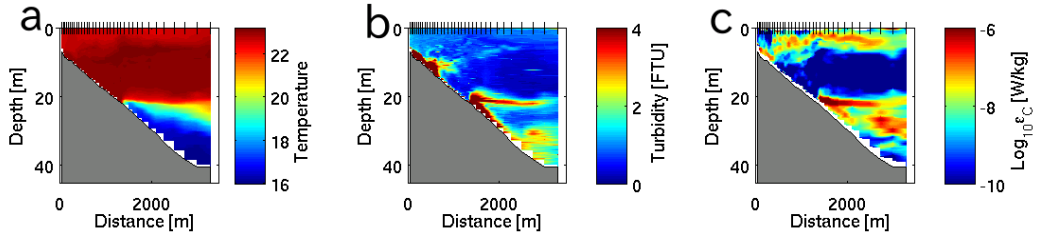

Fig. 6 Observed temperature (a), turbidity (b) and the rate of turbulent kinetic energy dissipation (c) in Otsuchi Bay, Japan when the internal wave propagates into the bay.

internal waves causes the strong sediment resuspension and contributes to cross-margin transport of deposited nutrients from the near shore to the interior of the offshore water column.

Keywords: internal wave, sediment transport, turbulence, bottom boundary layers

Forecasting ocean circulation and fishery-resource variabilities for operational use

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Abstract
Toward the clarification and forecast of new links between ocean/climate process and both biogeochemical and fishery environments, a new forecast/analysis system is currently developed as a component of the on-going national research program “Research Program on Climate Change Adaptation” (RECCA). The major goal is a high-impact application of a 4D-VAR data assimilation system for physical-biogeochemial coupled model to the stock assessment of neon flying squid in the North Pacific based on the accurate diagnosis of the spawning and feeding grounds, as well as the forecast of the potential fishing area using high-resolution model. The technical know-how obtained here can offer a future vision for an optimal fishery stock management and adaptive fishery operation with low cost and low CO_2 emission, and thereby leads to a sustainable social system through enhanced Japanese fishery activity and multi-disciplinary decision making that adapts policy to ocean and climate variations.

Keywords: data assimilation, physical-biogeochemical coupled model, neon flying squid

Modeling habitat suitability index for neon flying squid in the North Pacific by using a 3-dimensional ocean data assimilation product

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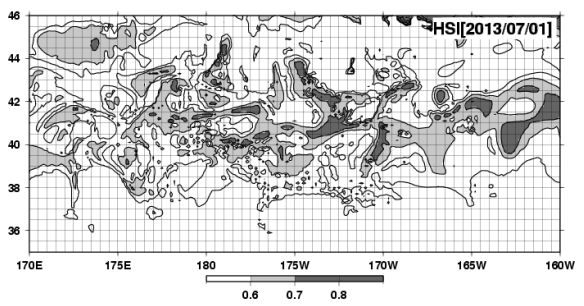

Fig.7 An example of HSI map for neon flying squid in 2013 summer.

Abstract

The neon flying squid (*Ommastrephes bartramii*) has a wide-spread distribution in subtropical and temperate waters in the world ocean. In the North Pacific, it plays an important role in the pelagic ecosystem and is one of the major targets in Japanese squid fisheries. There are two main fishing grounds for Japanese commercial vessels, that is, east of northern Japan (in detail, offshore of the Sanriku coast in northwestern North Pacific) in winter and the wide North Pacific area (35-45N) around the dateline in summer. In this study, the suitable habitat areas for both fishing grounds of the neon flying squid were investigated by using MOVE (Meteorological Research Institute multivariate ocean variational estimation) ocean data assimilation product, which can provide realistic fields of 3-dimensional ocean circulation and environmental structures including meso-scale eddies. The Japanese commercial fisheries data of neon flying squid during 2000-2010 and the MOVE datasets have been applied to the identification and characterization of possible habitat suitable areas for both fishing grounds by using a habitat suitability index (HSI) model. The results indicate that in the case of winter fishing ground, the high HSI area is likely to locate the northern edge of anti-cyclonic eddies generated in the Kuroshio-Oyashio transition zone offshore of the Sanriku coast, which suggests that the mixture of warm, nutrient-poor water in Kuroshio region and cold, nutrient-rich water in Oyashio region, and the local upwelling by meso-scale eddy activities

leads to high-productivity and subsequent suitable habitat for neon flying squid. This approach has a possibility to provide the accurate diagnosis of the fishing grounds, and thereby leads to the sustainable fishery operation with low cost and low CO_2 emission in dramatic changes in fishery resource distributions and abundance with climate change. This study is supported by the "Research Program on Climate Change Adaptation" Project (MEXT).

Keywords: neon flying squid, ocean data assimilation, habitat suitability index

Living coccolithophores in China Sea waters: Role in carbon cycle

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Abstract
We investigated the morphology, taxonomy, diversity and distribution of Living coccolithophores (LCs) in the China Sea Waters (CSW) the first time. 97 species were recorded, belonging to 4 orders, 11 families, and 44 genera. Genus *Syracosphaera* (20 species observed) presented the highest species-richness in the CSW. The overall LCs abundance in the research areas ranged from 1 to 2300 cells / ml, with an average value of 50 cells/ml. The dominant LCs species were *Gephyrocapsa oceanica, Emiliania huxleyi, Helicosphaera carteri*, and *Algirosphaera robusta*, in the order of species abundance. The total LCs abundance was highest in the East China Sea, followed by the South China Sea, Yellow Sea, Northern Yellow Sea and Bohai Sea. Seasonally, the LCs were most abundant in autumn, followed by spring, winter and summer. Temperature and nitrate concentration may be the major environmental factors controlling the distribution and species composition of LCs in the studying areas based on canonical correspondence analysis (CCA). PIC production by LCs in China Sea waters is obvious, contributing about10% total carbon production.

Keywords: living coccolithophore, carbon cycle, diversity, spatial and temporal distribution, China Seas waters

Responses of spring diatom assemblages in Oyashio waters of the western subarctic Pacific to CO_2 availability as estimated from molecular markers

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Abstract

An increase in atmospheric CO_2 concentration due primarily to the burning of fossil fuels is causing a rapid increase in seawater CO_2 level, resulting in decreases in the carbonic ion concentration and seawater pH (i.e., ocean acidification). The western subarctic Pacific, especially in the Oyashio region, is known to be one of the regions where the biological drawdown of partial pressure of CO_2 in surface waters is among the highest in the world. This is mainly due to the massive diatom blooms in spring. Although CO_2 availability is one of the important factors for controlling phytoplankton photosynthesis, it is unclear how the spring diatom assemblages in Oyashio waters can respond to the changes in CO_2 level. Therefore, we carried out an on-deck CO_2-manipulated bottle incubation experiment using surface seawater collected from Oyashio waters in the spring of 2011. Then the diatom-specific *rbcL* gene encoding the large subunit of RubisCO, the CO_2-fixing enzyme in the Calvin cycle, and a pigment maker for diatoms, fucoxanthin, were used for estimating the responses of the spring Oyashio diatoms to CO_2 availability. Diatoms and cryptophytes were predominant in the initial seawater. After 3-day incubations, chlorophyll (Chl) *a* concentrations in all CO_2 treatments (180, 350, 750 and 1000 ppm) increased from the initials, but the Chl *a* levels at 750 ppm and 1000 ppm were significantly lower than that at 180 ppm. The results indicated that the growth of the phytoplankton assemblages, which were mainly consisted of diatoms, was suppressed at the higher CO_2 levels. The copy number of diatom-specific *rbcL* gene fragments had a high correlation (R^2=0.910, n=25) with fucoxanthin concentration, suggesting that the *rbcL* gene copies can also be used for estimating the diatom abundance. A negative correlation was observed between CO_2 level and diatom-specific *rbcL* cDNA copies (R^2=0.506, n=12), indicating a decrease in the carbon fixation ability of the diatoms with an increase in CO_2 availability. The cDNA libraries of the diatom-specific *rbcL* gene fragments revealed a vulnerability of centric diatoms at the higher CO_2 levels. Overall, our results suggest that future ocean acidification can affect the photosynthetic physiology and species composition of diatoms in Oyashio waters during spring.

Keywords: ocean acidification, spring diatom bloom, *rbcL*, fucoxanthin, Oyashio

Temporal variation of picoplankton in the spring bloom of the Yellow Sea, China

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Abstract
Marine picoplankton refer to a functionally diverse group of organisms which are microscopic in size (≤2 μm in diameter), but very abundant in the marine water column. Picoplankton include cyanobacteria of the genera *Synechococcus* and *Prochlorococcus*, a great diverse assemblage of picoeukaryote and heterotrophic bacteria which do not carry out oxygenic photosynthesis. Picoplankton have drawn much research attention due to its essential role in oceanic processes such as carbon production, biomass and energy transfer. Researches focused on the distribution of picoplankton during Yellow Sea spring bloom are very limited. Temporal variation of *Synechococcus*, picoeukaryote and heterotrophic bacteria abundance and depth integrated biomass during three spring blooms in 2007 and 2009 were investigated in the Yellow Sea, China. Synechococcus and picoeukaryote responded differently to different types and course of spring blooms. During the diatom blooms of 2007 and Bloom B20 in 2009, Synechococcus and picoeukaryote abundances decreased sharply during the bloom period. However, during a mixed dinoflagellate and diatom bloom of Bloom B23 in 2009, Synechococcus and picoeukaryote increased in abundance and biomass along the bloom. During all three spring blooms, heterotrophic bacteria biomass had a similar increasing trend. Ciliate and heterotrophic nanoflagellate grazing could be responsible for Synechococcus and picoeukaryote abundance and biomass decrease during the spring blooms.

Keywords: *synechococcus*, picoeukaryote, heterotrophic bacteria, spring bloom, Yellow Sea

Picoplankton distribution in different water masses of the East China Sea in autumn and winter

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Abstract
Picoplankton distribution was investigated in different water masses of the East China Sea in November, 2006 and February, 2007. The autumn and winter cruises crossed three major water masses: the coastal water mass (CWM), the mixed water mass (MWM), which forms on the continental shelf, and the Kuroshio water mass (KWM). Picoplankton composition was resolved into four main groups by flow cytometry, namely *Synechococcus*, *Prochlorococcus*, picoeukaryotes, and heterotrophic bacteria. The average abundances of *Synechococcus*, picoeukaryotes, and heterotrophic bacteria were $(0.63 \pm 10.88)\times10^3$, $(1.61 \pm 1.16)\times10^3$, $(3.39 \pm 1.27)\times10^5$ cells/mL in autumn and $(6.45 \pm 8.60)\times10^3$, $(3.23 \pm 2.63)\times10^3$, $(3.76 \pm 1.37)\times10^5$ cells/mL in winter, respectively. *Prochlorococcus* was not found in the CWM and seldom observed in surface samples in either season. However, *Prochlorococcus* was observed in the MWM and KWM (approximately 10^3 cells/mL) in both autumn and winter. *Synechococcus* distribution varied considerably among water masses, with the highest levels in KWM and lowest levels in CWM. The depth-averaged integrated abundance of *Synechococcus* was approximately 5-fold higher in KWM than in CWM, which may be due primarily to water temperature. In the MWM, *Synechococcus* was resolved as two subgroups; the presence of both subgroups was more common in autumn. Picoeukaryote abundance varied less among water masses than *Synechococcus*, and heterotrophic bacteria depth-averaged integrated abundance exhibited the smallest seasonal variations with respect to water mass. Correlation analysis showed that relationships between picoplankton abundances and environmental factors (temperature, nutrients, and chlorophyll *a*) differed among the three water masses, suggesting that the three water masses have different effects on picoplankton distribution (particularly *Synechococcus*).

Keywords: *Synechococcus*, *Prochlorococcus*, picoeukaryotes, heterotrophic bacteria, water masses, East China Sea

Comparison of the two methods for primary production measurement.

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Abstract
We compared the primary production rates estimated by ^{14}C uptake and fast

repetition rate fluorometery (FRRF) in the Korean waters. The FRRF-derived primary production rates well correlated with the ^{14}C-based primary production rates despite the differences in methodology and time scale of the measurements (r^2=0.86, slope=1.67, p<0.001, n=23). However, the relationship between the two methods differed depending on season and place. The discrepancy between the two methods may be attributed to the responses of physiological processes (cyclic electron flow, the Mehler reaction and photorespiration) to high irradiance, and the uncertainties in the parameters such as photosynthetic unit size ($n_{PS\,II}$), photosynthetic quotient (PQ) used in the equations of FRRF-derived primary production estimation. Furthermore, the bottle effects can influence the measurements by the ^{14}C method. To check this possibility, short-term (two hours) experiments were conducted with three phytoplankton species (*Skeletonema costatum*, *Heterocapsa circularisquama*, *Coscinodiscus oculoides*) in the same way as with the ^{14}C method. Fluorescence variables were measured by using a Fluorescence Induction and Relaxation (FIRe) fluorometer at time intervals during the course of the two-hour experiments. On average, 10-20% of the primary production rates from the FIRe measurement decreased after short-term incubations under high light intensity.

Keywords: primary production rate, FRRF, ^{14}C, Korean waters

May the warm sea surface water of spawning areas of Japanese common squid in autumn contribute to the decreased survival of paralarvae and annual catch after 2000s?

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Abstract

Japanese common squid, *Todarodes pacificus* (Cephalopoda, Ommastrephidae) produce gelatinous, nearly neutrally buoyant egg masses that reside within or above the pycnocline at temperatures suitable for development. After hatching, the paralarvae ascend to the surface layer above the continental shelf and slope and are transferred into convergent frontal zones (Yamamoto *et al.* 2007). Laboratory studies reveal that hatchlings (<1 mm Mantle Length) ascend to the surface at temperatures between 18-24ºC, and especially between 19.5-23ºC (Yamamoto *et al*.,

2012). During the cool period around Japan in the late 1970s and early to late-1980s, the annual catch of *T. pacificus* decreased and only began to increase after the shift to the warm period (Sakurai *et al.* 2000). The catch is considered a good proxy for abundance and hence reproductive success. One reason for the increased paralarval survival during warm periods might be related to an increase in the size of the spawning areas (Rosa *et al.*, 2011). During cool periods there is less spawning along the continental slope and the squid are deeper due to an increased mixed layer depth caused by stronger winds. However, annual catches of *T. pacificus* are gradually decreasing after 2000s, which is thought a reason that the inferred spawning areas in autumn were covered by warm sea surface water above 24ºC. The survival of hatchlings is probably heavily affected by sea surface water above 24ºC. We will show that more warm condition of spawning areas of *T. pacificus* in autumn may contribute to the decreased survival of paralarvae and annual catch after 2000s.

Keywords: *todarodes pacificus*, spawning area, paralarvae, autumn, warm regime, SST

Chain response of microbial loop to the decay of a diatom bloom in the East China Sea

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Abstract

Algal bloom has been regarded as one of the key causes for the summer hypoxia phenomena in the bottom water adjacent to the Yangtze estuary in the East China Sea. Although a series of biological processes within microbial loop are involved in the developing course of oxygen depletion during the bloom decay, little has been known about the dynamics of microorganisms in response to the decaying process of the bloom through trophic cascade context. Here, we report some preliminary results of our observations about the chain-like response of microbial loop to the bloom decay, based on a series of onboard incubation experiments for 10 days in the East China Sea during a diatom bloom in August, 2011. In the monitoring program, a wide range of biological parameters, i.e. microalgae, fractionated chlorophyll-a (Net-, Nano-, Pico-Chl-a), cyanobacteria (CB), heterotrophic bacteria (HB), heterotrophic nanoflagellate (HNF), pigmented nanoflagellate (PNF), ciliate and virus-like-particles (VLP), as well as some environmental factors, i.e. dissolved oxygen (DO), dissolved organic mater

(DOM) and nutrients (NO_3^-, NO_2^-, PO_4^{3-}), were taking into account. In the process of bloom decay, the oxygen consumption was associated with the death of microalgae and the degradation of organic matter, to which the structure of microbial loop changed obviously. In the first step of bloom decay (0-4 days after incubation), rapid response was found in HB and ciliate growth, which was in accordance with the decrease of total Chl-a in the water column. However, compared with the rapid increase of HNF grazing rate, the increase of HNF cell density was rather inconspicuous, suggesting top-down predation pressure on HNF from ciliate or other predator at this step. In the second step (5-8 days after incubation), HB and ciliate decreased rapidly with the increase of HNF, revealing the release of HNF form ciliate predation pressure, although the grazing rate of HNF on HB declined with HB cell density. In the next step (9-10 days after incubation), the density of HNF became decrease and the density of HB increased again. However, deferent to the first step, ciliate kept decline in this step, suggesting that the decrease of HNF was not caused by the predation of ciliate but other reason, e.g. virus infection, in this step. Virus-like-particles (VLP) had been monitored in the whole process of our incubations. It was found that the importance of virus infection to microalgae and HB varied in deferent step of bloom decay. In the first step, virus infection mainly worked on the blooming microalgae, while in the second step and third step, it mostly worked on HB and HNF, respectively. According to the above observation results, it may be concluded that, in the decaying process of an algal bloom, the response of each link in microbial loop (i.e., HB, HNF, ciliate and virus) to the bloom decay has tight cascade relations, and such synergy effect should be important for the understanding of the role of microbial loop in hypoxia formation in the coastal waters.

Keywords: chain response, microbial loop, bloom decay, trophic cascade

Predator – prey interactions in planktonic food webs under changing environment

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Abstract

The planktonic food webs in marine ecosystems are complex and they play an important role in determining the carbon flux and cycling in the ocean. We have studied the various aspects of the interactions among predators and preys under different foodweb structure and environmental conditions. Here are a few recent findings: 1) Zooplankton with different feeding behaviors will cause different impacts on prey communities. Our results showed that among the 3 crustacean mesozooplankton species, *Parvocalanus crassirostris* was the most carnivorous species that caused the strongest cascading effect, which led to an increase in algal density as the rate of the cascading effect exceeded the direct consumption of algal prey by

intermediate consumers. In contrast, the marine cladoceran *Penilia avirostris* caused a decline in algal density because it was incapable of capturing the intermediate grazers, hence created no indirect positive effect on algae. *Temora turbinata* fed on ciliates and algal prey at similar rates so that the direct consumption of the algal prey was balanced by the indirect trophic cascade effect. In addition, the strength of the cascade effect induced by *Acartia erythraea* was significantly enhanced by increasing the densities of ciliates, due to a switch in feeding behavior from suspension feeding to ambush feeding. Our results imply that mesozooplankton omnivory is important in maintaining the stability of the community structure of microplankton because the effects of direct consumption and the cascading effect balanced each other due to the broad feeding strategies of predators. 2) Changes in prey cell properties affect the feeding behavior as well as growth of micro- and mesozooplankton grazers. Examples will be given on the effects cellular C:N ratio, cell size, and diatom Si content on zooplankton grazing, growth and production. These detailed predator – prey interactions further complicate the energy flow and carbon flux among microplankton food web, which is a great challenge to food web modeling.

Variation in the $\delta^{13}C$ of specific fatty acids in *Coilia mystus* during migration

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Abstract

Coilia mystus (tapertail anchovy) is a commercially important estuarine migratory species in Changjiang Estuary. In our previous study, *C. mystus* in four life stages (M1, M2, M3, M4) were collected in four seasons, respectively, and the potential diet variation of *C. mystus* during migration was suggested by the changes in bulk $\delta^{13}C$, $\delta^{15}N$ values and fatty acid composition of the dorsal muscle. However, some prey information of *C. mystus* indicated by the fatty acid composition can't be verified by the bulk $\delta^{13}C$. So, $\delta^{13}C$ values of specific fatty acids (FA-$\delta^{13}C$) in the *C. mystus* samples were analyzed with GC-C-IRMS, to investigate the FA-$\delta^{13}C$ values of the fish during its migration, and to reveal the dominant influencing factor of the FA-$\delta^{13}C$. According to the result, FA-$\delta^{13}C$ of fish in four life stages were all depleted compared to the bulk $\delta^{13}C$. The difference between the FA-$\delta^{13}C$ and bulk $\delta^{13}C$ was largest in *C. mystus* in M4, which ranged from -8.7‰ to -15.6‰. *C. mystus* samples can be divided into three groups (group M1, group M2+M3 and group M4) based on the cluster analysis of FA-$\delta^{13}C$. The FA-$\delta^{13}C$ character of the three groups was significantly different (ANOSIM, R=0.984, p=0.001). Those in M1 were the most depleted in the FA-$\delta^{13}C$, consistent with the character of bulk $\delta^{13}C$. Change of the FA-$\delta^{13}C$ of *C. mystus* during migration was specific for different fatty acid. There were significant differences in the $\delta^{13}C$ values of 17:0 (ANOVA, F=40.142, p=0.000) and 18:2n-6 (ANOVA, F=38.195, p=0.000) among the four stages, indicating that the

sources of 17:0 and 18:2n-6 in the fish were variable. The depleted $\delta^{13}C$ values of 17:0 and 18:2n-6 further indicated that terrigenous organic matter also contributed to the *C. mystus* in M4, which didn't be proposed with the bulk $\delta^{13}C$. The $\delta^{13}C$ values of 17:0 and 18:2n-6 were not different significantly ($p>0.05$). Considering the individuals in M2 and M3 were collected in the same region but in different seasons, the result indicated that season and life stage are not important factors affecting the $\delta^{13}C$ of the two fatty acids. Instead, the primary carbon source relative to the habitat is the key factor determining the $\delta^{13}C$ values of 17:0 and 18:2n-6. $\delta^{13}C$ of 16:1n-7 and PUFAs (20:4n-6, 20:5n-3, 22:6n-3) of individuals in M1 were significantly lower than those in other stages ($p<0.01$), but the change degree was comparatively smaller than 17:0 and 18:2n-6. Life stage seems to be an important factor to the $\delta^{13}C$ of PUFAs. Based on the preliminary study, two conclusions can be made. 1. changes of the FA-$\delta^{13}C$ values of *C. mystus* during its migration were very complicated; 2. dominant controlling factor for the FA-$\delta^{13}C$ was variable. Further study is needed to explicate the change character of FA-$\delta^{13}C$ in migratory fish.

Keywords: compound specific stable carbon isotope, fatty acid, *Coilia mystus*, migration

Understanding the food web dynamics of Yellow Sea ecosystem: the role of *Euphausia pacifica* using multi-approaches

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Abstract

Euphausia pacifica play a key role to transfer the energy to higher trophic level and maintain the function and structure of Yellow Sea ecosystem because of their abundance and high biomass. Although understanding their feeding ecology is necessary to accurately elucidate the structure and function of the Yellow Sea ecosystem, very limited information is available on their feeding ecology and behavior through the season. Therefore, we applied multiple approaches (*in-situ* feeding experiments, gut content analysis, trophic biomarkers,

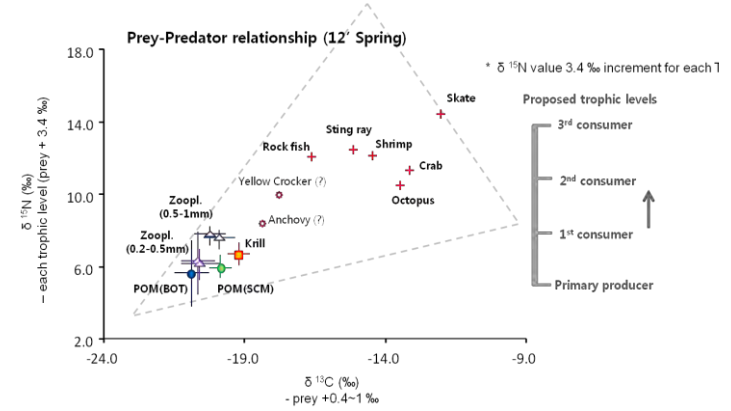

Fig. 8 C & N stable isotopic ratios of sampled organisms (from POM to predators) provide food web structures (prey-predator relationship).

etc.) to track the source of nutrient and diets of *E. pacifica* during spring and summer in the Yellow Sea. According to the gut content and trophic biomarker analysis, diets of *E. pacifica* were seasonally shifted from algal-based particles (i.e., diatom) to microbial-based particles (i.e., detritus, protozoa) as season progress. However, the preliminary results of *in-situ* feeding experiments suggest that adult *E. pacifica* seems to preferentially feed on ciliates and heterotrophic dinoflagellates among natural diet assemblages during spring algal blooms even though a large amount of other food items (diatoms, autotrophic dinoflagellates, *etc.*) were available. Therefore, more careful approaches and further experiements will be required to better understand the role of *E. pacifica* in the Yellow Sea ecosystem.

Keywords: *Euphausia pacifica*, Yellow Sea ecosystem, food web dynamics, feeding experiments, trophic biomarkers, gut contents

Influence of river discharge on phytoplankton absorption properties: A case study in the East China Sea and Tsushima Strait

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Abstract

To investigate the influence of fresh water on phytoplankton absorption properties, the phytoplankton absorption coefficient and pigments identified by high-performance liquid chromatography (HPLC) were measured at the surface and subsurface chlorophyll *a* maximum (SCM) in the East China Sea (ECS), which is highly influenced by river discharge from the Changjiang during summer. For comparison, data were also collected in the Tsushima Strait (TS) at the surface and SCM. The majority of ECS surface samples taken from the low-salinity Changjiang diluted water (CDW), and even most of SCM samples taken from waters beneath the CDW, displayed significant freshwater influences. The specific absorption coefficient normalized by total

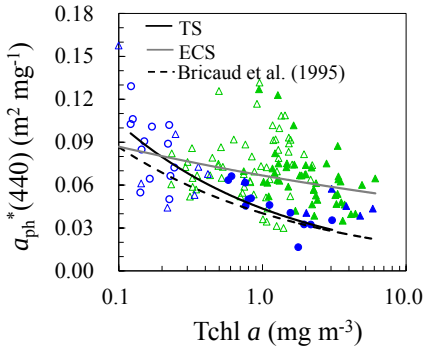

Fig. 9 $a_{ph}^*(440)$ versus Tchl *a*. The circle and triangle are samples from the TS and ECS, respectively. Green and blue symbols are samples with a surface salinity lower and greater than 32, respectively. Unfilled and filled symbols stand for samples from

chlorophyll *a* concentration (Tchl *a*), $a_{ph}^{*}(\lambda)$, of these samples was substantially higher than values derived from global regressions between $a_{ph}^{*}(\lambda)$ and the Tchl *a*. Using the pigment data derived from HPLC, the increase of $a_{ph}^{*}(\lambda)$ was found to be mainly caused by the phytoplankton size structure, which indicated that both surface and SCM samples in the ECS still incorporated considerable portions of pico-phytoplankton (cyanobacteria), even though the Tchl *a* was high. When water from the surface and the SCM were merged, variations in the phytoplankton size-fractions and $a_{ph}^{*}(\lambda)$ versus Tchl-a that were consistent with values for the global ocean were found in the TS but not in the ECS. Data for the ECS indicated that there was no correlation between Tchl-a and the size-fraction or total pigment absorption. As a consequence, $a_{ph}^{*}(\lambda)$ was poorly correlated with Tchl *a* and displayed large variability within a small Tchl *a* range. These findings suggest the need for care when considering the changing patterns of size-fractions versus Tchl *a* and the relationship between $a_{ph}^{*}(\lambda)$ and Tchl *a* in coastal regions that are significantly influenced by fresh water.

Keywords: Phytoplankton absorption, Packaging effect, Pigment composition, East China Sea, Tsushima Strait, Changjiang fresh water

Diet composition dynamics in relation to the Omega-3 fatty acid of Bali Sardine (*Sardinella lemuru*) in Bali Strait

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Abstract

Study on the dynamics of diet composition of Bali sardine (*Sardinella lemuru*) in related to Omega-3 was conducted at Bali Strait in two fishing seasons (transition-2 and the northwest monsoon) in 2013. Results showed that, there is a relationship between plankton abundance in water and fish stomach for both seasons, with R^2=0.9254 ($P<0.05$). Phytoplankton was dominant in water

Fig. 10. *Sardinella lemuru* of Bali Strait, Indonesia.

(99%) and fish stomach (98%) during transition-2. While zooplankton was dominant during northwest monsoon, 51% and 83% for water and fish stomach, respectively. Electivity index indicated that *A. bidentata, A. thrinex, C. karsteni, C. fusus, Coscinodiscus sp, R. alata,* and *Cyclopoid sp* be the main food choice for *S. lemuru* during transition-2, while nauplius *Herpacticoid, P. norvegica, P. Parvus,* and *R. alata* be the main food during northwest monsoon. Omega-3 fatty acid of *Sardinella lemuru* meat was found higher in transition-2 than that in northeast monsoon, i.e. 25.6% and 14.9%, respectively. It may be due to higher phytoplankton than zooplankton in fish diet during transition-2, and vice versa. This study may provide valuable information about the fishing season of *S. lemuru* that contain high omega-3 for human consumption, possibly contributing to proper management of the fishery of *Sardinella lemuru* in Bali Strait.

Keywords: diet composition, *Sardinella lemuru*, omega-3 fatty acid, plankton, fishing season.

Ecosystem responses to anthropogenic and natural forcings over the past 100 years in the coastal areas of the East China Sea elucidated from biomarkers

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Abstract

The ecosystem of the coastal areas of the East China Sea (ECS) has experienced obvious changes during the past 30 years, which were commonly attributed to anthropogenic disturbances. However, it is a challenge to distinguish between the influences of anthropogenic activities and climate changes due to the lack of high resolution data, both temporally and spatially. We report TOC and biomarker (dinosterol and brassicasterol) data of five box cores (CJ43, DH5-1, #32, #34, DH6-3) from the coastal area of the ECS, which afford phytoplankton productivity and community structure records at decadal-scale resolution for the last 100 years. The temporal and spatial variations of these biomarker records provide one approach to assess the ecosystem responses to anthropogenic and climate forcings during the past 100 years in this region.

Phytoplankton productivity in all cores increased during the last 50 years, but community structure as indicated by the dinoflagellate/diatom ratio shows different trends. Biomarker records in cores DH5-1 and CJ43 collected near

the Changjiang Estuary reveal an increase in the dinoflagellate/diatom ratio during the past 50 years, which could be related to increased DIN and reduced silicate inputs from the Changjiang River, providing conditions more favorable for dinoflagellate growth. In contrast, the dinoflagellate/diatom ratio has decreased during the past 30 years in cores #32, #34 and DH6-3 further away from the Changjiang Estuary in the south, suggesting limited influence of the Changjiang water but an increased impact of coastal upwelling on these sites. For these sites, strengthened upwelling can transport high silicate bottom water to the surface, providing conditions more favorable for diatom growth. Therefore, both anthropogenic activities and climate-driven coastal upwelling have contributed to increased productivities, but these two forcing mechanisms have resulted in contrasting community structure changes at different sites in the coastal area of the ECS.

Keywords: the East China Sea, biomarkers, community structure, Changjiang River, coastal upwelling

The role of Kuroshio on the food-web structure and fisheries production off Japan: Introduction of SKED project

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Abstract
Kuroshio is a warm western boundary current of the North Pacific flowing along Taiwan, Rhukyu Islands and Japan. In spite of low-nutrient concentration of Kuroshio water, the Kuroshio region is an important spawning/nursery ground of various fish species and also a good fishing ground. In order to understand the mechanisms of high fisheries productivity from oligotrophic condition, i.e., Kuroshio Paradox, and find a way for sustainable use of the ecosystem services, we started a research project: Study of Kuroshio Ecosystem Dynamics for Sustainable Fisheries (SKED), from October 2011. We SKED scientists are investigating the structure and dynamics of the Kuroshio Ecosystem by means of field observation, satellite remote sensing and mathematical modeling. One of the main themes of the SKED is what physical processes supply nutrients to the euphotic zone. In the presentation, I will introduce the background and research plan of the project and obtained results in the first years.

Keywords: Kuroshio, SKED, nutrients, ecosystem

Dissemination of potential fishing zone prediction map of Japanese common squid in the coastal waters, southwestern Hokkaido, Japan

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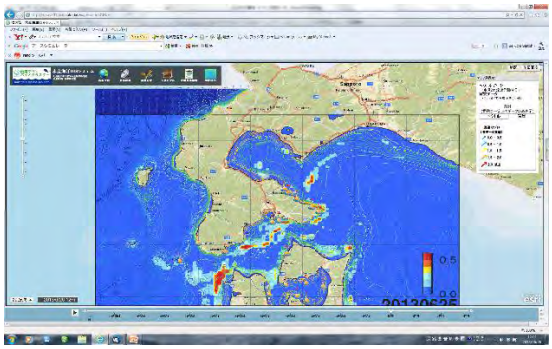

Fig.11 Sample image of PFZ prediction map on Web

Abstract

Japanese common squid (*Todarodes pacificus*) is of high commercial importance for Japanese fisheries, and there is an increasing concern for its conservation in recent decades. To understand the mechanisms behind this species spatial and temporal distribution, we evaluated fisheries data derived from Meteorological Satellite Program/Operational Linescan System (DMSP/OLS) to represent locations of the daily presence and absence of squid aggregations. Combined with model-derived environmental factors from the 4D-VAR data assimilation system, we investigated the correlation between squid distributions and various environmental factors in different water depths. Bathymetry and other habitat factors which had close correlations were applied to predict daily potential fishing zones (PFZ) using habitat suitability index (HSI) model coupled with presence/absence squid fishing aggregation database. Validations based on an independent dataset showed a better performance of the model predictions of squid aggregations than our previous model, which was established with satellite-derived environmental data. Additionally, the model-derived data can provide future predictions without weather restrictions. With the assistance of local fishery associations, we facilitate local fishing activities with our models. Our four-day prediction map (Fig. 11) was delivered to fishermen every day from July in 2013 to help their selecting fishing positions. We examined performance of our prediction model in comparison between NPP/VRIIS night light images and PFZ maps. We will present the effect of environmental factors on Japanese common squid distribution and share

information of applications of PFZ modeling. This study is supported in part by the “Hakodate Marine Bio Cluster Project”(MEXT).

Keywords: *Todarodes pacificus*, prediction map, potential fishing zone, habitat suitability index, 4D-VAR

Impacts of climate change on suitable region for Japanese scallop aquaculture in Dalian, China and Funka Bay, Japan, using GIS-Based model and satellite remote sensing.

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Abstract

Climate changes and human activities affect coastal environments and aquaculture, threatening food security and economic growth. Japanese scallop (*Mizuhopecten yessoensis*) culture is economically important to coastal communities in Funka Bay, Japan and Dalian, China (Fig.12). Therefore, this study was conducted to identify the most suitable regions for hanging culture of Japanese scallop in these two areas using geographic information system (GIS)-based models and satellite remote sensing data. The biophysical parameters such as sea temperature, chlorophyll, suspended sediment concentration and bathymetry were derived from the MODIS data. The social-infrastructural parameters such as distance to town, pier and farm and constraint parameters including harbor, area near town and river mouth were extracting from ALOS AVNIR-2 images. Suitability scores were ranked on a scale from 1 (least suitable) to 8 (most suitable). Suitable zones in the two regions combined with extreme weather events [El Niño/La Niña-Southern Oscillation (ENSO) events, the winter East Asian Monsoon (EAM), and Arctic Oscillation (AO)] were used to examine the impacts of climate events on regional coastal environments and scallop aquaculture. Results suggested that the EAM strongly affected the aquaculture areas via winds in Dalian. The suitable area increased significantly during strong EAM in years 2006 and 2011. Conversely, the area suitable for scallop aquaculture in Funka Bay significantly decreased during a strong El Niño year (2009–2010). During the strong AO negative phase, the region of Dalian was significantly influenced by cold temperatures.

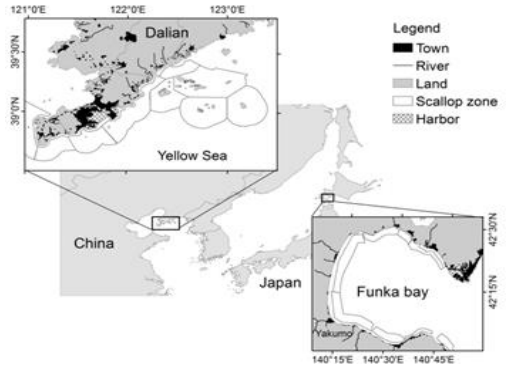

Fig. 12 Study area in Dalian and Funka Bay

Keywords: Dalian, Funka Bay, GIS, Japanese scallop, site selection, remote sensing

Fisheries management under species alternation from the aspectt of regional economy and food security.

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Abstract

The increase of Japanese pilchard (*Sardinops melanostictus*) in the 1980s and the sudden collapse in the early 1990s revealed the difficulty of fisheries management under the species alternation phenomena. Purse seiners are mainly regulated by the limitation of the number of vessels, but rapid increase of Japanese pilchard motivated purse seiners to go through the regulation by enlarging the transport ships. After the disapeearence of Japanese pillchard in the early 1990s, purse seiners suffered from their overcapacity and large debt. Some of them retired their business by scrapping their ships supported by government fundings. Others weathered their crisis by severe exploitation of the strong year classes of chub mackerel (*Scomber japonicus*) in the 1990s. Their behavior is considered to prevent the recovery of chub meckrel stock in the 1990s.

How we can manage the fishery which harvest the pelagic species flucuating largely? We tried to answer this challenge from the aspect of local community and food security. We examined how we can protect the strong year classes of chub mackerel severely by retrospective analysis. We made four management options for the regulation of new bessel construction and preventing the overfishing of the strong year class of chub mackerel.. 1) Governement responsibly scraped their ships by the public funds, after the decline of Japanese pillchard,. 2) Government restricted the construction of new vessels by govenmental order. 3) Government imposed the landing tax per catch (2 yen per kg) to control the investment for new ships. 4) Government introduced ITQ (individual transferable quota) system for promoting the self-adjustment of the number of purse seiners. We compared the several advanateges and disadvanateges of these options. We also conducted Input-Output analysis and evaluate and the negative impact to regional economy by introducing these options. Finally, we examined the contributions to food security when these options succeeded in helping the recovery of chub mackerel stock. Option 1 required to government to spend a lot of money, but Japanese fishing industry can fully utilize Japanese pillchard stock. The advantage of option 2 is that government do not spend any money for structural adjustment, but it is difficult that governemtn persuades fishers. The merit of option 3 is that government use the collected landing tax for scrapping the surplus ships. But its demerit is the restriction of the landings gives the largest negative impact to local economy among four options. The

disadvantage of ITQ system (Option 4) is that the expected price of ITQ is too low to compensate for the excesive fishers, so government have to pay the additional funding for scrapping ships. It is estimated that all options contributes to the recovery of chub mackrel and push up food self-sufficiency rate of seafood by 2%.

Keyword: fisheries management, Japanese pillchard, purse seiner, management options, regional economy, food security

POSTER PRESENTATIONS

The internal tides and ecosystem dynamics around Oshima Island: A preliminary study

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Abstract

It has been observed that the shelf break and ridge are area of enhanced biology productivity. Oshima Island located south of Japan is one of the islands that are situated on the Izu Ridge. The Izu Ridge itself is a submarine ridge with sloping bottom elongated southward and well known as a significant generation region of semidiurnal internal tides. This semidiurnal internal tides generated at the northern part of the Izu Ridge were found propagates to Sagami Bay.

In this study, we employed the Stanford Unstructured Non-hydrostatic Terrain-Following Adaptive Navier-Stokes Simulator (SUNTANS) (Fringer et al. 2006) to simulate internal tides in regions of steeply sloping topography near Oshima Island. Using this high-resolution, coastal following and non-hydrostatic model, we were not only able to simulate the internal tides, but also study the generation, propagation and dissipation mechanisms through the large model domain including Sagami Bay and Tokyo Bay.

Here we found that there are two physical processes that exert strong controls on the generation of internal tides near the Oshima Island (1) the internal tide energy concentration due to an effective ray reflection at the Izu Ridge sloping bottom and (2) the barotropic tidal currents over the slope that acts as generator of internal tides. The internal tide climate is likely to be dominated by any internal waves generated via interaction between barotropic tidal flow and bottom topography of the Izu Ridge. In the future, our study will then focus on the understanding of possible interactions between primary production, distribution and internal tides. With supported by new ecosystem model and high-resolution planktonic data from laser imaging fluorometer instrument. Subsequently, we will couple this ecosystem model with SUNTANS model to provide the information on the ecosystem dynamics around Oshima Island.

Keywords: Izu Ridge, internal tides, numerical model, ecosystem model, ecosystem dynamics.

A first step towards modeling the impact of the 2011 Tōhoku earthquake and tsunami on estuary dynamics in Ōtsuchi Bay, Japan

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Abstract
The marine ecosystem in Ōtsuchi Bay (Iwate Prefecture, Japan) was severely damaged by the tsunami generated by the 2011 Tōhoku earthquake. Sediment loss and rubble deposits are just a few examples that have changed the estuarial dynamics of the bay. As part of a multidisciplinary project, the Tōhoku Ecosystem–Associated Marine Sciences (TEAMS), the effects of and changes to turbulent mixing in the estuary are being studied to aid in the recovery and revival of the marine ecosystem and coastal industry. Here, early efforts to model the internal waves and sediment resuspension in the bay using an unstructured, nonhydrostatic ocean model (SUNTANS) will be discussed. In addition, high-resolution observational profiles, used to validate the model, will also be presented.

Keywords: turbulent mixing, internal waves, nonhydrostatic mixing, tsunami

Rapid acidification rates in the western North Pacific subarctic region, offshore Sanriku area

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Abstract
Recently, ocean acidification has become of great concern by influence on marine organisms and ecosystems and consequent impacts on fishery and sightseeing which depend heavily on marine resources and services. Regional acidification trends as well as the global acidification trend are important for evaluation of these impacts and projection of the future. In this study, we estimated the acidification trend in the western North Pacific subarctic region, offshore Sanriku area, by using observed pCO_2 and estimated total alkalinity. The pCO_2 data were taken from SOCAT V2 database and recent observations by Japan Meteorological Agency (Fig. 13).

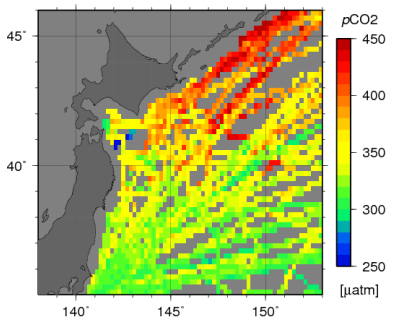

Fig. 13 Winter averaged pCO_2 map

The total alkalinity data were estimated by the novel method using sea surface dynamic height and sea surface salinity.

The pH and aragonite saturation rate (Ωarg) in this region have decreasing trends with high interannual and subannual variability (Fig. 14). The Ωarg

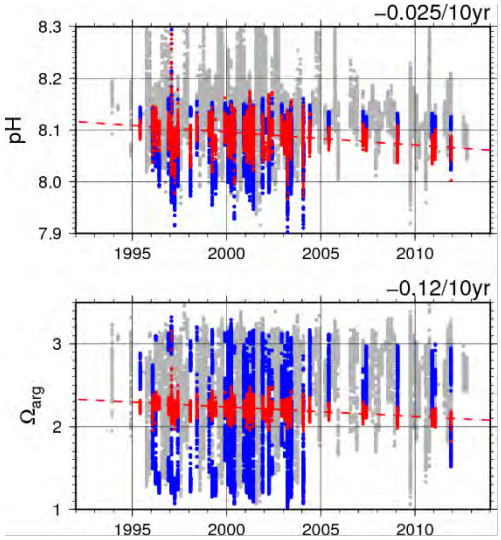

Fig. 14 Time series representations pH and Ωarg in the region offshore Sanriku (Gray: all data, Blue: winter, Red: normalized winter)

drops down to nearly 1 in winter. The calculated decreasing rates are −0.025 ± 0.001 /10yr for pH and −0.12 ± 0.00 /10yr for Ωarg in winter (Dec.-Mar.). From spring to autumn, large variability of pH and Ωarg due to high biological activity were observed, which prevented calculating significant trends. We corrected this biological disturbance with satellite chlorophyll-*a* concentrations and then calculated trends for pH and Ωarg. Significant decreasing trends (−0.030 ± 0.001 /10yr in pH and −0.14 ± 0.00 /10yr in Ωarg) were calculated as well. Both trends were indistinguishable from the winter ones. Decreasing trends in this region are larger (more rapid acidification) than those in subtropical western North Pacific.

Keywords: Ocean acidification, Long-term trend, Subarctic, SOCAT

Quasi-horizontal observations of biophysical phenomena in the base of the mixed layer

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Abstract

Evidence that waveform structures in the density field at the base of the mixed layer are correlated with an increased phytoplankton concentration is presented here in a quasi-horizontal perspective (Fig. 15). We carried out a field experiment near Jogashima, Japan, using a new tethered quasi-horizontal microstructure profiler: TurboMAP-Glider (TMG). The TMG is a unique instrument, capable of measuring ocean microstructure (temperature and turbulent velocity shear), chlorophyll and turbidity simultaneously. We used the

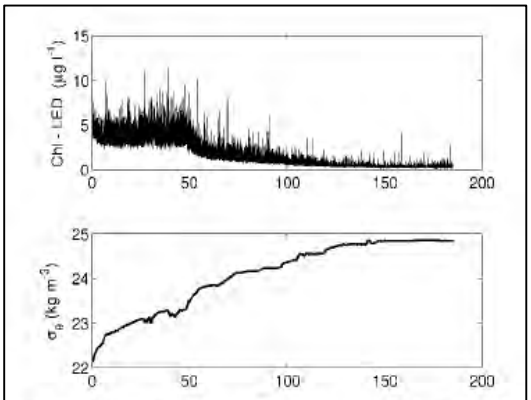

Fig.15Chlorophyll measured by a Light Emitting Diode (LED) fluorescence sensor (upper panel) and potential density anomaly (σ_θ) during a single TMG deployment (lower panel).

ratio between the Thorpe length scale and the Ozmidov length scale as a tracer to demonstrate that waveform structures are probably due to horizontal inhomogeneity of the density field and are likely caused by internal waves. The TMG makes high-resolution measurements of the chlorophyll-a distribution at the base of the mixed layer, where hydrodynamic shear, often linked to phenomena such as the Kelvin-Helmholtz instability and the Holmboe instability, can disrupt the vertical migration of phytoplankton at the base of the mixed layer.

Keywords: phytoplankton, mixed layer, shear-driven hydrodynamics, internal waves

Intensive mixing along an island chain controls oceanic biogeochemical cycles

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Abstract

In the oceanic region, the present export of organic matter is large enough to deplete the thermocline of nutrient within less than 60 years [Sarmiento and Gruber, 2006]. The return process of nutrients from the deep ocean to the thermocline is thus critical for maintaining biological productivity and formation of the high-nutrient low-chlorophyll (HNLC) region. However, the physical processes explaining the upward transport of macro- and micro-nutrients from the meso-pelagic layer to the surface have not been clearly identified. The subarctic Pacific is a HNLC region in which phytoplankton growth is broadly limited by iron (Fe) availability. It has been observed that even with Fe limitation, the western subarctic Pacific (WSP) has effective phytoplankton growth and more seasonality in lower trophic levels. Therefore, differences in the Fe supply processes must explain the decrease in seasonal phytoplankton growth that is seen from west to east. Fe flux in the WSP should fall to a “moderate” value that is higher than the eastern side, yet not sufficient to cause nutrient depletion. Although we recognize several Fe supply processes in the WSP, the mechanisms that control the “moderate” value have not been explained. Here we demonstrate the

pivotal role of tidal mixing at the Kuril Island chain (KIC) for determining the "moderate" value. A basin scale Fe section clearly showed that sedimentary Fe is discharged from a sub-polar marginal sea to the western North Pacific in the intermediate layer. The re-distribution of the Fe-rich intermediate water by intensive mixing, which occurs in the pass of the KIC, is the predominant process for determining the ratio of micro- to macro-nutrients in the subsurface. This ratio can quantitatively explain the differences in surface macro-nutrient consumption between the western and eastern subarctic, as well as the formation of the HNLC region in the North Pacific. Our results provide observational evidence that the strong vertical tidal mixing in the island chain, which is located at the margin of the Pacific Ocean, plays a pivotal role in transporting Fe and nutrients from deep water to the surface. The natural Fe fertilizing system, including the mixing at the KIC, simultaneously explains one of the largest biological pumps [Buesseler et al., 2007] in the world and the formation of the HNLC region in the North Pacific [Tsuda et al., 2003; Boyd et al., 2004].

Plant-herbivory interaction under acidified ocean

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Abstract

Rising CO_2 mediated ocean acidification (OA) together with climate change and global warming alters the availability of carbon to the marine environment and lead to large variations in carbon-nutrient-ratios in marine macrophytes. This high atmospheric CO_2 partly sequestered by global ocean will probably enrich coastal seaweeds with carbon but suppress nutrient availability to herbivores. Nutritional quality of food for mesograzers will alter in response to the changes of high carbon-nutrient ratio in marine seaweeds. These processes potentially influence marine benthic ecosystems on all hierarchical levels from cells to communities. Intensive research has been made on the impact of OA on marine biota in order to predict future implications for food web dynamics and other ecosystem processes. My M.Sc-thesis addresses (1) the direct effects of OA on the growth and metabolism of the coastal seaweed, *Fucus vesiculosus* and (2) functional responses of the dominant herbivore, *Idotea baltica*, to the potentially altered nutritional quality of the seaweed. In laboratory perturbation experiments, fragments of *F. vesiculosus* were exposed for 4 weeks to two different CO_2 scenarios. Experimental CO_2 levels of 280 ppm (pre-industrial atmospheric level) and 700 ppm (IPCC projection for the year 2100) respectively, were adjusted by incubation of seawater with pre-mixed gases. Biomass of *F. vesiculosus* was monitored throughout the experiments. Nutritional quality was measured by analyzing C, N, P and ash content of the *F. vesiculosus* tissues. Herbivore responses were measured in terms of ingestion rates, assimilation efficiency and respiration. Results

indicate that growth of *F. vesiculosus* is negatively affected under acidified conditions. Elemental composition of algae remains similar in both pCO_2 manipulations. Consumption rates, assimilation efficiency and respiration did not differ significantly between *I. baltica* that has been feeding on algal fragments from different CO_2 treatments. From the experimental evidence it can be conclude that, reduced growth of primary producers along with unchanged grazing rates under higher CO_2 condition might negatively affect seaweed populations with potential implications for entire benthic communities. The direct effects of OA on marine macroalgae might not propagate through higher trophic levels.

A novel approach for modeling spatial variability of phytoplankton in oceanic ecosystem

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Abstract

The measurement of phytoplankton distributions in ocean ecosystems provides the basis for the elucidation of the influences of physical process on plankton dynamics. Technological advances allow for the measurement of phytoplankton data to greater resolution. High resolution data displays high spatial variability. How it changes with depth is shown in figure 16 (a, b) which was observed at the mouth of Tokyo bay, Japan on June 18, 2011. This figure shows the fluorescence microstructure measurement simultaneously detected by Niskin bottle (red), SeaPoint (black), LED (blue) sensor and LASER (green) sensor.

For theoretical understanding of plankton dynamics and addressing various questions, several models, starting from very simple to highly complex, have been developed over the last few decades. In conventional mathematical models, the mean value of the measured variable is

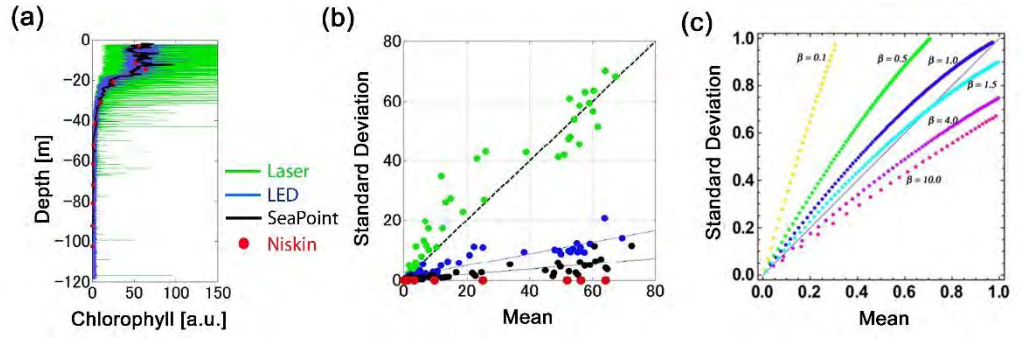

Fig. 16 (a)Examples of fluorescence microstructure measurement by Niskin bottle (red), SeaPoint (black), LED (blue) sensor and LASER (green) at different depths from the ocean surface at the mouth of Tokyo bay, Japan. (b) Mean and standard deviation of chlorophyll signals by the four sampling methods. (c) Mean and standard deviation of phytoplankton by varying a single parameter as obtained from closure model.

approximated in order to compare with the model output. This approximation may misinterpret the actual scenario of planktonic ecosystems, especially when we look at the system at micro-scale level. To consider intermittency of variables, in this work, we have applied a new modeling approach to the planktonic ecosystem, called the closure approach which has been widely used in Physical Ocean modelling. In this approach, the variables are divided into mean and fluctuating parts, and the fluctuating parts are considered to be new variables of the system. By taking the spatial average of the equations of motions we get the closure equations which are then solved to see the effect of fluctuation on the mean variables.

Using the closure approach for a simple nutrient-phytoplankton model in this theoretical study, we have shown how consideration of the fluctuating part of a model variable can affect the system dynamics. Also we have found a critical value of one model-parameter (which depends on fluctuating terms) below which the conventional non-closure model and the mean value from the closure model exhibit the same result. Therefore, this analysis gives an impression about the importance of the fluctuating part of model variables and also an idea when to use closure approach for model formulation. Figure 1(c) shows the plot of mean versus standard deviation of phytoplankton at different depths as obtained using this new modeling approach which gives good conformity to this approach.

Keywords: mathematical model, closure approach, phytoplankton, nutrient, micro-scale measurement

Distribution of neutral sugar and its compositions as indicators of matter degradation state in the East China Sea surface sediments

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Abstract
Neutral sugar (NS) is a kind of the most abundant constituents of organic matter. Its abundance and composition in sediments have important implications for understanding the sources, degradation states and other biogeochemical processes. In this paper, total organic matter (TOC) and NS were determined in the surface sediments samples collected from the East China Sea (ESC) in 2010, and NS abundance and its components in indicating sources and degradation states of organic matter were also discussed. Results showed that the TOC in the surface sediments of the ECS ranged from 66.8 to 1441.7 μmol/g, with an average value of 409.4 ± 55.2 μmol/g, and the NS in this area ranged from 0.40~4.87 μmol/g, with an average value of 3.07 ± 0.31 μmol/g, while the neutral sugars mole%C yields of TOC ranged from 1.88% to 8.93%.

Generally, TOC and NS had the similar spacial distribution trends, which were high in the coast and low in the open sea, high in the south of ECS and low in the north of ECS. And with the increasing grain sizes of the sediments, the contents of TOC and NS decreased and the mole yield of glucose (Glc) increased, while the mole yield of galactose (Gla), mannose (Man) and xylose (Xyl) decreased，which indicated the degradation states become obviously. Moreover, we found that the ratio of Mol% (Glc+Fuc) / Mol% (Gal+Ara) could be used as an indicator to estimate the degradation state of organic matter. The degradation degree of organic matter increased with the decrease of the ratio of Mol% (Glc+Fuc) / Mol% (Gal+Ara) .

Keywords: East China Sea, surface sediments, total organic matter, neutral sugars, biodegradation

Distribution of dissolved iron in the East China Sea during summer

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The distribution and variability of dissolved iron in the surface water of the East China Sea was examined with respect to concurrent physical and biogeochemical observations including macronutrient concentrations during cruises conducted in summer. At stations southwest of the Cheju, we observed depletions of nitrate and phosphate in the water column down to ca. 30 m depth, where a sharp subsurface chlorophyll maximum was developed just above the nitracline. In spite of the strong vertical gradient observed in the macronutrients and phytoplankton chlorophyll biomass at the base of the euphotic zone, concentrations of dissolved iron at the subsurface layers showed a nearly constant vertical distribution or a slight increasing pattern with depth. Consistently high dissolved iron concentrations, around 1 nM, in the water column suggest that availability of macronutrients is the primary factor controlling phytoplankton production in the euphotic zone and there is a sufficient iron supply to the central part of the East China Sea. The dissolved iron concentrations in the surface water were 0.4–0.5 nM at stations near the southern edge of the East China Sea continental shelf, and 0.6–0.9 nM at the eastern edge of the continental shelf. These relatively high concentrations in the offshore regions could be the result of organic complexation of dissolved iron by natural organic ligands, and more information is, thus, needed on the iron complexation and physic-chemical speciation in seawater of the East China Sea.

Keywords: iron, nutrients, East China Sea

Alkaline phosphatase activity in Tokyo Bay

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Abstract

Tokyo Bay is characterized as an enclosed system and a highly eutrophic area. Recently, concentration of dissolved inorganic phosphorus (DIP) in surface water of this bay has been reduced. DIP may thus potentially limit phytoplankton growth in the eutrophic Tokyo Bay. Phytoplankton generally utilize DIP as orthophosphate, however, under DIP-depleted conditions, phytoplankton utilize P from dissolved organic phosphorus (DOP) using an alkaline phosphatase (AP), together with bacteria. The present study investigated temporal variation in alkaline phosphatase activity (APA) in the inner part of Tokyo Bay in order to understand recent P cycling there. Water samples for APA assay were monthly collected at 0 and 20 m of stations F3 (35°30.42'N, 139°49.48'E) and F6 (35°25.12'N, 139°47.48'E) during November 2012 to August 2013. The samples were filtered by using 0.2, 0.7, and 190 μm pore-sized filters to examine APA among different size fractions. APA in each filtrate was assayed by a fluorometric method with excess addition of 4-methylumbelliferyl-phosphate (200 μmol L^{-1}). APA data obtained from this method mean maximum potential rates of APA. We defined that APA in the size fractions of <0.2 μm, 0.2-0.7 μm, and 0.7-190 μm roughly corresponds to dissolved component, bacteria, and phytoplankton, respectively. Total APA (sum of three fractions) at 0 and 20 m of both stations ranged from <2 to 2117 nmol L^{-1} h^{-1} throughout the study period. APA in phytoplankton fraction generally showed high contributions to the total APA in the water column throughout the seasons (73±32%), following that in dissolved component (17±31%) and bacteria (10±17%). The total APA was generally higher at 0 m than 20 m, and reached to peaks at 0m of both F3 (2117 nmol L^{-1} h^{-1}) and F6 (144 nmol L^{-1} h^{-1}) in July. These summer peaks were 2 to 3 orders of magnitude higher than other APA data. According to the previous APA data in the inner part of Tokyo Bay, a maximum potential APA also showed peaks at 0 m during summer. However, the present APA at 0 m in July was 2 orders of magnitude higher than APA at 0 m in summer of 1970s, suggesting that DIP limitation of phytoplankton growth has considerably appeared in recent years. In this symposium, we will discuss the relationships between APA and environmental parameters such as DIP concentration and phytoplankton biomass.

Keywords: alkaline phosphatase, phosphorus, temporal variation, Tokyo Bay

Numerical simulation of giant jellyfish *Nemopilema nomurai* population dynamics in East China Sea

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Abstract
In East China Sea, blooms of giant jellyfish *Nemopilema nomurai* have become increasingly frequent in recent years (i.e. in 2006, 2007, 2009, 2012). To understand the relationship between physical environment and jellyfish bloom, an individual-based model of *Nemopilema nomurai* is developed, coupled with a hydrodynamic model (POM) and a lower trophic level ecosystem model (NEMURO). Seasonal variations of circulation, water temperature and mix-layer depth from POM are used as external forcing for NEMURO and the jellyfish model. Biomass of large zooplankton (i.e. Copepoda) which jellyfish mainly feeds on is output from NEMURO and is controlled by the consumption of jellyfish on them. The growth, development, strobilation and death of jellyfish are simulated. Result of the simulation agrees well with observations. The model provides a tool for future study of jellyfish population dynamics.

Keywords: giant jellyfish, East China Sea, individual-based model

The impacts of climate events on aquaculture site-selection model for Japanese kelp (*Saccharina japonica*) in southern Hokkaido, Japan

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Abstract
Japanese kelp (*Saccharina japonica*) is one of the most valuable cultured and harvested kelp species in Japan. In this study, we added a physical parameter, sea surface nitrate (SSN) estimated from satellite remote sensing data, to develop a suitable aquaculture site-selection model (SASSM) for hanging cultures of Japanese kelp in southern Hokkaido, Japan (Fig.17). The local algorithm to

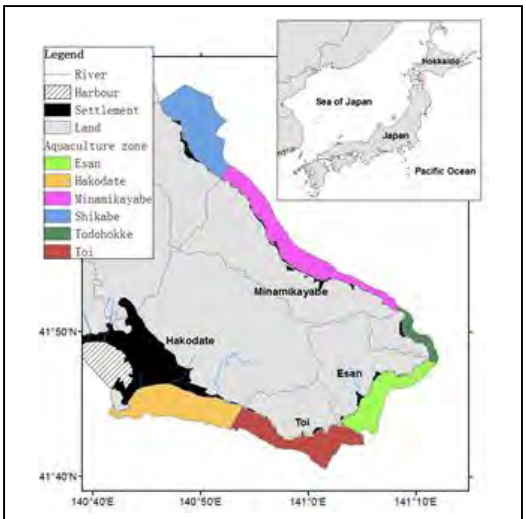

Fig. 17 Study area in Funka Bay

estimate SSN was developed using satellite measurements of sea surface temperature and chlorophyll-a. We found a high correlation between satellite- and ship-measured data (r^2 = 0.87, RMSE = 1.39). Multi-criteria evaluation was adapted to the SASSM to rank sites on a scale of 1 (least suitable) to 8 (most suitable). We found that 64.4% of the areas were suitable (score above 7). Minamikayabe was identified as the most suitable area, and Funka Bay also contained potential aquaculture sites. In addition, we examined the impact of El Niño/La Niña–Southern Oscillation (ENSO) events on Japanese kelp aquaculture and site suitability from 2003 to 2010. During El Niño events, the number of suitable areas (scores 7 and 8) decreased significantly, indicating that climatic conditions should be considered for future development of marine aquaculture.

Keywords: ENSO, Japanese kelp, SASSM, satellite remote sensing, sea surface nitrate.

Grazing and viral lysis on autotrophic nano- and picoplankton and heterotrophic bacteria in the Otsuchi Bay

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Abstract
Protist grazing and viral lysis are now known to be the major mortality factors of planktonic microbes in marine environments. Theory has indicated that whether microbial production is mainly consumed by protists or lysed by viruses has strikingly different ecological and biogeochemical consequences. However, our knowledge regarding the relative importance of protist grazing and viral lysis as mortality forces of autotrophic and heterotrophic microbes in coastal waters is severely limited, hampering a better understanding of the structure and function of microbial food webs in coastal environments. This study investigated the relative importance of grazing and viral lysis as mortality factors of autotrophic pico/nanoplankton and heterotrophic bacteria in the Otsuchi Bay, a productive embayment located at the Tsunami-damaged Sanriku coast, Japan, in order to gain insights into principal pathways of energy and nutrient

flows within microbial food webs.

Seawater samples were collected from a depth of 5 m at a pelagic site of the Otsuchi Bay in September 2012. A modified dilution method was used to evaluate simultaneously the grazing pressure and viral lysis on the major microbial groups (autotrophic picoplankton including *Synechococcus* and *Prochlorococcus*, autotrophic eukaryotic nanoplankton, and heterotrophic bacteria) discriminated by flow cytometry. We found that protist grazing was a major cause of mortality for autotrophic pico- and nanoplankton, whereas we failed to detect significant impact of viral lysis on these microbes. In contrast, both protists and viruses were important agents for heterotrophic bacterial mortality. Ciliate grazing appeared to exert cascading effects on microbial dynamics. Our results demonstrate that grazing and viral lysis exert different mortality pressure on different microbial groups.

Keywords: protist grazing, viral lysis, dilution technique, coastal marine environments

Relationships of interannual variability in SST and phytoplankton blooms with giant jellyfish (*Nemopilema nomurai*) outbreaks in the Yellow Sea and East China Sea

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Abstract

Giant jellyfish (*Nemopilema nomurai*) outbreaks in relation to satellite sea surface temperature (SST) and chlorophyll-*a* concentrations (Chl-*a*) were investigated in the Yellow Sea and East China Sea (YECS) from 1998 to 2010. Temperature, eutrophication, and match–mismatch hypotheses were examined to explain long-term increases and recent relaxations of *N. nomurai* outbreaks. We focused on the timing of SST reaching 15°C, a critical temperature enabling polyps to induce strobilation and allowing released ephyra to grow. We analyzed the relationship of the timing with interannual variability of SST, Chl-*a*, and the timing of phytoplankton blooms. Differences in environmental characteristics among pre-jellyfish years (1998–2001), jellyfish years (2002–2007, 2009), and non-jellyfish years (2008, 2010) were assessed on this basis. The SST during late spring and early summer increased significantly from 1985 to 2007. This indicated that high SST is beneficial to the long-term increases in jellyfish outbreaks. SST was significantly lower in non-jellyfish years than in jellyfish years, suggesting that low SST might reduce

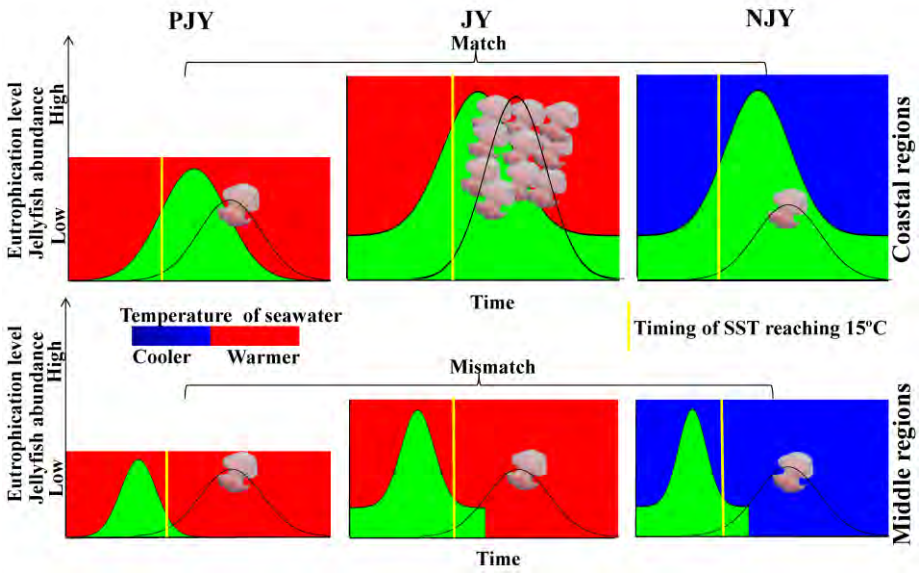

Fig. 18 Conceptual diagram of the temporal relationship between jellyfish outbreaks and environmental variables

the proliferation of *N. nomurai*. We identified three (winter, spring, and summer) major phytoplankton bloom regions and one summer Chl-*a* decline region. Both Chl-*a* during non-blooming periods and the peak increased significantly from 1998 to 2010 in most of the YECS. This result indicates that eutrophication is beneficial to the long-term increases in jellyfish outbreaks. Timing of phytoplankton blooms varied interannually and spatially, and their match and mismatch to the timing of SST reaching 15°C was not corresponded to the long-term increases in *N. nomurai* outbreaks and the recent absence.

Keywords: interannual variability, SST, satellite chlorophyll, jellyfish, outbreak

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