ISSN 0503-1540

Tome 29 *Decembre* *1991* Numéro 4

La mer

うみ

Proceedings of the French-Japanese Workshop
for Ocean Flux Studies

1991 年 12 月

日 仏 海 洋 学 会

La Société franco-japonaise
d'océanographie
Tokyo, Japon

Note pour la présentation des manuscrits

La mer, organe de la Société franco-japonaise d'océanographie, publie des articles et notes originaux, des articles de synthèse, des analyses d'ouvrages et des informations intéressant les membres de la société. Les sujets traités doivent avoir un rapport direct avec l'océanographie générale, ainsi qu'avec les sciences halieutiques.

Les manuscrits doivent être présentés avec un double, et dactylographiés, en *double interligne*, et au recto exclusivement, sur du papier blanc de format A4 (21×29,7 cm). Les tableaux et les légendes des figures seront regroupés respectivement sur des feuilles séparées à la fin du manuscrit.

Le manuscrit devra être présenté sous la forme suivante:

1° Il sera écrit en japonais, français ou anglais. Dans le cadre des articles originaux, il comprendra toujours le résumé en anglais ou français de *200 mots* environs. Pour les textes en langues européennes, il faudra joindre en plus le résumé en japonais de *500 lettres* environs. Si le manuscrit est envoyé par un non-japonophone, le comité sera responsable de la rédaction de ce résumé.

2° La présentation des articles devra être la même que dans les numéros récents; le nom de l'auteur précédé du prénom *en entier*, en minuscules; les symboles et abréviations standards autorisés par le comité; les citations bibliographiques seront faites selon le mode de publication: article dans une revue, partie d'un livre, livre entier, etc.

3° Les figures ou dessins originaux devront être parfaitement nettes en vue de la réduction nécessaire. La réduction sera faite dans le format 14,5×20,0 cm.

La première épreuve seule sera envoyée à l'auteur pour la correction.

Les membres de la Société peuvent publier 7 pages imprimées sans frais d'impression dans la mesure à leur manuscrit qui ne demande pas de frais d'impression excessifs (pour des photos couleurs, par exemple). Dans les autres cas, y compris la présentation d'un non-membre, tous les frais seront à la charge de l'auteur.

Cinquante tirés-à-part peuvent être fournis par article aux auteurs à titre gratuit. On peut en fournir aussi un plus grand nombre sur demande, par 50 exemplaires.

Les manuscrits devront être adressés directement au directeur de publication de la Société: M. MURANO, Université des Pêches de Tokyo, Konan 4-5-7, Minato-ku, Tokyo, 108 Japon; ou bien au rédacteur étranger le plus proche: H. J. CECCALDI, EPHE, Station marine d'Endoume, rue Batterie-des-Lions, 13007 Marseille, France; E. D. GOLDBERG, Scripps Institution of Oceanography, La Jolla, California 92093, Etats-Unis; T. ICHIYE, Department of Oceanography, Texas A & M University, College Station, Texas 77843, Etats-Unis; ou T. R. PARSONS, Department of Oceanography, University of British Columbia, Vancouver, B. C. V6T 1W5, Canada.

Proceedings of the French-Japanese Workshop for Ocean Flux Study

organized by

Maison franco-japonaise
Ocean Research Institute, University of Tokyo
Société franco-japonaise d'Océanographie

special contribution by
CNRS - ORSTOM - IFREMER (France)

Maison Franco-Japonaise-Tokyo
25-27 Novermber 1991

La mer 29; 133-134, 1991
Société franco-japonaise d'océanographie, Tokyo

Foreword

Hubert J. CECCALDI

Ecological equilibrium of the planet depends on the physical, chemical and biological interactions established between continents, atmosphere and the surface of the oceans.

We have to increase our knowledge in each of these three fields, because, as other living organisms, we, men, are belonging to all the biogeochemical cycles who exist in the planet.

One of the most important field where we need better knowledge is the ocean because it regulates all the life of the planet, directly and indirectly, by the way of water, carbon dioxide, methane, oxygen, salts, dusts, etc.

Future mankind cannot survive without a good knowledge of these exchanges, because the number of men is increasing progressively, exponentially and their consumption of natural elements increases in the same time. On the other hand, the surface of the planet becomes more and more artificial, and we need to know the normal processes linked to the natural life, as well as possible.

One of the first problems to be resolved by the scientists is to know if the sea water composition have a stable composition at a historical scale, or even at a geological scale, or if its composition varies, following what rules.

Continental erosion represents the main source of mineral matter contained and dissolved in natural sea water. Other sources are the particles transported by the wind, the ashes produced by volcanoes and the submarine hydrothermalism.

Generally, one considers the oceans as a system in dynamic equilibrium, where the input of foreign substances is compensated by the sedimentation processes. Ocean consitutes a natural reservoir well mixed if one considers its renewal at the scale of one million years.

The deepest water masses reached roughly an age of 1600 years. This means that the renewal of water have been realized 600 times within the last million years.

There is a dynamic equilibrium of all elements dissolved in the sea water masses, each element staying a certain period of time into the sea water.

This observation leads us to the concept of *residence time* of the elements in the sea water.

All our mesures seem to indicate that the mean composition of the sea water have not varied too much since the origin of the ocean. Biogeochemical processes have not varied to a large extent. Some living phylums exist without change since very long periods.

But when the life appears within the ocean, the living organisms have used the most abundant elements who were present into the sea; and these elements played a fundamental role on the marine life.

Salinity of sea water seems to have not evolved very much since a very long time, as the marine organisms does not survive very long when the salinity increases beyond the actual normal salinity of sea water.

On the other hand, we have shown that the residence time of different elements in the sea depends on their position in the Mendeliev Table; and also that the elements contained in the living matter of the marine organisms have also a proportional repartition and a proportional biological residence time of the elements constituting the total salinity of the oceans.

Lastly, it is absolutely necessary that de-

tailed researches will be developed in the study on natural fluxes of all elements, especially the metallic ones, in order to begin to understand the true impact of pollutions, and their role within the natural marine environment. From a dynamic point of view, the huge increase of number of mondial population, as well as the great increase in the use of the coastal areas lead us to acquire fundamental data in that field.

The major aim of the reseach program on oceanic flux consisits to understand the main factors directing carbon and other element fluxes playing a specfic role in natural waters, where living organims are present.

Among the most important countries dealing with oceanographic researches, France and Japan are between the most concerned by the results of such a program.

A privileged cooperation has been organised in that field, between French scientists and Japanese specialists, in the frame of cooperative scientific meetings of Maison franco-japonaise. Several scientific meetings occurs, almost every year, in different fields: aquaculture, artificial reefs, red tides, physical oceanography, microbiology, quality of coastal waters, resource management, use and conflicts of coastal areas, remote sensing, biological recruitement among the most important topics.

This meeting on Ocean Fluxes gathered the most promient specialists on the subject, on the French side as well as on Japanese side. It has been really fruitful, as the national programs of the two countries have been ex-amined and studied in detail, as the level of the exchanges has been very high, and as the planning of the future meetings has been decided.

I would like to thank particularly Professor IIYAMA Toshimichi, of Chiba University, Scientific advisor of Maison franco-japonaise, Dr. NOZAKI Yoshiyuki and Dr. KOIKE Isao, of Ocean Research Institute of the University of Tokyo and Dr. ARUGA Yusho, of Tokyo University of Fisheries, President of Société franco-japonaise d'Océanographie.

I am very confident that the future cooperation between the two delegations will be very fruitful, at sea as well as in laboratories especially if they are integrated in larger international terms.

I am proud that Maison franco-japonaise and the two Sociétés franco-japonaises d'Océanographie, in France as well as in Japan, have played a significant role in the organization of such an efficient meeting.

(Maison Franco Japonise, 3, kanda Surugadai 2-chome, Tokyo, 101 Japan)

La mer 29: 135, 1991
Société franco-japonaise d'océanographie, Tokyo

Long term variability of the CO_2 cycle (Abstract)

Jean-Claude DUPLESSY*

Analysis of air bubbles trapped in ice cores indicates that the CO_2 concentration was smaller during cold periods than under warm interglacials. Under those long time scales, the atomospheric CO_2 concentration is slave of the ocean chemistry and circulation. We describe first the experimental evidences for changes in the ocean circulation and chemistry during the last 150,000 years, derived from stable isotope and AMS C-14 analysis of deep sea sediment cores. Using a simple ocean box-model, we explore then the impact of the major oceanic changes which occurred during the last glacial maximum on the CO_2 cycle:

−reduced NADW formation,
−enhanced Intermediate North Atlantic wate formation,
−enhanced flux of Antarctic Bottom Water,
−enhanced productivity of the ocean, including the Southern Ocean,
−changes in the $CaCO_3$ vs Organic Matter ratio in the new production.

Model simulations show that the observed atmospheric CO_2 concentration variations during glacial conditions cannot be explained only by these mechanisms if the modern oceanic production, which is used as a reference, is correctly estimated. Beyond a reevaluation of the modern oceanic productivity, additional mechanisms should be investigated, such as variations of the Redfield ratio or a better utilization of the oceanic nutrients under glacial conditions.

* CNRS, Centre des Faibles Radioactivites

La mer 29: 136-138, 1991
Société franco-japonaise d'océanographie, Tokyo

French activities related to JGOFS

Guy JACQUES*

In 1989, the CNRS started the France-JGOFS Programme managed by a Scientific Committee and an Inter-Agency Committee. France-JGOFS develops three main types of operations :

1) processes studies in oceanic oligotrophic areas.

• *Eumeli* (1991-93) in the tropical oligotrophic area on the 20° N latitude is related to the North Atlantic Spring Bloom Experiment. With four research cruises of 45 days each in the period 1991-92, *Eumeli* involves a greater part of the french sediment-traps as well as an important material mobilisation.

• *Antares* (1992-95) will be focused on carbon and silicon cycles in three main subsystems: the Permanently Open Oceanic Zone, the Seasonal Ice Zone and the Polar Front Zone.

2) flux studis in high gradient transitional marine areas.

These operations are managed to reduce the time scale of observations and to focuse on key period in the production cycle:

• *Ecomarge* aims to quantify the carbon stored along the continental margins close to the french marine costs, with an emphasis on the exchanges at the water-sediment interface.

• *Frontal* try to know if the frontal systems are areas of increased vertical fluxes. During the 1991-93 period, *Frontal* will emphasize the study the Alméria-Oran frontal system in the Mediterranean Sea.

3) long term monitoring based upon multi-instrumented mooring stations

The three sites are selected in areas of easy access by coastal vessels in order to carry out regular transects and frequent examination of moored apparatus; in Ligurian Sea (1990), in the Gulf of Lions (1991) and in the Indian sector of the Southern Ocean (1992).

The french community is focused on a series of process studies:

Air Sea exchanges

Measuring and modelling the biogeochemical processes of air/sea fluxes of CO_2, sulfur compounds and organic material (aerosols).

Upper Ocean processes

Parametriation of the processes controlling the production in oligotrophic systems

The aim is to build a model of the main processes governing the exportation of C based on the physical forcing and the physiological behavior of algae. The ultimate goal is to drive the model with the pigment concentration in the upper layer as remotely detectable by an ocean color sensor.

Open ocean nitrogen cycling

The focus will be to study in detail nitrogen cycling in the euphotic zone of oligotrophic systems using ^{15}N-isotope tracer methodology and measurement of nitrate at nanomolecular levels.

Interactions and transfert rates in the microbial loop

Two main goals have to be solved : to determine the role of microzooplankton in the organic material transfer towards the

*Scientific Secretary of France - JGOFS Programme

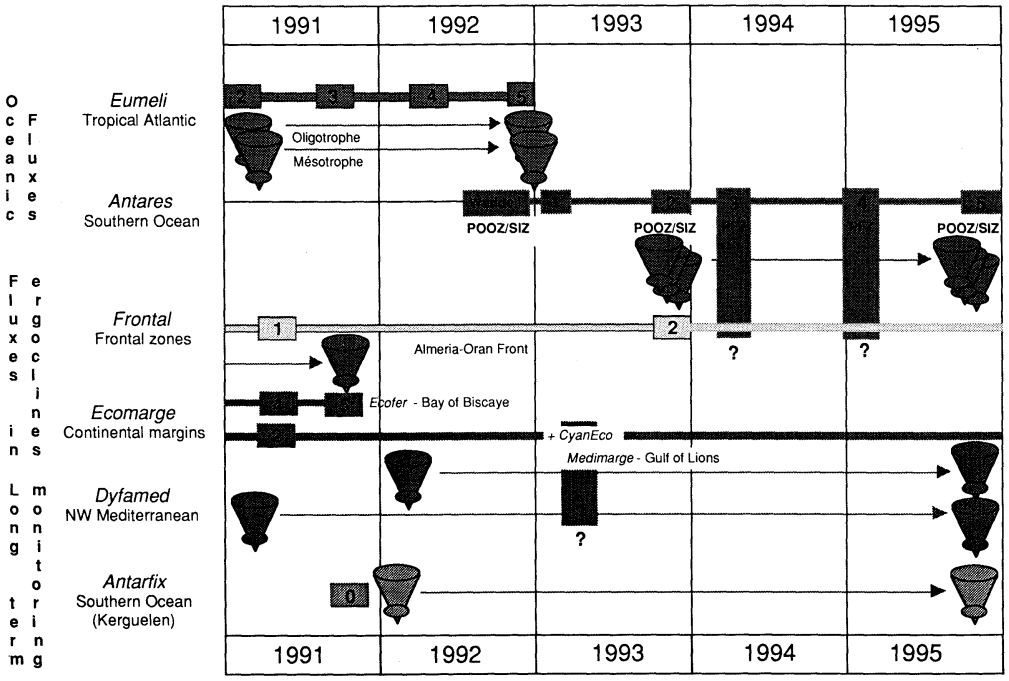


Fig 1

upper trophic levels and to estimate the respective production by ciliates of settling pellets and of non settling pellets.

Transformations and fluxes in the water column

Interactions between DOM-aggregates / micro-organims and zooplankton

The analysis of selected organic tracers could improve our knowledge about the respective roles of various types of organisms from the microorganisms to the macrozooplankton. Emphasis will be placed on the fate of organic material by the way of "gelatinous zooplank-ton", an efficient mucus producer.

Microbial activity

The evaluation of the DOM pool able to be uptaked by microorganisms (assimilation/ mineralization) will be done using an original experimental approach by microcosm simulating *in situ* conditons now under development.

Benthic processes

Particle fluxes and processes in the nepheloid layer

The different processes involved in the recycling of particles arriving at the sea floor must be examined as well as the quantification of their fluxes. A strategy of long term sea floor observations has been developped in order to display periods of deposition and periods of resuspension.

Spatial distribution: role of deep sea megafauna

Knowing the vertical particulate organic carbon input and in conjunction with estimate nutrition rates of deposit feeders, we try to strike the balance of nutritive requirements at the water sediment interface for dominant deep sea communities.

Modelling

Special attention is given to simulation and prediction of the biogeochemical cycles as the ultimate objective is to predict the

evolution of biogeochemical dynamic resulting from climate variability and other perturbatons of the system.

The french community is developping models coupling the dynamics of the system and the conservation of the biogeochemical species. These models are combined with a series of process-specific models:

Coupling physical and biological models on a seasonal time-scale.

Air-sea gas exchange.

Inverse models in steady state regime.

Ligh／photosynthesis relationships with geochemical and cimatological implications.

New and regenerated production.

N- and P- cycles.

Biogeochemical cycle of the organic sulfur compounds.

Zooplankton feeding

Biogenic transport in surface and deep marine waters.

Organic biomarkers to investigate transformation processes of organic matter.

Chemical fluxes at the sedimen-twater interfaces.

Biogeochemical processes at the sediment-water interface.

Biogeochemical benthic compartment.

La mer 29: 139, 1991
Société franco-japonaise d'océanographie, Tokyo

Japanese contribution to IGBP and JGOFS-MESC

Isao KOIKE* and Nobuhiko HANDA**

Within the span of a single human generaton at present, the earth's environment is changing more rapidly than it has been encountered in any period of human history. Much of this change may be due to the rapid development of economics and technology in the world-wide scale and may give considerable effects on the generations to come, however we know only little of such change at present. To understand and predict the change of the earth environment more precisely, the special committee for the International Geosphere and Biosphere Program (IGBP) identified seven established core projects, three proposed projects ant two potential core projects until march, 1991.

After extensive discussions by the scientific groups within the Japanese Council of Scientific Union, the council adopted to send the recommendation concerning the Japanese Plan of IGPB (International Geosphere and Biosphere Program) to the Japanese Government in July of 1990. The Japanese Government distributed this recommendation to each of the governmental ministries and agencies, of which eleven responded to participate this program. Research projects recommended by JCSU are as follows;

1) Global Change in Almospheric Trace Gases and its Interaction with Biosphere
2) Biogeochemical Cycle and Primary Productivity in the Ocean
3) Climate change and Terrestrial Ecosystem
4) Modelling of Climate Change with Special Reference of the Interaction between Atmosphere, Hydrosphere and Biosphere
5) Monitoring of Global Change
6) Past Global Change
7) Interaction between Global Change and Human Activity

Based on this recommendation, the Ministry of Education, Science and Culture (MESC) initiated to start making own plan for IGBP by the planning committee for IGBP under the umbrella of the Science Council of MESC. The council adopted following recommendation and decided to start IGBP-MESC from the fiscal year of 1992 if it is financed.

1) Atmospheric Trace Gased and Terrestrial Ecosystem
2) Geochemical Cycle and Marine Ecology
3) Terrestrial Ecosystem and Water Cycle
4) Modelling of Climate Change
5) Monitoring of Global Change
6) Past Global Change
7) Interaction between Global Change and Human Activity

* Ocean Research Institute, University of Tokyo, 1-15-1, Minamidai, Nakano-ku, Tokyo, 164 Japan
** Water Research Institute, Nagoya University, Chikusa-ku, Nagoya, 464-01 Japan

La mer 29: 140-143, 1991
Société franco-japonaise d'océanographie, Tokyo

JARE-The Sea Ice Ecology and Flux Study (SIEFS Program, 1991-1994)

Yasuhiko NAITO* and Mitsuo FUKUCHI**

During the last decade several international programs of the Southern Ocean biology, such as BIOMASS, were strongly promoted and biological information has increased remarkably. Nevertheless, our knowledge of sea ice biology in this region is still scarce and limited. The biological process characterized by the prominent seasonal variation and sea ice is unique, and significance of the sea ice study is increasing in relation to recent concerns on the global change.

Taking above into consideration, Scientific Committee on Antarctic Research (SCAR) established a new specialist group "Group of specialist Southern Ocean Ecology". The new group identified the urgent need of developing a coordinated multidisciplinary research program to investigate how the Antarctic sea ice and it's dynamics influence the marine biological process, ecosystem and matter cycling. The group held two workshops on "Ecology of Antarctic Sea Ice Zone" and noted that the exisitng Southern Ocean JGOFS (SOJGOFS) program, one of the SCAR-IGBP programs, is an important component of the group's program.

In parallel with the SCAR-SOJGOFS developement, Japanese IGBP program was also formalized in several disciplines. The Japanese National Committee for IGBP was established as a special committee of the Science Council of Japan. Among seven marine research working groups issued by Special Committee of IGBP, the marine process working group "Matter cycling and biological production in the ocean" recognized the important role of the polar regions in the global environmental change. The research item of "Biological processes and matter cycling in polar region" was included as one of five main items.

Concurrently, the Japanaese National Committee for JGOFS was also formally established as subcommittee of the Liaison Committee for Oceanic Research of the Science Council of Japan. While the Japanese JGOFS is focusing its main interests into western North Pacific Ocean, the Polar region is also recognized as an important JGOFS related research area.

In accordance with above activities, Japanese Research Expedition (JARE) developed a new program Sea Ice Ecology and Flux Study (SIEFS) which aims to understand the biological process of this unique biosphere. In the program along wiht the biological and ecological studies, the flux study will be conducted as a major part of Southern Ocean JGOFS. SIEFS starts from 1991/1992 season as five years program of JARE. During the first three years the program will be conducted through a year at Syowa Station area where first ice prevails.

The Antarctic sea ice play important roles in the Antarctic marine biological process and ecosystem. The sea ice cover the vast area of the Southern Ocean and it extends and retreats seasonally (16×10^6 6km^2 at maximum and 2.5×10^6 6 km^2 at minimum, ZWALLY *et al.*, 1979). Sea ice gives important habitat to many organisms and, a unique ice biota is formed within and just beneath ice. Ice algae is known as dominant organisms among the ice biota. In the brine socket of sea ice, many micro-organisms are found and Antarctic krill strongly graze on the ice algae and others within ice biota during the

*Natinal Institute of Polar Research
9-10, Kaga 1-chome, Itabashi-ku, Tokyo, 173 Japan

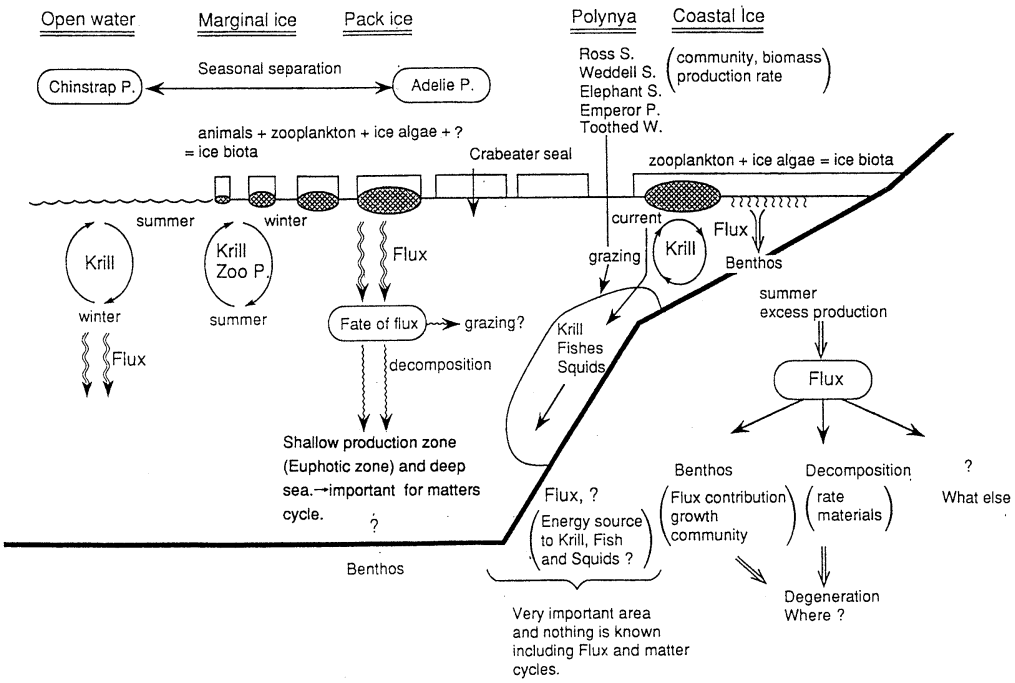


Fig. 1. In relation to ice condition and geographical topography, Antarctic sea ice area is sperated into the pack ice area, the coastal polynya area and the fast ice area and schematic zones are given.

winter season (MARSCHALL, 1988). Not only such smaller organisms but larger predators such as penguins and seals have strongly association with ice. They either rest and breed on it or forage beneath ice.

As well as sea ice, prominent seasonal variation of the solar radiation also influence the Antarctic marine process and ecosystems. Strong solar radiation in summer and poor in winter make large difference in primary production between both season and give unique overwintering strategies to the higher producers. The seasonal variation is more prominent in higher latitude. In general, fast ice develops in the coastal water within the coastal shelf zone and pack ice extends toward north from fast ice. The coastal polynya develops frequently between the fast ice and the pack ice area where shelf break or shelf zone are found. As shown in figure 1, different schematic zone is given in relation to sea ice, bottom topography and oceanographic features in the Southern Ocean and features of the biological process and ecosystem are different between these zones.

In the coastal zone, ice algae contribute to the primary production more than the primary production in the water column (WATANABE and SATOH, 1987). Released algae in summer when ice melts sank to bottom as the excess production. The fate of these flux, mostly ice algae is unknown, however primary production seems to linked directly to the benthos. The biomass of the benthos in this area is very high (NUMANAMI *et al.*, 1986). In winter, almost nothing of primary production occurs in this area (Fig. 2), and the Antarctic krill (*Euphausia superba*) feed on detritus on the bottom (KAWAGUCHI *et al.*, 1986).

Ice algae grow in the pack ice zone and become major component of the flux. However, it is not certain when and how ice algae of in pack ice is released and grazed. The facts we know is that the Antarctic krill feed on the ice algae and some others

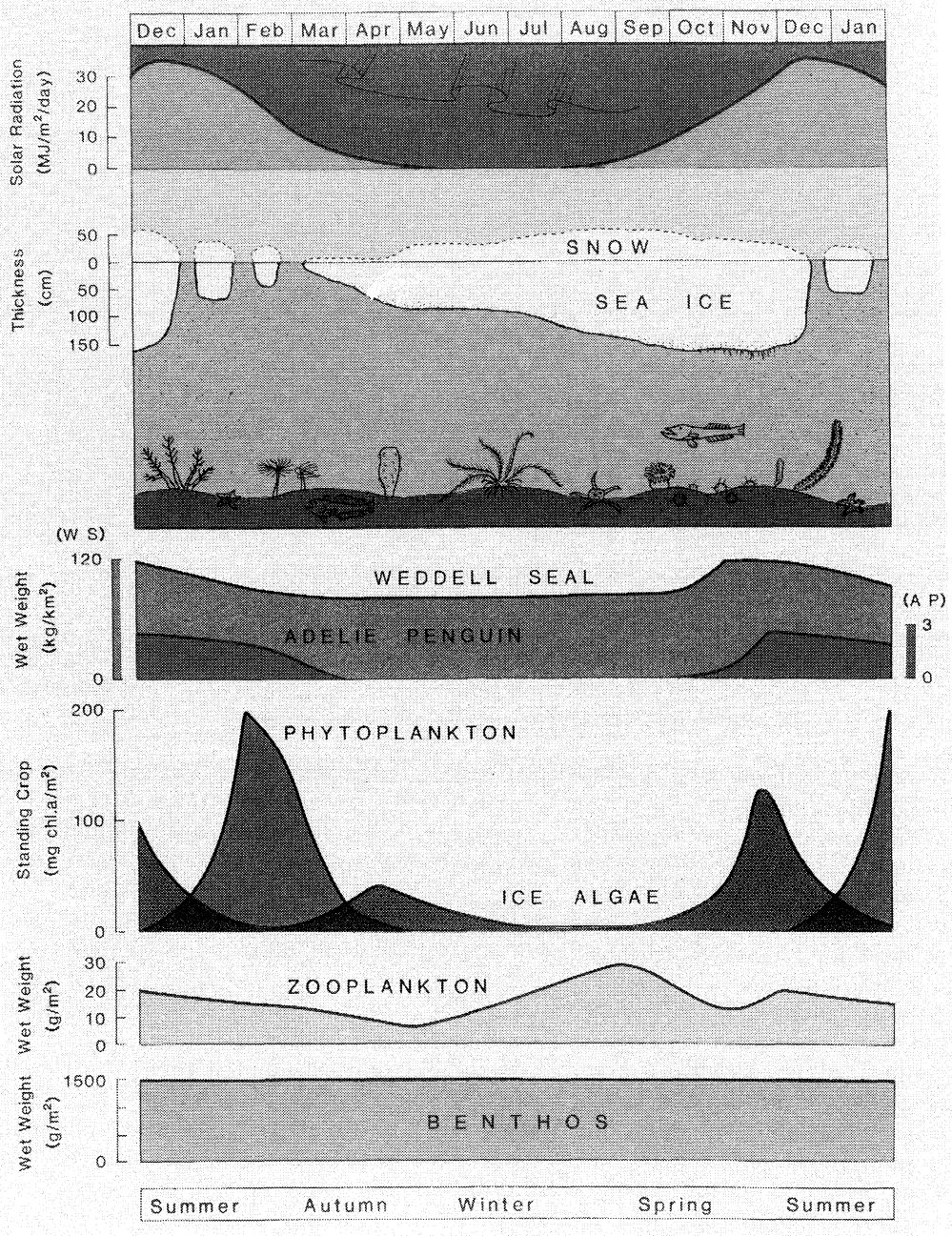


Fig. 2. Seasonal variation of solar radiation influences the biomass of the marine organisms.

beneath the ice during winter (MARSCHALL, 1988) and Adelie penguin and crabeater seal, of which diet is the krill, are distributed within the pack ice while some penguins do not come into the pack ice zone (AINLEY and DEMASTER, 1990). In summer the pack ice retreat and primary production increase in water column in the pack ice area. These area also important source of flux. The fate of flux is still unknown.

The shelf and shelf brake zone where coastal polynia develops is a kind of hot spot. According to ICHII (1990), the high concentrations Antarctic krill and minke whale are found in this area. Also subantarctic southern elephant seal migrate to this area to forage benthic animal, mostly cephalopods (HINDEL *et al.*, 1991. in press) Emperor penguin also forage this area through a year. However productivity, biological process and fate of flux of this area is not known due to logistic difficulty for observation.

During SIEFS program JARE will conduct several filed experiments to estimate biological production and to determine the source nad fate of flux using the several mooring buoy system which are equipped sediment traps, fluorescent meter, current meter and etc. SIEFS's particular interest is focussed on the role of ice in the above relevant subjects in different zones as mentioned.

Reference

AINLEY, D. G. and D. P. DEMASTER (1990) : The upper trophic levels in polar marine ecosystems. *In* : SMITH, W. O.(ed.) Polar Oceanography, Part B, Chemistry, Biology and Geology. Academic Press, San Diego, 599-630.

HINDELL, M. A., H. R. BURTON and D. J. SLIP (1991): Foraging areas of southern elephant seals, *Mirounga leonina*, as inferred from water temperature data. Australian Journal of Marine and Freshwater Research, **42**, 115-128.

ICHII, T. (1990): Distribution if Antarctic krill conceted by Japanese drill trawlers and minke whales.
Proceedings of the NIPR Symposium on Polar Biology, No. 3, **36-56.**

KAWAGUCHI, K., S. ISHIKAWA and O. MATSUDA (1986) : The overwintering strategy of Antarctic krill (*Euphausia superba Dana*) under the coastal fast ice off the Ongul Islands in *Lutzow-Holm* Bay, Antarctica. Mem. Natl Inst. Polar Res. (Spec Issue), **44**, 67-85.

MARSCHALL, H. P. (1988): The overwintering strategy of Antarctic kril under the pack-ice of the Weddell Sea. Polar Biol. **9**, 129-135.

NUMANAMI, H., E. HAMADA, Y. NAITO and A. TANIGUCHI (1986) : A biomass estimation of epifaunal megabenthos by stereophotography around Syowa Station, Antarctica. Mem. Natl Inst. Polar Res., Spec. **44**, 145-150.

WATANABE, K. and H. SATOH (1987) : Seasonal variations of ice algal standing crop near Syowa Station, East Antarctica, in 1983/84. Bull. Plankton Soc, Jpn., **34**, 131-150.

ZWALLY, H. J., C. L. PARKINSON, F. S. CARSEY, P. GLOERSEN, W. J. CAMPBELL and R. O. RAMSEIER (1979): Antartic sea ice variations 1973-1975. *In* : KREINS, E. R. (ed.) Fourth NASA Weather and Climate Review. National Aeronautics and Space Administration, Washington, D. C., 335-340.

La mer 29: 144-149, 1991
Société franco-japonaise d'océanographie, Tokyo

L'Institut National des Sciences de l'Univers Centre National de la Recherche Scientifique

Daniel L. CADET*

Résumé : La mission de l'Institut National des Sciences de l'Univers est décrite. Une présentation des équipements nationaux en océan-atmosphère est faite. Le contenu des grands Programmes Nationaux gérés par l'INSU et qui constituent la participation française au Programme International Géosphère-Biosphère est décrit.

1. L'Institut National des Sciences de l'Univers :

Pour mener une recherche de haut niveau dans le domaine des sciences de l'Univers, la communauté scientifique doit avoir accès à de grands équipements observatoires astronomiques, observatoires des sciences de la Terre, avions de recherche atmosphérique, moyens navals, etc... Ce type d'équipements n'est plus de la dimension d'un seul Laboratoire. Ils doivent être gérés au niveau national.

L'INSU a été créé pour permettre à la communauté scientifique française en géophysique d'accéder aux équipements nécessaires à une recherche moderne dans le domaine des Sciences de l'Univers. L'INSU a pour mission délaborer, de développer et de compétence Cette mission s'exerce pour l'ensemble de la communauté qu'elle appartienne au CNRS ou aux Universités françaises.

L'INSU a été créé par décret d'Etat le 13 février 1985. Il faisait suite à l'Institut National de Géophysique de d'Astronomie (INAG) créé à la fin des années 60 en élargissant son domaine de compétence à l'océanographie.

Bien qu'administrativement dépendant du CNRS, l'INSU est ene co-tutelle du CNRS (Ministère de la Recherche et de la Technilogie) et de la Direction de la Recherche et des Etudes Doctorales (DRED) du Ministère de l'Education Nationale. Son budget est en annexe de celui du CNRS. Ainsi, il exerce sa mission dans son domaine de compétence pour l'ensemble de la communauté nationale du CNRS et de l'Education Nationale.

La Direction de l'INSU exerce également celle du Département Sciences de l'Univers (SDU), l'un des sept Départements Scientifiques du CNRS. Le Département est en charge de la gestion quotidienne des Laboratoires qui lui sont rattachés et des ressources humaines (Chercheurs, Ingénierus, Technicients et Administratifs (ITA)).

L'INSU exerce la tutelle d'un certain nombre de Laboratoires d'une liste établie conjointement par le CNRS et la DRED. Il s'agit des Observatoires des Sciences de l'Univers (OSU) qui ont les fonctions d'enseignement (au travers de leur Université de rattachement), de recherche (dans ses Laboratoires de recherches associés au CNRS) et d'observation associée à un Observatoire (par exemple, suivi de l'environnement marin pour les OSU marins).

L'INSU est doté d'un Conseil d'Administration et d'un Comité Scientifique chargé de conseiller la Direction sur la programmation scientifique et les priorités en matiére de grands équipments.

Il existe trois Divisions: Astronomie-Astrophysique, Sciences de la Terre et Océan-Atmosphere. Chaque Division s'appuie sur une Commission Spécialisée, émanation du Conseil Scientifique de l'INSU, en ce qui concerne le financement des équipments des Laboratoires (par exemple, un premier plan quadri-annuel d'équipment informatique des Laboratoires

*Directeur-Adjoint
Division Ocean-Atnosphere
77 Avenue Denfert-Rochereau,
75014, PARIS

a été mené sur la période 1985-1990), la participation aux grandes opérations inter nationales, le renouvellement deséquipments nationaux.

L'INSU est doté d'une Division Technique dont le rôle est de superviser le développement des gros équipments et de mener les études d'instruments d'ampleur nationale. Il existe égalements une Division Administrative chargée de la gestion financiére.

La gestion des cherchurs et des ITA est menée par le Département SDU. Le recrutement et l'evaluation sont réalisés par le Comité National de la Recherche Scientifique.

2. Les Equipements Nationaux en Océan-Atmosphère:

L'INSU gére deux types d'équipements en océan et atmoshère.

En atmosphère il s'agit de l'Avion de Recherche Atmosphérique et de Télédétection (ARAT). Ils'agit d'un Fokker-27 appartenant à l'Institut Géographique National qui opèra pour l'INSU, le Centre National d'Etudes Spatiales et Météo-France. L'INSU a la charge de l'équipement et de la mise à disposition de l'ARAT pour la communauté atmosphérique. Cet avion qui est devenu opérationnel en 1990, après un chantier important de transformation, participe à toutes les grandes campagnes importantes de la com munauté.

Il existe un plan pluri-annuel de développement instrumental. L'ARAT a été equipé des instruments météorologiques de mesures des paramètres moyens et des flux turbulents. La construction de trois systèmes Lidars a été décidée. Le Lidar aérosols est opérationnel depuis le milieu de l'année 1991. Le Lidar dial permettant d'obtenir des profils de tem pérature et d'humidite devrait êtrr opérationnel dans le courant de l'année 1993. Le troisième Lidar est un système Doppler développé en collaboration fronaco-allemande et qui devrait effectuer son premier vol en 1995.

Dans le domaine océanographique, l'INSU arme une flotte c ôtière et assure ainsi à la communauté océanique française l'accès à un

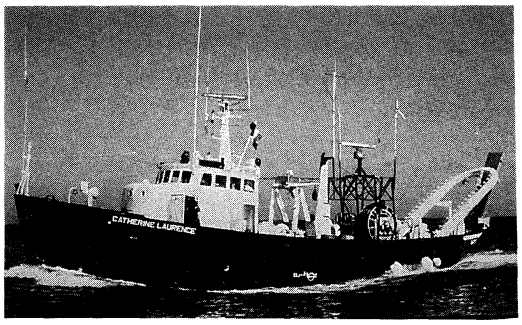


Fig. 1.

moyen indispensable. Cette flotte est composée de huit unités dont la longueur s'établit entre 15m et 25m et d'unités plus petites disposées dans les Stations Marines (OSU marins). La gestion est assurée par l'Antenne INSU de Toulon. Un personnel de 54 marins opére ces moyens navals. La Fig. 1 donne un exemple d'une unité navale gérée par l'INSU.

La programmation scientifique de ces navires est faite par deux Comités Inter Régionaux, un pour la façade Méditerranéenne et l'autre pour la façade Manche-Atlantique. Ces Comités sont chargés d'évaluer les propositions scientifiques necessitant un bateau, de définir une politique d'équipeàments des bateaux et de proposer une programmation à l'amement.

Certains des navires ayant atteint la limite d'âge, l'INSU est en train de mener un plan de renouvellement de sa flotte. Ce plan doit conduire dans un premier temps à la construction d'une nouvelle unité sur la facade méditerranéene et le désarmement de trois unités vétustes. Cette première phase devrait être terminee en 1993. La deuxième étape devrait conduire à la construction d'un nouveau navire sur la façade Manche-Atlantique à l'échéance 1994-95.

L'INSU finance un certain nombre d'équipements océanographiques mis à la disposition de la communauté Pour gérer ce parc instrumental (mouillages, pièges à sèdiments, carottiers, etc...), l'INSU sést doté d'une Antennelocalisée à Brest qui gère ces équipements, les remet en état après utilisation, etc...

L'INSU finance les différentes équipes du

CNRS et des Universités, pour des missions soit sur les navires hauturiers français gérés par l'IFREMER soit sur des navires océanographiques étrangers.

3. Les Laboratoires

Les Laboratoires océan-atmosphere dont l'INSU a la responsabilité sont localisés sur l'ensemble du territoire national.

Dans le domaine océanographique, la France dispose de quatre Observatoires Marins des Sciences de l'Univers. Trois d'entre eux sont localisés sur la façade méditerranéenne. Il s'agit du Centre Océanologique de Marseille rattaché à l'Université d'Aix-Marseille II, de l'Observatoire de Villefranche-sur-Mer et de l'Observatoire de Banyuls tous deux rattachés à l'Université de Paris 6. L'Observatoire de Roscoff situé sur la façade Manche dépend de l'Université de Paris 6. Il existe également la Station Marine de Wime-reux dépendant de l'Université de Lille.

Le potentiel de chercheurs et d'enseignants-chercheurs travaillant dans ces OSU est d'environ 400. Ces OSU servent également de point d'appui pour les autres Laboratoires pour mener des recherches marines car les OSU disposent de capacité d'accueil. Les OSU jouent également un rôle important dans l'enseigement de l'océanologie en permettant aux étudiants d'accéder à la mer.

La Figure 2 fournit une carte de la localisation des Laboratoires dépendant de la Division Océan-Atmosphère de l'INSU et du Département SDU du CNRS.

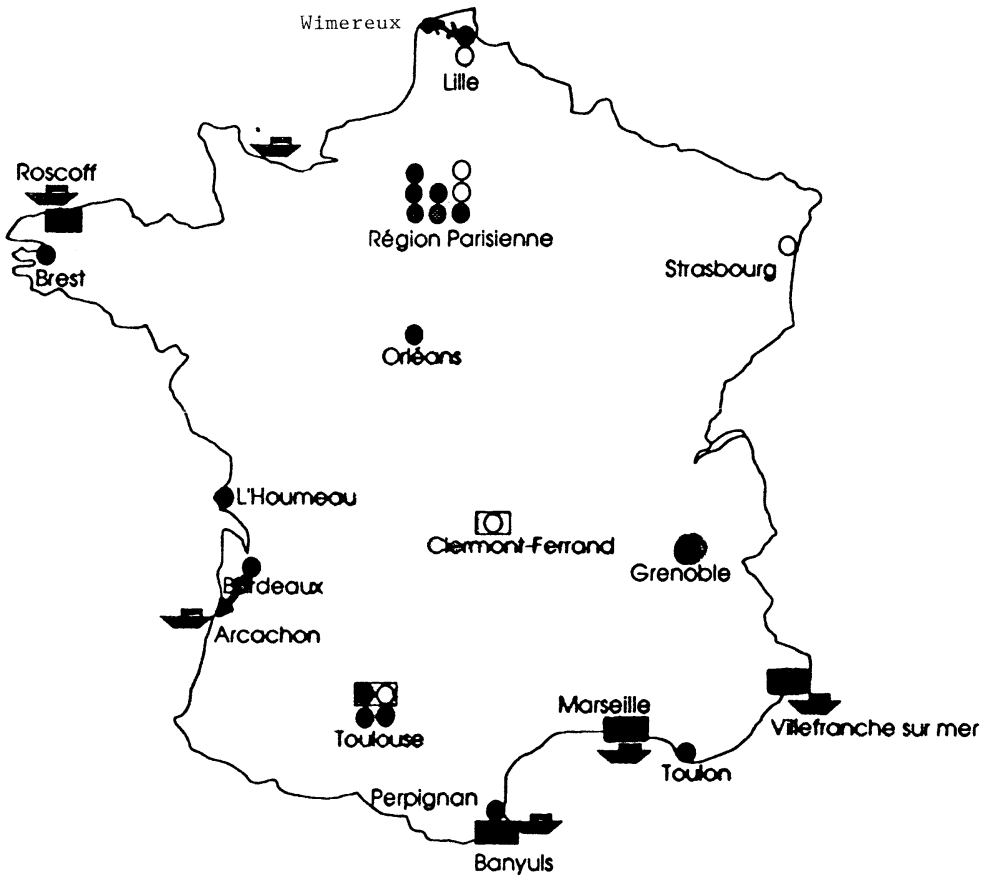


Fig. 2. Géographie de la recherche "ocean-atmosphère" au CNRS.

4. Les grands Programmes Nationaux gérés par l'INSU

L'INSU a une fonction importante de programmation de recherche française qu'il exerce au travers de sa gestion d'un certain nombre de Programmes Nationaux dont la plupart sont liés au Programme Mondial de Recherche sur le Climat (PMRC) de l'Organisation Météorologique Mondiale et le Programme International Géosphère-Biosphère (PI-GB) de l'Union Internationale des Sociétés Savantes. Nous passons ci-après en revue ces Programmes.

Le Programme National d'Etude de la Dynamique de Climat (PNEDC), établi en 1980, a pour objectif d'améliorer notre comprèhension des mécanismes qui établissent le climat, en régissant les fluctuations et, à plus long terme, d'en prévoir l'évolution future. Il s'agit de la contribution française au PMRC. La stratégie adoptée a été de privilégier les axes dans lesquels les chercheurs française excellaient et disposaient de bonnes conditions pour mener leurs travaux an plus haut niveau. Au cours des cinq dernières années, le PNEDC a permis de focaliser les recherches françaises sur cinqthèmes. Ce Programme regroupe 8 organismes francais de recherche.

*Le thème **paléoclimatologie** coordonne les recherches sur la reconstitution de l'évolution du climat au cours des derniers 250000 ans à partir de l'analyse des carottes Antarctiques (Station Vostok) et GRIP (Gröenland). C'est à partir de ces travaux qu'a été reconstitutée l'evolution du contenu de l'atmosphère en CO_2 et CH_4 au cours du dernier cycle glaciaire. Les moyen navals fran çais pertemment également de travailler sur les carottes océaniques. Dans le domaine continental, la reconstitution de climat est menée à partir de carottes obtenues en Afrique de l'Est et au Tibet.

*La concentration du CO_2, le principal gaz à effet de serre, augmente dans l'atmosphere et pourrait jouer d'ici le milieu du siècle prochain un role prépondérant dans le contrôle du climat. Les efforts français dans la com préhension du **cycle du carbone** visent à étudier le réservoir atmosphérique actuel, à déterminer les échanges entre l'atmosphère et l'océan, à comprendre le rôle joué par la biosphère continentale et de prévoir l'impact climatique d'une augmentation.

*La participation française au Programme **TOGA** (Tropical Ocean and the Global Atmosphere) est définie au sein du PNEDC. Géographiquement les travaux français en ce qui concerne les observations sont localisés dans l'ouest Pacifique (radiales biannuelles, déploiement de bouées, participation au réseau international de mouillage ATLAS) et au maintien de réseau de marégraphes de l'Atlantique. La France réalise l'archivage des don nées sub-surface TOGA. Un modéle d'océan Pacifique a été développé.

*La participation au programme **WOCE** (1992-1996) du PMRC va consister à mener des campagnes océanographiques dans l'Atlantique sud et le sud-ouest de l'Océan Indien jusquén Antarctique ainsi que la détermination du transport de masse et de chaleur entre les océans Pacifique et Indien in Indonésie. L'une des opérations françaises importantes sera la mise en orbite du satellite franco-américain TOPEX-POSEIDON qui va permettre d'atteindre une précision inégalée dans la mesure des paramètre de la circulation superficielle océanique.

*Le théme **GEWEX** concetre les efforts sur le premier objectif du PMRC, c'est-à-dire la description et la simulation de la variabilité du climat aux échelles temporelles mensuelles et saisonniéres. Les opérations HAPEX dont la première s'est déroulée dans le sudouest de la France en 1986 et la prochaine aura lieu en 1992 au Sahel constituent les opérations françaises dans le domaine. Ce thème comprend un important volet de modélisation qui a conduit à l'élabo-ration du modèle communautaire climatique français.

Le **Programme Atmosphère Météorologique et Océan Superficiel (PAMOS)** qui regroupe les efforts de l'INSU et de la Météorologie frongaise a pour objectif principal la desciription et la compréhension des processus de transfert et de transformation d'énergie qui déterminent aux petites et aux moyenne

séchlles les variations des milieux atmosphériques et océanique et qui interagissent aux grands échelles avec l'évolution mètèorologique et climatique.

Les objectifs prioritaires du PAMOS sont la réponse de l'atmosphère à la variabilité des surfaces continentales (étude de l'écoulement au-dessus d'une montagne) et constitué des campagnes SOFIA en juin 1992 et SEMAPHORE en Août-novembre 1993. Cette deuxième expérience doit mettre en oeuvre des moyens importants (ARAT, plusieurs bateaux, réseau de bouées déri-vantes etc···).

L'INSU gère le **Programme national Atmosphère Moyenne (PAMOY)** dont le but est l'étude de l'évolution de la couche d'ozone, son impact sur le climat et sur l'environnement. Plus récemment l'étude de la physicochimie de la basse stratosphère dans le cadre de notre compréhension de l'impact d'une flotte aéronautique est devenu un autre thème du PAMOY. Le PAMOY a soutenu la participation française à la campagne européenne EASOE de l'hiver 1991-92 d'étude des mécanismes responsables des diminutions locales de la concentration de l'ozone stratosphérique. Le PAMOY coordonne l'effor français de validation sol des instruments embarqués sur le satellite américan UARS (Upper Atmosphere Research Satellite). L'installation et le fonctionnement de la Station Géophysique de l'Observatoire de Haute Provence, première station du réseau international Network for the Detection of Stratospheric Change constitue l'un des thèmes forts du PAMOY.

Lancè en 1989, le **Programme National Flux Océaniques,** volet français de **JGOFS** a pour but de comprendre et de modéliser le cycle du carbone et des principaux éléments qui interagissent avec le milieu marin vivant. Dans ce programme, la priorité est donnée au rôle de la "pompe biologique" dans les échanges océan-atmosphère puis dans le devenir du carbone organique dissous et particulaire entre la couche de surface et les eaux profondes puis le sédiment.

JGOFS-FRANCE soutient trois types d'opérations:

1) Les études de processus à l'échelle de bassins océaniques, opérations s'insérant dans la planification internationale de JGOFS. Ces actions s'appuient sur des campagnes hauturières, utilisent la télédétection et la modélisation couplée dynamique-processus biologiques.

*__ANTARES__ (1992-1995) est le volet français de JGOFS dans l'océan austral. Il va comprendre trois types d'action:

• En 1992, participation à des campagnes biologiques étrangères sur le cycle de la silice et la structure des tailles des communautés biologiques.

• A partir de 1993, des campagnes seront menèer sur le Marion-Dufresne dans le sud de l'Océan Indien pour étudier l'océan ouvert et le front polaire.

• Des mouillages d'une durée d'un an de lignes instrumentées, dans chaque sous-système de l'océan austral.

*__EUMELE__. Il s'agit d'une opération commencée en 1989 et se terminant en 1992. Cinq campagnes ont été réalisées en trois ans afin d'étudier les processus gouvernant la production primaire de l'Atlantique tropical nord (large de la Mauritanie) pour trois zones couvrant une gamme d'activité photosynthétique représentative de l'océan mondial.

2) Des études de flux dans les aires marines à forts grandients.

*__ECOMARGE__ étudie les flux de matière et d'énergie sur les marges continentales. Deux chantiers ont été étudiés: le Golfe du Lion en Méditerranée et le Golfe de Gascogne en Atlantique. A partir de 1992, ce thème donnera la priorité à la modélisation du fonctionnement de l'interface eau-sédiment, à l'expérimentation *in situ* et au suivi à long terme de la marge du Lion.

*__FRONTAL__ cherche à déterminer de rôle des fronts océanique dans l'augmentation de la production planctonique et des flux de matière. En 1991 ce thème s'est focalisé sur le front Alméria-Oran.

3) Des suivis à long terme conduits autour de stations permanentes multiinstrumentées.

*ANTARFIX sera implantée au début 1992 au sud-ouest de Kerguelen dans l'océan Indien sud.

*DYFAMED se déroule depuis 1986 en mer Ligure (Méditerranée). L'accent est mis sur la compréhension des interactions entre le cycle biologique du carbone et les échanges de matière air-mer.

L'INSU assure la co-gestion avec IFREMER du Programme National d'Océanographie Côtière (PNOC) dont le thème princial est la quontification et la modélisation des flux bio-géochimiques et de contaminants dans la zone côtière. Trois chantiers ont été définis: Méditerranée, Golfe de Gascogne et Manche occidentale. Ce Programme, qui démarre en 1992, devrait représenter la contribution française au Core-Project LOICZ de PIGB.

L'INSU gère égalment le Programme National Récifs Coralliens (PRCO) et le Programme National d'Etude de l'Hydrothermalisme Océanique (PNEHO).

5. CONCLUSIONS

L'INSU, Agence de moyens en Géophysique pour la communautè française permet de donner les moyens aux scientifiques de travailler au plus haut niveau de la recherche en mettant à disposition des scientifiques des moyens nationaux et en poursuivant une politique d'équipement.

L'INSU assure aussi la gestion d'un certain nombre de Programmes Nationaux qui regroupent les efforts français dans le cadre des Programmes PMRC et PIGB. L'exstence de ces Programmes résulte d'une large comcertation entre les différentes Agences francaises impliquées dans ce domaine de recherche.

La mer 29: 150-151, 1991
Société franco-japonaise d'océanographie, Tokyo

FLUPAC, a contribution to equatorial Pacific JGOFS (Abstract)

Aubert LE BOUTEILLER*

Oceanographers at the ORSTOM Centre de Nouméa, New Caledonia, are organizing a study in the western eqatorial Pacific as part of JGOFS. The FLUPAC programme (Flux in western equatorial Pacific) aims at assessing the amount of carbon of photosynthetic origin being exported from the photic layer down to the deeper layers. The effort, therefore, will concentrate on the upper layer of the open ocean, neglecting other aspects of JGOFS programmes such as sedimentation of particles on the ocean floor.

Process studies

The FLUPAC programme focuses on the region west of the international dateline, an area where the major scale of variability is the interannual one related to El Niño-Southern Oscillation (ENSO) events. We have asked for shiptime aboard R/V Atalante for the beginning of 1994. The FLUPAC cruise will consist of two eight-day stations along the equator between 155° E and 180° E. One other cruise abroad R/V Atalante is planned for the end of 1993, which is the OLIPAC cuise asked by our colleagues of JGOFS-France.

A combination of different methods will be used to estimate the flux of exported carbon during specific cruises planned for 1993. The downward carbon flux leaving the photic zone may be shared into (1)the sinking of small particles, as sampled by sediment traps; (2)the loss of carbon, ingested by zooplankton during its vertical migrations; (3)the release of dissolved carbon from sinking particles as assessed from the comparison of particulate and dissolved C/N/O/P ratios.

New primary production, which is another estimate of the downward flux, will be determined from NO_3-N and N_2 uptake measurements. ^{14}C uptake, oxygen production, daytime increase in particulate carbon and nitrogen, chlorophyll and number of phytoplankton cells, will be measured to provide various assessments of total primary productivity, a key-parameter for JGOFS. Phytoplankton biomass will be obtained from chlorophyll analyses, transmissometry, particulate carbon and nitrogen and cell counts by microscopy and flow cytometry.

Finally, new production will be assessed also from nitrate inputs to the photic zone through vertical advection and mixing, two processes taking place in the equatorial area. Specific cruises are planned for that purpose and should consists of ADCP, CTD hydrocasts and rosette samplings for nutrients and pigments during TOGA-COARE intensive observation period (Nov.1992 - Feb. 1993): inputs and outputs of nitrate will be quantified for a "box", several degrees wide.

Monitoring studies

Temperature, salinity, current, wind, nutrients, chlorophyll and zooplankton biomass have been measured since 1985 by bi-annual SURTROPAC cruises along 165° E from 20° S to 10° N and will continue until 1995. Besides XBT's, surface salinity and CO_2 are measured from ships of opportunity. Ocean

*ORSTOM, B. P. A5, Nouméa, New Caledonia

colour sensors, such as CZCS in the past (for the 1978-1984 period), should allow the monitoring of the western extension of the phytoplanktonic equatorial enrichment area, to be made. A processing is presently being done at ORSTOM/Nouméa on CZCS imagery to test the feasibility of remote sensing in the western equatorial Pacific. One main goal is to calculate total and new production from satellite data, especially from the future Sea Wifs imagery.

La mer 29: 152-154, 1991
Société franco-japonaise d'océanographie, Tokyo

Northwest Pacific Carbon Cycle Study (NOPACCS)-MITI

Joji ISHIZAKA* and Kimitoshi ISHIKAWA*

Abstract: An introduction of Northwest Pacific Carbon Cycle Study (NOPACCS) which is a research and monitoring project of carbon cycles in the Northwest Pacific Ocean initiated by Ministry of International Trade and Industry is given. Brief summary of the results of 1990 cruise and future perspective are discussed.

Northwest Pacific Carbon Cycle Study (NOPACCS) is a research and monitoring project of carbon cycles in the Northwest Pacific initiated by Ministry of International

Table 1. Parameters for measurements of two Hakurei-Maru cruises on 1990 (NH90-3) and on 1991 (NH91-2).

NH90-3
CTD (with PAR, Fluorescence, Transmission, DO)
Surface Monitoring : pCO_2(1hr.), T-S-Fluorescence (5min.)
DO, Salinity
Carbonate System: ΣCO_2(GC), pH, Alkalinity
Nutrients: NO_3-N, NO_2-N, PO_4-P, SiO_2-Si
Chlorophyll: >20 μm, 20-3 μm, 3 μm-GF/F
Fluorescence Microscopy : Bacteria, Pico, Nanoplankton
Netplankton
Sediment Trap (0°, 15°N)

NH91-2
CTD (with PAR, Fluorescence, Transmission, DO)
Surface Monitoring: pCO_2(1hr.), T-S-Fluorescence (5min.)
DO, Salinity
Carbonate System : ΣCO_2(GC), pH, Alkalinity
Nutrients : NO_3-N, NO_2-N, PO_4-P, SiO_2-Si, NH_4-N
Chlorophyll: >10 μm, 10-3 μm, 3-1 μm, 1 μm-GF/F
Fluorescence Microscopy : Bacteria, Pico, Nanoplankton
Netplankton
POC, PON
Sediment Trap (0°, 13°N, 48°N)

*National Instituite for Resources and Environment, Tsukuba, Ibaraki, Japan

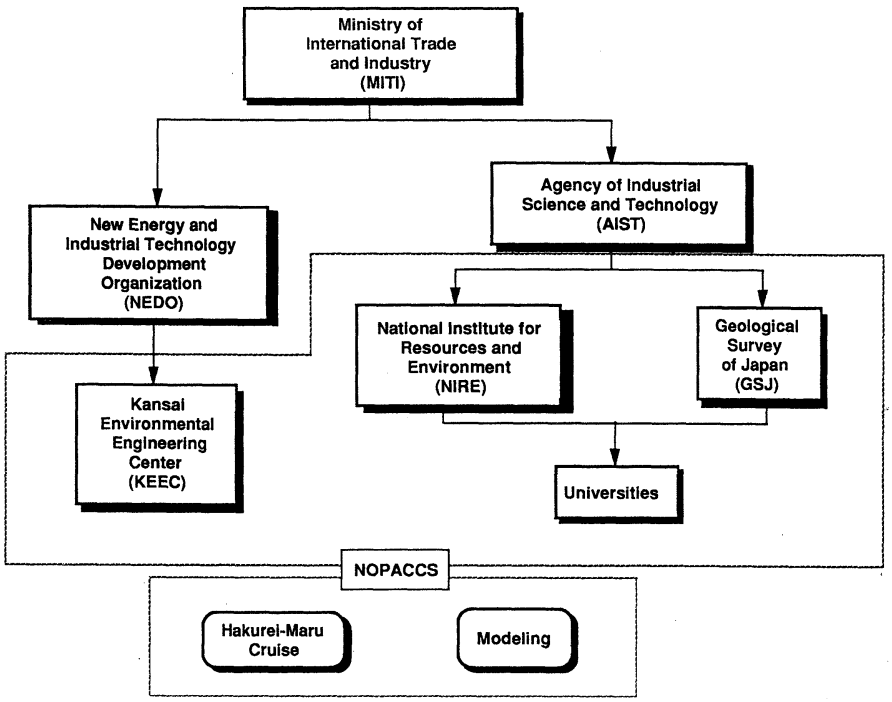


Fig. 1. Organization of NOPACCS.

Trade and Industry (MITI). Main objectives of the project are monitoring of carbon-related materials and rates of the transformations and developement of carbon cycle model in the Northwest Pacific. These objectives area important because oceanic contributions to control CO_2 gas in the atmosphere, which is one of the most significant global warming gas, are still unknown. The project started from 1990, and it will continue at least 1994 with large possibilities to be extended more years. Direct sponsor of the project is New Energy and Industrial Technology Development Organization (NEDO), and Kansai Environmental Engineering Center Coop. (KEEC) is working on the project. Two research institutions of Agency of Industrial Science and Technology (AIST) which is a part of MITI, National Institute for Resources and Environment (NIRE) and Geological Survey of Japan (GSJ), are coordinating the project with cooperation of some scientists from universities (Fig. 1).

Contribution of NIRE is mainly upper ocean processes which focuses biological activities and its influences to carbonate chemistry and to particle flux. R/V Hakurei-Maru cruises which covered from 45° N to 8° S and from 48° N to 15° S along 175° E were conducted during August to October of 1990 and 1991, respectively. Hydrographic observations of surface 300 m include CTD combined with several other sensors, carbonate system, nutrients, size-fractionated chlorophyll and plankton sampling were conducted (Table 1). Surface pCO_2, T-S, and chlorophyll were monitored continuously through the cruises.

Detail results of the cruises will be published elsewhere in near future, and ony brief summary of the results of 1990 cruise are described here. In terms of water mass distributions, we found distinct differences between subarctic water, Kuroshio Extension, subtropical gyre and equatorial region. Each region showed clearly different chemical and biological characterstics. Subarctic water

contains high nutrients and total carbonate and chlorophyll maximum at the surface. Concertration of nutrients and total carbonate decreased and chlorophyll maximum deepened to the south. Nitrate depleted and total carbonate concentration was less than 2.0 mM at the surface of subtropical gyre where the subsurface chlorophyll maximum was located about 100m deep. At the equatorial region, high-nutrients and high-total-carbonate cold subsurface water upwelled to about 75 m and chlorophyll concentrations were slightly higher than the one of gyre. Community structures of these water masses were also different. We found distinctive segregation of distributions of cyanobacteria and prochlorophyte. Partial pressures of CO_2 at the surface water were also different with water massses while the pressure in the air was almost constant. Partial pressure of surface water at the north of 38° N was smaller than one of air and indicates the possibility of CO_2 flux to ocean and possible source regions were around 30° N, equator, and 8° S.

In the last two years, no rate measurement of the carbon cycle was conducted on the cruises except the settling of mooring sediment traps through the years. More rate measurements inclading primary productivity measurements and floating sediment trap experiments, will be included from 1992 cruise which is scheduled in the same season. Spring and summer time cruises are planned in 1993 and 1994.

On the same time, coupled physical-biological-chemical modelling efforts are also started. Initially this modelling efforts focus on upper layer processes with vertically one-dimensional, time-dependent model. This model will reproduce seasonal changes of carbon cycle along 175° E. The model may be coupled with three-dimensional general circulation model in future.

La mer 29: 155-158, 1991
Société franco-japonaise d'océanographie, Tokyo

JAMSTEC program on deep-sea carbon fluxes: present situation and future plans

Yoshito TSUJI*, Makio HONDA*, Takeo TANAKA* and Hiroshi HOTTA*

Abstract: The Japan Marine Science and Technology Center (JAMSTEC) was incorporated in 1971 as a general oceanographic institution with priority areas of research:deep-sea survey and research, ocean observation and coastal sea areas development and utilization. JAMSTEC has considered the balance beween science and technology, and engaged in the development of tools necessary for those researches such as deep-sea submersibles. Using these submersibles, hydrothermal phenomena with chimneys covered with deep-sea organisms were discovered in the Okinawa Trough, and cold seepage phenomena with colonies of clams in Sagami Bay; JAMSTEC is now engaged in basic studies of deep-sea organisms growing in those environments where such phenomena are observed. Also, CO_2 rich fluid and hydrate formation on the seafloor were found in the Okinawa Trough in 1989. A preliminary study of CO_2 status in the deep sea, focusing on the observation of the property change using the submersible SHINKAI 6500, was carried out in 1990. Marine snow observation using the submersible was started in 1990 and we found a midwater maximum of marine snow abundance in Suruga Bay. JAMSTEC has two future plans on deep-sea carbon fluxes: one is to clarify biological cycles of biogenic elements, joining an intergovernmental and international research project on bio-geochemical cycles in the ocean margins. The other is a study to evaluate the carbon flux from the hydrothermal vent field in the Okinawa Trough.

JAMSTEC was founded in 1971 with the cooperation of government, academic and private circles, for the propose of promoting the marine science and technology in Japan, its management coming under the general supervision of the Science and Technology Agency (STA).

JAMSTEC has carried out following various fields of R & D projects: development of diving technology for the effective utilization of the seafloor space on the continental shelf with depth up to 300 m, development of wave power energy technology and creation and utilization of calm sea space behind a large wave power generation system. JAMSTEC also attempts to understand dynamic processes of the ocean: studies on large-scale oceanic change phenomena, and the development of technologies required for carring out such studies, e.g., ocean acoustic tomography and ocean laser profiling.

JAMSTEC has engaged (and still does) in the development of tools necessary for deep-sea research in forms of manned and unmanned submersible systems. For manned submersibles, we are now equipped with the SHINKAI 2000 with depth capability up to 2,000 m, and the SHINKAI 6500 with depth capability up to 6,500 m. For unmanned probing, we have the Dolphin 3K, with depth capability up to 3,300 m. All of those submersibles are in active service now; one of the prominent discoveries is hydrothermal phenomena with active "black-smoker" in the Okinawa Trough.

* Japan Marine Science and Technology Center, Yokosuka, 237 Japan

JAMSTEC has engaged in basic studies of deep-sea organisms growing in those environment where hydrothermal phenomena and cold seepage phenomena were observed. A series of deep tow surveys in the North Fiji Basin conducted in the Japan-France cooperation research revealed a hydrothermal vent communities: deep-sea mussels, hairly gastropods, galatheid crabs, brachyuran crabs, barnacles and zoarcid fishes (HASHIMOTO *et al.*, 1989a). Deep-sea surveys at the Minami-Ensei Knoll in the Okinawa Trough showed dense deep-sea communities of sponges, deep-sea mussels, tube worms, shrimps, anomuran stone crabs, vesicomyid clams and tongue fishes in environments with hydrothermal fluid pouring from fissures in rock outcrops and coarse sandy bottom with grayish white alteration in colour (HASHIMOTO *et al.*, 1990). Cold seep communities dominated by the giant clam were found at the Okinoyama Bank site (HASHIMOTO *et al.*, 1988) and along the slope foot of the Hatsushima escarpment (HASHIMOTO *et al.*, 1989b) in Sagami Bay.

Self ejecting liquid CO_2 was found in 1989 in the hydrothermal active area of Izena Hole in the Okinawa Trough (KIMURA *et al.*, 1990). SAKAI *et al.* (1990) observed formation of CO_2 hydrate from CO_2-rich liquid which emerge from a white alteration zone into the bottom seawater, and sampled liquid CO_2 bubbles into an acryl cylinder to observe their phase change during the ascent of the SHINKAI 2000. The discoveries of liquid CO_2 and CO_2 hydrate make an in situ experiment for JAMSTEC to examine the physico-chemical property of CO_2-H_2O system in the deepsea (HONDA *et al.*, 1991). Dry ice (solid CO_2) put into a transparent acryl cylinder without bottom was carried to the deepsea using SHINKAI 6500; formations of liquid CO_2 and CO_2 hydrate and inversion of density between liquid CO_2 and the ambient seawater wereobserved, confirming the same manner of the CO_2 status change as predicted from the phase diagram for CO_2. Also, this experiment showed formations of "makaroni-like" solid which seemed to be CO_2 hydrate containing liquid CO_2 in it, and require more precise experiments in future to know the property of the solid in detail.

JAMSTEC also carried out measurement of quantitative distribution of marine snow in Suruga Bay on 29th April 1990, using a camera and a strobe and a clear-sight (a cylinder with the clear water inside and the light-shielded body except transparent parallel planes) on the submersible SHINKAI 2000 (TSUJI *et al.*, 1991). Marine snow particles were analyzed using an image analyzer and the profiles of marine snow abundance were obtained. One of the profiles showed a maximum of marine snow density in the midwater (TSUJI and SUKIZAKI, 1992). The analysis of marine snow abundance profiles showed the significant differences between the size classes; the larger the size, the deeper the depth of maximum density is located. A comparison of the profiles between marine snow abundance and salinity suggested two processes for the occurrence of the size different profiles: marine snow advection with high salinity waters to the water column where it was observed and size sorting by sedimentation in the water column (TSUJI and SUKIZAKI, in preparation).

JAMSTEC will start two projects on the studies of deep-sea carbon fluxes. One is the study on bio-geochemical cycle in the ocean margins; multi-disciplinary research on biogeochemical cycles and fluxes of biogenic elements in ocean margins. This project is one of the new proposals for the "Special Coordination Funds for Promoting Science and Technology (SCF)" of STA, and will be started in fiscal year 1992 for a period of five years. This project aims to clarify quantitatively bio-geochemical cycles of biogenic elements by hourly, daily, seasonally and yearly time-series surveys in the marginal seas of the Pacific, and moreover to evaluate the role and the function of marginal seas in global changes. The Changjiang and Yellow rivers, which empty into the East China Sea, transport large amount of nutrient and suspended matter

from land to the ocean. The knowledge of the influence of these large rivers on the oceans will give us a suitable model for the estimate of the exchange at continental margins in the global ocean flux stydy. The East China Sea is the primary target area, followed by the Japan Sea, the South China Sea and the Okhotsk Sea. The other project is to estimate the influence of the carbon flux produced by hydrothermal activity on the ocean interior and the seafloor in the Okinawa Trought; it will be started in fiscal year 1992 for a period of more than five years. The study includes the survey of the distribution of hydrothermal vents, time-series carbon fluxes at the typical vent site, horizontal and vertical transport of carbon produced from the vent system and from the thermal vent communities, and the comparison of carbon fluxes among the hydrothermal, the biogenic and the terrigenic origins. The survey of the distribution of the CO_2 hydrate under the seafloor is essential to estimate the volume of self ejecting CO_2 liquid in the field. The facilities such as submersibles, sediment traps, marine snow camera, high-resolution sub-bottom profiler and long time-range monitoring stations on the seafloor will be utilized.

References

HASHIMOTO, J., S. MATSUZAWA and H. HOTTA (1988): Searching for Biological Communities at the Okinoyama Bank Site in the Sagami Bay. JAMSTECTR DEEPSEA RESEARCH **4**: 177-188.

HASHIMOTO, J., D. JOLLIVET and 88 SHIPBOARD PARTY (1989a): The hydrothermal vent communities in the North Fiji Basin: Results of Japan-France Cooperative Research on board KAIYO 88, La mer, **27**: 62-71.

HASHIMOTO, J., S. OHTA, T. TANAKA, H. HOTTA, S. MATSUZAWA and H. SAKAI (1989b): Deep-sea communities dominated by the giant clam, *Calyptogena soyoae* along the slope foot of Hatsushima Island, Sagami Bay, central Japan. Paleogeography, Paleoclimatology, Paleoecology, **71**: 179-192.

HASHIOMOTO, J., K. FUJIKURA and H. HOTTA (1990): Observations of Deep Sea Biological Communities at the Minami-Ensei Knoll. JAMSTECTR DEEPSEA RESEARCH, **6**: 167-179.

HONDA, M., J. HASHIMOTO, J. NAKA and H. HOTTA (1991): CO_2 Hydrate Formation and Inversion of Density between Liq. CO_2 and H_2O in Deep Sea: Experimental Study using submersible "Shinkai 6500" . In the proceedings of The First International Workshop on Interaction between CO_2 and Ocean, 3-4 December 1991, Abiko.

KIMURA, M., T. OOMORI, E. IZAWA, Y. KATO, T. ONO, T. TANAKA, T. KOIKE and S. NISHIOKA (1990): Newly found vent system and ore deposits in the Izena Hole in the Okinawa Trough, Japan. JAMSTECTR DEEPSEA RESEARCH, **6**: 87-97.

SAKAI, H., M. YAMAMOTO, T. TANAKA, T. GAMO, E. KIM, J. ISHIBASHI, K. SHITASHIMA, T. MATSUMOTO, T. OOMORI, J. YANAGISAWA and M. TSUTSUMI (1990): Geochemical studies of the hydrothermal system at the Izena Cauldron using "SHINKAI 2000" ——reports on dive numbers 413 and 415, and on the liquid CO_2 bubbles and hydrate collected during dives number 424. JAMSTECTR DEEPSEA RESEARCH, **6**: 69-86.

TSUJI, Y., S. SUKIZAKI, E. IKEMOTO and K. OTSUKA (1991): A Simple Method for in situ Measurement of Marine Snow Abundance: Clear-site Method. JAMSTECTR DEEPSEA RESEARCH **7**: 63-71.

TSUJI, Y. and S. SUKIZAKI (1992): Measurement of marine snow abundance using the submersible. In press.

深海の炭素循環に関する海洋科学技術センターの研究活動：現状及び将来

辻　義人・本多牧生・田中武男・堀田　宏

海洋科学技術センター（センター）は総合的な海洋開発・研究機関として1971年に設立され，主たる研究活動として深海調査研究，海洋観測及び沿岸域の開発利用を行っている。センターは科学と技術の調和を重視しており，研究に不可欠な施設・技術（たとえば有人・無人の深海潜水調査船）の開発を行ってきた。これらの潜水調査船によって特有の深海生態系を有する沖縄トラフの熱水噴出域及びシロウリガイ群集を有する相模湾の冷水湧出域が発見され，現在センターではこれらの生物に関する基礎研究を行っているところである。また，海底における液体二酸化炭素の噴出及び二酸化炭素－水ハイドレイトの形成が1989年に沖縄トラフではじめて観測された。これを実験的に再現するために，センターでは沈降中の「しんかい6500」によって深海における二酸化炭素の相変化の観測を1990年に実施した。さらにセンターは，1990年から潜水調査船を使用したマリンスノーの調査を開始し，駿河湾の中深度層においてマリンスノー密度の最大を観測した。センターは，深海の炭素循環に関して二ケの将来計画を有する。一つは，科学技術庁の振興調整費「縁辺海における物質循環に関する国際共同研究」に参加し，複数の国内（国外）研究機関とともに東シナ海を主とした縁辺海において生物地球化学的な調査・研究を行うものである。他は，海洋の物質循環に与える熱水噴出域の影響を定量的に評価するために，沖縄トラフにおいて調査・研究を行うものである。

La mer 29: 159-165, 1991
Société franco-japonaise d'océanographie, Tokyo

Measurement of marine snow abundance using the submersible

Yoshito TSUJI* and Shunji SUKIZAKI*

Abstract: Marine snow photographs were taken every 50 m depth interval from 50 m to 1950 m in Suruga Bay (water depth, 1972m) on 29th April 1990, using a camera and a strobe and a clear-sight (a cylinder, 20 cm in diameter and 60 cm in length, with the clear water inside and the light-shielded body except the transparent parallel planes), on the submersible SHINKAI 2000 descending at about 10 m/min. We analyzed a total of 5710 marine snow particles using an image analyzer and made marine snow abundance profiles (number and density). Both profiles increase with depth below 1500 m except at depths of 1700 m and of 1950 m (20 m above bottom); density has a maximum in the midwater. The causes of the increases and the maximum are suggested as being due to advection.

1. Introduction

Marine snow are aggregated particles with a length of more than 0.5 mm and have significance as transport agents which fluxes much of surface-derived matter to the ocean interior and the sea floor. Advances in our understanding of the characteristics and abundance of marine snow have been hidered by problems associated with sampling and quantifying these fragile aggregate in nature (ALLDREDGE and SILVER, 1988). We found frequently disaggregation of marine snow in eddies produced by sharp edges of instruments on the submersible, even diving at a slow speed of 10 m/min.

The sampling problems have needed *in situ* observations using SCUBA (ALLDREDGE and GOTSCHALK, 1988 ; 1989) and the submersible (INOUE *et al.*, 1955; ALLDREDGE and YOUNGBLUTH, 1985), and recently HON-JO *et al.* (1984) developed a system to assess particle spectra directly in the water columun. The system uses a well-collimated beam which is produced by a sophisticated light source such as a combination of stroboscopic light and a Fresnel lens, and the system installed in a frame is lowered using a wire from a surface ship.

* Japan Marine Science and Technology Center, Yokosuka, 237 Japan

The submersible is a stable free-fall platform in the sea and free from rapid movement; usually it dives without propulsion. If we pay careful attentions to the layout of a system for marine snow observation, the submersible can get rid of those disturbing of fragile marine snow which might occur when the system is lowered using a wire from a ship and the ship tosses by waves. We used the submersible SHINKAI 2000 and equipped it with a simple system which was consisted of an ordinary strobe and a transparent cylinder in front of a camera, to take a clear marine snow photographs.

Suruga Bay was chosen for the survey station because pilots of the submersible have observed abundant marine snow almost all the diving times in the Bay.

2. Methods

Fig.1 shows the concept of the clear-sight method. The clear-sight we used is an acryl cylinder with the clear water inside and the light-shielded body the except the transparent parallel planes; it is after "clear-site", a plastic bag filled with clear water, which is used by divers to take clear photographs in the turbid seawater. A clear-sight excludes less sharp and relatively larger images which exist closer than the focused subject and hide sharp images at the focused distrance. Each

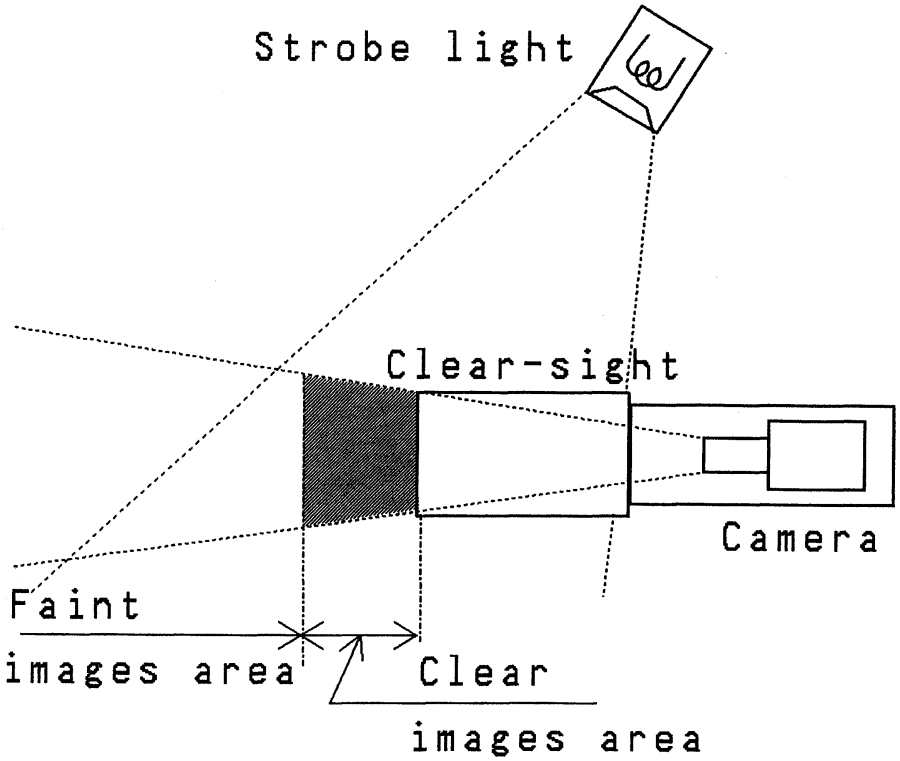


Fig.1. Concept of the clear-sight method. The clear-sight is an acryl cylinder with the clear water inside and the light-shielded body except the transparent parallel planes. A clear-sight placed in front of the camera excludes less sharp and relatively larger images which would exist closer than the focused subject.

photograph taken with a clear-sight contains both sharp and faint marine snow images; sharp and faint ones correspond to focused and farther objects, respectively. The faint ones are easily excluded using aimage analyzer.

We mounted a clear-sight (diameter, 20 cm; length, 60 cm) horizontally on the front side of the SHINKAI 2000; The front end of the clear-sight was placed far enough from the foremost of the SHINKAI 2000 to avoid the wake produced by it. The other end was placed just in front of a camera (f 28 mm ; F 3.5; object distance in water, 0.8m).

Three photographs were taken every 50 m depth interval (the depth difference between the first and the third photographs is less than 2 m) from 50 m to 1950 m in Suruga Bay (34° 43.00′ N, 138° 35.50′ E; water depth 1972 m), central Japan on 29th April 1990 ; the SHINKAI 2000 Started diving at 9:47 a.m. and descended about 10 m/min., half the regular speed. The submersible stopped diving to survey horizontally at about 1800 m for 17 minutes and resumed diving to bottom. We supposed that the disaggregation of marine snow by eddies produced at the edge of the front end of the clear-sight was negligible because of two reasons: the simple shape of the clear-sight with the lesser eddy production and the sparse existence of marine snow which reduces its chance to near eddies.

A image analyzer (NEXUS system) with a digitizer (768 × 493 pixels, the brightness unit ranges 0 - 255) gave area of each particle and a particle-number in a photograph, excluding faint images (less bright than 170

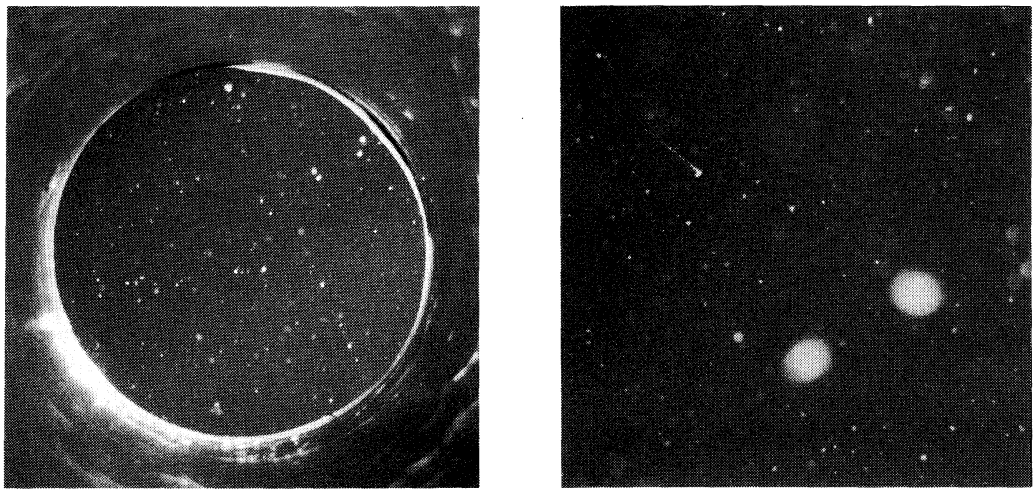
brightness). The size resolution and the sampling volume (a sum of three photographs) for this study were estimated to be 0.3 mm and 9.3 liter, respectively, according to an assumption: if a strobe gives equal brightness to all particles in front of a camera, the brightness of a particles decreases inversely with the square of the distance between the particle and the camera.

The volume of a particle was calculated from the diameter of the corresponding circle, assuming that the particle was sphere and the area of the image of the particle was equivalent to a circle. The details of clear-sight method can be seen elsewhere (TSUJI *et al.*, 1991).

3. Results and discussion

Fig. 2 shows photographs of marine snow taken at the depth of 450 m in Suruga Bay, with and without a clear-sight. Almost all the images in the photograph with a clear-sight are clear compared to the ones in the photograph without it. We analyzed a total of 5710 marine snow particles; Kruskal-Wallis analysis of variance of ranks (CAMPBELL, 1967) showed that the locations of the median of marine snow populations in three photographs of the same depth are the same ($p>0.05$) through all depths except three depths (300 m, 700 m and 1150 m), particle data of which were not excluded from other depths' because of a little effect on the whole depth profiles.

Fig. 3 shows profiles of particle-number (particles / liter), density (a sum of the volume of particles in three photographs taken at the same depth to sampling volume; cubic mm/liter) and salinity and temperature measured by a STD on the submersible. Particle-number is almost the same (about 12 particles/liter) from 100 m to 1450 m and increases with depth below 1450 m except two declines at 1700 m and at 1950 m; the decrease at 50 m seems to be due to the effect of the strong ambient lights on the photographing in the shallow waters. Density has a midwater maximum at 600 m and local maxima in the deeper depths, slightly increasing with depth below 1500 m except the declines at the same depths as particle-number. Salinity has a large variation in the depths shallower than about 500



(a) (b)

Fig. 2. Photographs of marine snow taken simultaneously at the depth of 450 m in Suruga Bay, (a) with and (b) without a clear-sight. (a) shows clear images of particles with the inside of the clear-sight sean on the outer part of the photograph. (b) contains some faint and enlarged images of particles. (From TSUJI *et al.*, 1991)

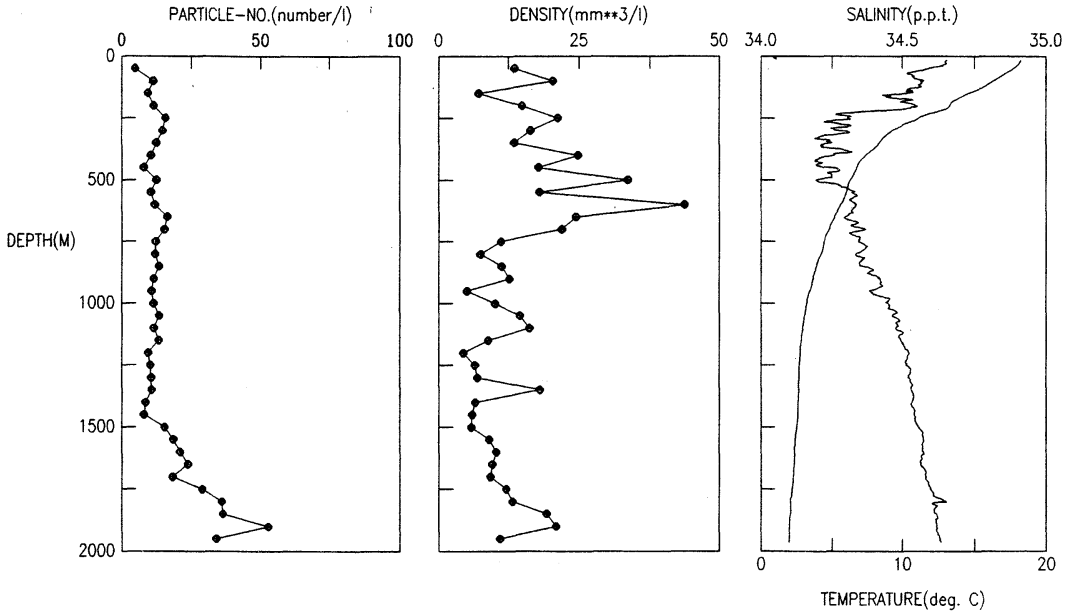


Fig. 3. Profiles of particle-number (particles/liter), density a (sum of the volume of particles in three photographs taken at the same depth to the sampling volume; cubic mm/liter) and salinity and temperature measured by a STD on the submersible. Note that salinity peaks at about 1800 m show the effect of the horizontal movement of the submersible at that depth. Density has a mid-water maximum at 600 m and local maxima in the deeper depths; both ponticle-number and density have general increases with depth below 1450 m. It is noticeable that the depths of large salinity intrusions are located shallower than that of the density maximum.

m with intrusions of high salinity waters. It is noticeable that the depths of large intrusions are located shallower than that of the density maximum.

The observations of midwater maximum of marine snow density agreed with previous reports (ASPER, 1986, 1987; GARDNER and WALSH, 1990); the cause of the maximum was suggested as advection of sediments which were resuspended on the shallow bottom (ASPER, 1986; GARDNER and WALSH, 1990) by the strong bottom current (LAMPITT, 1985). The station of this observation is located only 5 km off Senoumi Seamount with the summit depth of 32 m and it is probable that sediments on the shallow Seamount were resuspended and transported horizontally to this station by the currents. That the midwater maximum of marine snow density observed in this study appeared at the deeper depth than those of strong salinity intrusions, is sugges-ted as the sedimentation of the transported particles in the water column.

It is noticeable that although the general increase of particle-number below 1450m may correspond to the near-bottom nepheloid layer over rough topography as VANGRIESHEIM and KHRIPOUNOFF (1990) suggested, it has two declines instead of homogeneity as they indicated.

Fig. 4 shows enlarged profiles of particle-number, temperature and salinity below 1000 m. Features of profiles of temperature and salinity change significantly at 1450m. Trends of profiles above 1450 m are extrapolated to the deeper depths so that the differences (hatched area in Figure 4) between the profiles and the corresponding extrapolated trends can be seen clearly. All the diffrence

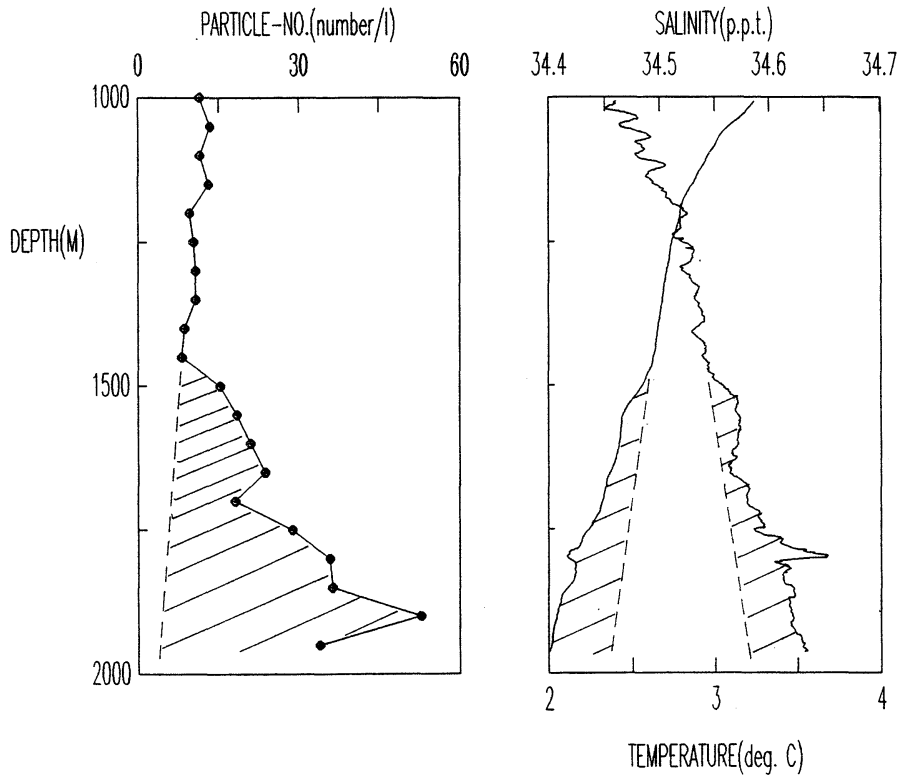


Fig.4. Enlarged profiles of particle-number, temperature and salinity below 1000 m. Hatched area show the differences between profiles below 1450 m and corresponding extrapolated lines (dashed line) of the trends above 1450 m toward the deeper. Peaks of salinity and temperature at about 1800 m, see the caption of Fig. 3. Trends of temperature and salinity change significantly at 1450 m; below that depth particle-number increases.

area are similar in general shape; a decline of particle number at 1700 m corresponds to a sharp decline of salinity and a decline of slope of temperature, but at a shallower depth by 50 m (one interval for the measurement in this study). The decline of particle number at 1950 m corresponds declines of slopes of temperature and salinity near that depth. Considering the shape similarities, we suggested that the increase of particle number is not due to resuspension of bottom sediment just below this survey station, but bue to horizontal transport of particles with intrusions as indicated for near-bottom nepheloid layers (MCCAVE, 1983; RICHARDSON, 1987).

The intrusions seem to have two layers. They have colder and higher-salinity waters than the near-bottom waters previously existed. The main waters of the lower layer exist presumably more than 20 m above bottom and transported from the seaward, the northward current (0.2 knots, 290 degree; inward direction for the Bay) was measured by a current meter on the submersible.

In this study, we showed clearly a midwater maximum and near-bottom increases of marine snow abundance, using the submersible with a simple photographing method. The causes of both are suggested as horizontal transport of particles. The slow sinking submersible showed significant advantages to measure the size distribution of fragile

marine snow (TSUJI and SUKIZAKI, in preparation). Therefore, we suggest that using the submersible is effective to measure the large-size particle distributions precisely and that analysis of dynamics or modeling for large particles such as marine snow must account for horizontal transport, in particular, in the marginal sea.

Acknowledgments

We thank members of "SHINKAI 2000" operation team and the captain and crew of mother ship "NATSUSHIMA" for help in the field, K.OTSUKA for instruction of NEXUS system and M. KYO and T. ITOH for help with preparing the figures.

References

ALLDREDGE, A. L. and M. YOUNGBLUTH (1985): The Significance of microscopic aggregates (marine snow) as sites for heterotrophic bacterial production in the mesopelagic zone of the subtropical Atlantic. Deep-sea Res., **32,** 1445-1456.

ALLDREDGE, A. L. and M. W. SILVER (1988): Characteristics, dynamics and significance of marine snow. Prog. Oceanogr., **20,** 41-82.

ALLDREDGE, A.L. and C. GOTSCHALK (1988): *In situ* settling behavior of marine snow. Limnol. Oceanogr., **33,** 339-351.

ALLDREDGE, A. L. and C. GOTSCHALK (1989): Direct observation of the mass flocculation of diatom blooms : Characteristics, settling velocities and formation of diatom aggregates. Deep-sea Res., **36,** 159-171.

ASPER, V. L. (1986):Accelerated settling of marine particulate matter by 'marine snow' aggregates. WHOI-86-12, 1-189.

ASPER, V. L. (1987):Measuring the flux and sinking speed of marine snow aggregates. Deep-Sea Res., **34,** 1-17.

CAMPBELL, R. C. (1967): Statistics for biologists. Cambridge University Press, England, 242 pp.

GARDENER, W. D. and I. D. WALSH (1990): Distribution of macroaggregates and fine-grained particles across a continental margin and their potentia rolel in fluxes. Deep-sea Res., **37,** 401-411.

HONJO, S., K. W. DOHERTY, Y. C. AGRAWAL and V. L. ASPER (1984): Direct optical assessment of large amorphous aggregates (marine snow) in the deep ocean. Deep-Sea Res., **31,** 67-76.

INOUE, N., S. NISHIZAWA and M. FUKUDA (1955): The perfection of a turbidity meter and the photographic study of suspended matter and plankton in the sea using an undersea observation chanber. Proceedings of the Unesco Symposium on physical Oceanography, 1955, Tokyo.

LAMPITT, R.S. (1985): Evidence for the seasonal deposition of detritus to the deep-sea floor and its subsequent resuspension. Deep-Sea Res., **32,** 885-897.

MCCAVE, I.N. (1983): Particle size spectra, behavior, and origin of nepheloid layers over the Nova Scotian continental rise. J. Geophys. Res., **88,** 7647-7666.

RICHARDSON, M.J. (1987): Particle size, light scattering and composition of suspended particulate matter in the North Atlantic. Deep-Sea Res., **34,** 1301-1329.

TSUJI, Y., S. SUKIZAKI, E. IKEMOTO and K. OTSUKA (1991): A simple method for *in situ* measurement of marine snow abundance: clear-site method. JAMSTECTR DEEPSEA RESEARCH, **7,** 63-71.

VANGRIESHEIM, A. and A. KHRIPOUN-OFF (1990): Near-bottom particle concentration and flux: Temporal variations observed with sediment traps and nephelometer on the Meriadzek Terrace, Bay of Biscay. Prog. Oceanog., **24,** 103-116.

潜水調査船を使用したマリンスノーの鉛直分布観測

辻　義人・鋤崎俊二

1990年の4月29日，駿河湾（水深1972mの場所）において10m/分で沈降している「しんかい2000」に取り付けたスチールカメラ，ストロボ及びクリアサイト（直径20cm，長さ60cmの両端が透明な円筒で，内部に清水を満たしたもの）を使用して50mから1950mまでのマリンスノーの写真を撮影した。画像処理装置によって全部で5710ヶのマリンスノー粒を解析し，マリンスノーの数と総体積の鉛直分布を求めた。マリンスノーの鉛直分布は1500m以深で深度とともに数が増加し，中深度層で総体積が最大を示した。これらの増大の原因が移流によることが示唆された。

La mer 29: 166-169, 1991
Société franco-japonaise d'océanographie, Tokyo

Particle transfer and benthic biological processes at continental margins. Results from the Atlantic and Mediterranean ECOMARGE program

Alain DINET*

Abstract: The benthic boundary is the ultimate place where decisive processes occur for organic fluxes. It is in the upper layer of sediment that most of the organic matter reaching the bottom is either converted into biomass or loss through burial. Assessing both ways of transformation of POM seems therefore important with respect to a carbon budget in the ocean. A classical approach to the problem is to measure different benthic parameters (e.g., abundance of the different faunal components, viable counts of bacteria, organic matter content in sediment, etc...) from which a "benthic response" to fluxes is assessed. It is emphasized that such an approach brings severe limitations because of sampling bias when operated from the surface and lack of information on the biological and geochemical processes. On the contrary, recent underwater technology developments, especially manned submersible availability for scientific research, allow us to make first attempts to an *in situ* approach of the deep-sea dynamic processes, taking into account the pressure factor. Examples of *in situ* experiments currently runned on the french continental margins are given (e.g., colonization, radioisotope-labelling of sediment and/or organisms, microbial metabolism, bottom oxygen consumption, etc...) and their interest is discussed in the scope of oceanic flux studies.

Introduction

Considering the fate of particulate fluxes in the ocean, the benthic boundary is the ultimate place where decisive processes occur for organic compounds. It is in the sediment, and particularly in its upper layer (first centimeters) that most of the organic matter attaining the bottom is subject to changes leading either to its convevsion in biomass or to its loss through burial. Thus, with respect to a carbon budget in the ocean, it seems important to assess both ways of transformation of particulate organic matter (POM). During the past decade, the approach to the question has been widely descriptive. In a first step, studies were conducted with the aim of quantifying the sedimentary POM and the benthic biomass which are normally related to the pelagic fluxes, especially in the deep zones devoided of autochtonous production. While at the world ocean scale the general trend is a concordance between highest organic accumulations in sediments and more dense benthic populations (ZENKEVITCH *et al.*, 1971) poor agreement (sensu correlation) is found at the level of standard faunal and biochemical parameters. In particular, the fauna aboundance is rather unexplained by factors such as organic carbon and nitrogen (DINET and KHRIPOUNOFF, 1980). Spatial and temporal variability of the factors appears responsible for the lack of correlation, thus leading to a new strategy in the descriptive approach: the time-series surveys.

Descriptive approach

Such an approach has been developed during the ECOMARGE program on two working sites located at the northwestern Mediterra-

* Observatoire Océanologique de Banyuls, Laboratoire Arago, 66650 Banyuls-sur-Mer, France

nearn (Gulf of Lions) and northeastern Atlantic (Bay of Biscay, Cap Ferret Canyon).

In the Gulf of Lions, the particulate transfers mainly generated by the Rhône river discharge are forced by the Liguro-Provençal Drift, a powerful hydrodynamic structure of this oceanic area (MILLOT, 1990). This feature induces an asymetry in the advective inputs to the deep varying with in a ratio 1:7 from the east to the west (DURRIEU DEMADRON *et al.*, 1990) open slope recieves a mere 10 to 20% of the flux. An increase of organic carbon is pointed out in the sediments of the lower continental slope.

In the Bay of Biscay, Gironde estuary provides the main source of particulate matter which is channelized towards the deep sea through the Cap Ferret Canyon. Stratification of water masses and setting up of a front at certain periods are the limiting factors for advection. Under these conditions nepheloid layers are detected just below the euphotic zone, close to the canyon walls and in the upper reaches of submarine valley (DINET *et al.*, 1990).

In both areas, all measurements and observations confirm the fertilizing influence of shelf-and slope-derived material and underlines the prominent role of canyons in the energetic transfer to the deep sea. Several biological and biogeochemical parameters were measured repeatedly (i.e., monthly to bimonthly) at the Mediterranean site over a two-years period to evaluate the benthic response to the particulate inputs, mainly advective, on the shelf-slope break. Standing crops as well as activities varied according to the flux seasonal variations estimated by sediment traps deployed in the water column (MONACO *et al.*, 1990) and by chlorophyllous pigments in sediments (GUIDI, 1987; BUSCAIL, 1987; BUSCAIL *et al.*, 1987) and the entire ecosystem appeared forced by phytoplanktonic blooms. Apart from the quantitative fluctuations (estimated range of variation: 1 to 40) of organic material reaching the bottom, the quality of POM is also highly variable with time and is likely a major governing facter for benthic activity. Over a year cycle, the proportion of amino-acids in the upper first cm of sediment may vary between 12 and 43% and the total hydrolyzable fraction ranges from 35 to 73% of the material (BUSCAIL *et al.*, 1990). From the set of data cited above, a tentative budget of organic carbon has been calculated for the Mediterranean site. It shows that some 60% of sedimented POM is remineralized at the water-sedimented interface, the remaining (40%) being lost through burial (BUSCAIL *et al.*, 1990). Following this statement, two remaining questions are: which processes may lead to the recycling of sedimented organic carbon and what is the relative importance of biotic vs. abiotic ways of remineralization? Here are the problems which have originated the experimental phase of the ECOMARGE program presented hereafter.

In situ Experimental approach

Radioisotope-labelling experiments were performed by BUSCAIL (1987, 1991) and GUIDI *et al.* (in prep.) using different organic substrates refering to marine and/or continental material (i.e, ^{14}C-Glutamic acid ^{14}C catechol) injected at sediment-water interface samples taken from box cores.

Analyzing the ^{14}C distribution in the upper layers of sediment and adjacent water, several pathways of organic matter transformation have been assessed such as respiration, assimilation, adsorption and polimerization. However because these assays were conducted on board research vessels under atmospheric conditions, their interpretation has been restricted by the fact that pressure, at least a major factor in the deep, was neglected in the protocol.

With the advances in underwater technology accomplished during the seventies, solutions to the problem now do exist. Remote submarine vehicles (ROV) and submersibles are the tools for a heuristic approach to the deep-sea dynamics involving biological and biogeochemical processes. In France, the availability of the IFREMER manned subm

ersibles "CYANA"(3000 m) and "NAUTILE" has allowed first attempts to *in situ* measurements of microbial activity in the abyssal zone (CAHET and SIBUET, 1986). An original instrumentation designed by GUIDI and GUIDI (in prep.) for radioisotope-labelling experiments and parallel *in situ* vs. on board atmospheric assays conducted during ECOMARGE operations have confirmed the prominent influence of pressure in deep-sea processes. Uptake of ^{14}C-labelled dissolved and particulate material was found to be much higher at 1000 m depth in the Mediterranean as compared with surface tests (BUSCAIL, 1991; GUIDI, pers. comm.). Although still debated, the hypothesis of rapid processes in the deep-sea (for instance, microbial utilization of ^{14}C-glucose) has received some support from this type of assays (CAHET and SIBUET, 1986). Other evidence of an intense biological activity is also provided by recolonization of defaunated and/or organically-enriched substrates placed on the bottom by "CYANA" (DINET, unpublished) or in free submarine vehicles (DESBRUYERES *et al.*, 1980). The recent availability of submersibles has allowed to multiply and diversify *in situ* operations at the sediment-water interface (e.g., sediment and organism sampling, water filtering, trap deployment, video recording, etc...) and particularly to conduct them in a very accurate way, under visual control. It is clear that such methodological progress might significantly improve our knowledge of energy echange processes and should preferentially be used in the study of the deep-sea benthic boundary layer.

References

BUSCAIL, R.(1987): Transfert de composés organiques (^{14}C) àl'interface eau-sédiment de différents sites bathymorphologiques de la marge méditerrancé enne occidentale. Coll. int. d'Océanologie de la CIESM,, p. 75.

BUSCAIL, R. (1991): Le cycle du carbone sur unu marge continentale: aspects biogeochimiques du transfert de la matiére organique à l'interface eau-sediment. Thése Doctoratés-Sciences, Univ. Perpignan, 642pp.

BUSCAIL, R., L. GUIDI and F. DE BOVEE (1987): Flux de matiére organique, variation des paramétres biochimiques et dynamique dans le canyon Lacaze-Duthiers (golfe du Lion). Colloque international d'Océanologie de la CIESM, p.73

BUSCAIL, R., R. POCKLINGTON, R. DAUMAS and L. GUIDI(1991): Fluxes and budget of organic matter in the benthic boundary layer over the northwestern Mediterranean margin Cont. Shelf Res., **10 (9/11)**, 1089 - 1122.

CAHET, G. and M. SIBUET (1986): Activité biologique en domaine profond: transformations biochimiques *in situ* de composés biochimiques marqués au carbeon-14 a' l'interface eau-sédiment, par 2000 m de profodeur dans le golfe de Gascogne. Mar. Biol., **90**, 307315

DESBRUYERES, D., J. Y. BERVAS and A. KHRIPOUNOFF (1980): Un cas de recolonisation rapide d'un sédiment profond. Oceanol. Acta, **3 (3)**, 285-291.

DINET, A.,M. CREMER, H. ETCHEBER, J. M. FROLDEFOND, J. M. JOUANNEAU, O. WEBER, X. DURRIEU DEMADRON, F. NYFFELER, J. CARBONNE, S. HEUS-SNER, P. BISCAYE, O. DONARD, J. URRUTIA, and P. LABORDE (1990): Flux study in the Cap Ferret Canyon, Bay of Biscay (northeast Atlantic). Eos, **71**, 53.

DINET, A and A. KHRIPOUNOFF (1980): Rapports quanyiyatifs entre le méiobenthos et la matiére organique sédimen-taire en zone abyssale. *in* "Biogéochimie de la matiére organique sédimentaire à l'interface eau-sédiments marins". Coll. int. CNRS 293, pp. 319-324.

DURRIEU DEMADRON, X., F. NYFFELER and C. H. GODET (1990): Hydrographic structure and nepheloid spatial distribution in the Gulf of Lions continental margin. Cont. Shelf Res.,**10 (9-11)**, 915-929.

GUIDI, L. (1987): Les pigments chlorophylliens à l'interface des sédiments profonds. Colloque international d'Océa-

nologie de la CIESM, p. 47.

MILLOT, C. (1990): The Gulf of Lions' hydrodynamics. Cont. Shelf Res., **10 (9-11)**, 885-894.

MONACO, A., P. BISCAYE, J. SOYER, R. POCKLINGTON and S. HEUSSNER (1990): Particle fluxes and ecosystem response on a continental margin: the 1985-1988 Mediterranean ECOMARGE experiment. Cont. Shelf Res., **10 (9-11)**, 809-839.

ZENKEVITCH, L. A., Z. A. FILATOVA, G. M. BELYAEV, T. S. LUKYNOVA and I. A. SUETOVA (1971): Quantitative distribution of zoobenthos in the world ocean (in Russian). Byull. mosk. Obshch. Ispyt. prir., otd. Biol., **76**, 27-33.

La mer 29; 170-173, 1991
Société franco-japonaise d'océanographie, Tokyo

Preliminary studies on the energy budget of a deep-sea nematode

Yoshihisa SHIRAYAMA*

Abstract: Ingestion and absorption rates of a nematode, *Paramonohystera* sp., were measured to discuss the energy budget of meiofauna in the deep sea. Its respiration rate was estimated using a datum of the same species collected at another locality in another cruise. The ingestion rate measured was distinctively low, and the energy ingested did not balance with the energy respired. The absorption rate was found to be comparable to the ingestion rate. These results suggested that dissolved organic matter is as important as particulate organic matter as an energy source for the deep-sea nematode.

1. Introduction

The deep-sea environment has been believed as a food-limited world for a long time (THIEL, 1975, 1979). This idea has been strongly supported by the measurement of metabolism of deep-sea fishes (SMITH and HESSLER, 1974; SMITH and BROWN, 1983). In these studies, respiration rates of deep-sea species have been found to be one to two order of magnitude slower than their shallow-water relatives, and this reduction of the metabolic activity has been discussed as an adaptation to the energy-limited environment.

Recently, on the other hand, active respiration rates of deep-sea meiofaunal taxa have been measured by present author (SHIRAYAMA, 1992). The later results further lead to a question how meiofauna obtain enough energy in the deep-sea environment.

Ingestion rates of meiofauna have been measured using a radioactive substance as a tracer (MONTAGNA, 1984a). It is impossible to carry out such an experiment in the field due to the strict regulation for the use of radioactive material in Japan. However bathyal meiofauna is active under one atmospheric pressure even though they experienced rapid decompression, as proven in the respiration rate measurement (SHIRAYAMA, 1992). The present study is to add some information regarding the ingestion rates of a bathyal nematode *Paramonohystera* sp. obtained through the experiment carried out in a laboratory. It was also aimed to discuss about the balance of input and output of energy along the deep-sea nematode.

* Ocean Reseach Institute, University of Tokyo, 1-15-1 Minami-dai, Nakano-ku, Tokyo, 164 Japan

2. Materials and Methods

Respiration rates of deep-sea nematodes were measured using the stoppered-diver method (HAMBURGER, 1981), a kind of Cartesian diver technique. Detail of the method as well as the materials used have been described elsewhere (SHIRAYAMA, 1992). *Paramonohystera* sp. used for the measurement of ingestion rate were collected from a bathyal depth of the Suruga Bay, central Japan using a box corer at station A3 of the R.V. Tansei-Maru cruise KT-86-01. The sampling station was situated at 35° 00.96′ N and 138° 41.18′ E at a depth of 1214 m. *Paramonohystera* sp. was by far more abundant than other nematode species at this station.

Immediately after the sampling, subsamples of the sediment were taken using acrylic-resin subcores (3.6 cm in inner diameter) on board ship. They were kept in cool (5° C), and transferred into a laboratory on land for the tracer experiments.

Tritiated thymidine or ^{14}C-amino acid

mixture was inoculated into the overlying water of each subcore and stirred gently. Then subcores were incubated at 5° C for 0, and 270 minutes, and finally formalin was added to stop the experiments.

An aliquot of sedment sample was taken and washed with sea water on the millipore filter of 0.2 μm opening. The radioactivity of the filter was measured using a liquid scintillation counter to measure the final radioactivity of the particulate organic matter in the sediment.

Another aliquot of the sediment was taken to count bacterial abundance. The microbes were stained with DAPI, and their number was counted under a fluorescent microscope. *Paramonohystera* specimens were sorted out under a binocular dissecting microscope from the sediment which was washed with 100 μm mesh sieve. After drawing its lateral view using camera lucida to measure the body mass, each individual was digested by soluene 100 in a scintillation vial. Liquid scintillator was added into each vial and the radioactivity was measured using a liquid scintillation counter.

3. Results

Respiration rate of the *Paramonohystera* species used in the ingestion rate measurement was not measured. To discuss the energy budget of the nematode, the value of the same species (0.78 nl O_2 hr^{-1}) collected at another area in another cruise will be used in the present study. It should be noticed that spatial difference is not very large for the respiration rate of the deep-sea nematodes (SHIRAYAMA, 1992). Above value was standardized for an individual of 1 nl in body mass using the method of HEIP *et al*, (1985). According to them, respiration of 1 ml oxygen is equivalent to consumption of 0.4 mg carbon. Using this conversion facter, the respiration rate of *Paramonohystera* was estimated as 0.31 ngC hr^{-1} ind^{-1}.

In the experriment using tritiated thymidine as a tracter, the ingestion rate of *Paramonohystera* sp. of the same body mass was measured as 1.4 nl sediment hr^{-1} ind^{-1}.

This result was not reasonable because it meant a nematode individual ingested more volume of sedment than its own every hour. On the basis of the abundance of bacteria in the sedment (3×10^9 cells cm^{-3} sediment) and the radioactivity of the sedimentary particles (3.7×10^5 DPM cm^{-3} sediment), the label of single bacterium was calculated as 1.2×10^{-4} DPM. Assuming the nematode ingested bacteria selectively, these value lead to the figure that *Paramonohystera* sp. ingested 7,400 bacterial cells hr^{-1} ind^{-1}. Assuming the amount of organic carbon in a single bacterium as 10^{-13}gC $cell^{-1}$, *Paramonohystera* sp. was estimated to ingest 0.74 ngc hr^{-1} ind^{-1}

When ^{14}C-amino acid was used as a tracer, the ingestion rate of the same animal was caculated to be as high as 35,000 cells hr^{-1} ind^{-1}. I assumed the difference of measured ingestion rate between the two experiments was a result of the direct absorption of the dissolved amino acid by the nematode from

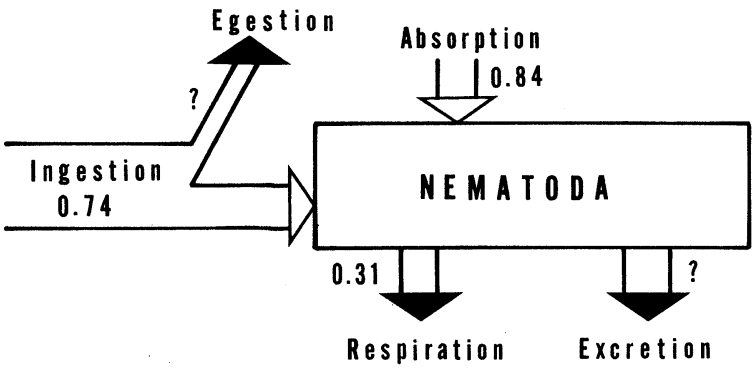


Fig.1. Diagram showing the energy balance of a deep-sea nematode.

the pore water. The radioactivity of DOC was estimated as 0.53 DPM ngC^{-1}. Assuming that DOC concentration was constant during the experiment, the absorption rate of *Paramonohystera* could be calculated as 0.84 ngC hr^{-1} ind^{-1}. The summary of measurements is shown in Fig. 1 schematically.

4. Discussion

The ingestion rates of a nematode measured using a ^{3}H- Thymidine as a tracer pointed out that *Paramonohystera* ingested about twice as much energy as they respired. This figure does not necessarily mean the nematode can obtain enough energy by means of ingestion, because it is impossible to assimilate all the ingested material, even though the animal seemed to feed on particulate organic matter selectively. When amino acid was used as a labeled substance, they seemed to obtain more energy which might be enough to balance their energy consumption by their active respiration. These results suggests that DOM plays important role as a energy source of deep-sea nematode.

MONTAGNA (1984b) has reported that shallow-water meiobenthos uses glucose as its energy source. Recently, the present author found numerous tubercles in the anterior region of other deep-sea nematode species belonging to the genus *Desmoscolex* (SHIRAYAMA, and Hope 1992) in the way of scanning electron microscopic observation. This ultrastructure may also suggest utilization of DOM by deep-sea nematodes.

Further studies are however clearly necessary to prove the above idea. It is especially desired to carry out *in situ* tracer experiments in the deep sea using a manned submersible.

Acknowledgments

The author would like to express his sincere gratitude to the officers and crew of .V. Tansei Maru of his institute and of manned-submersible "Shinkai 2000" of JAMSTEC for their help in sampling deep-sea sediments used in the pressent study. This research was partially supported by the grant-in-aid of the Ministry of Education, Science and Culture, Japan, No. 59480004, 61740371, 62740371 and 02740317.

References

HEIP, C., M. VINCX and G. VRANKEN (1985): The ecology of marine nematodes. Oceanogr. Mar. Biol. Ann. Rev., **23**, 399-489.

MONTAGNA, P. (1984a): *In situ* measurement of meiobenthic grazing rates on sediment bacteria and edaphic diatoms. Mar. Ecol. Prog. Ser., **18**, 119-130.

MONTAGNA, P. (1984b): Competition for dissolved glucose between meiobenthos and sediment microbes. J. Exp. Mar. Biol. Ecol., **76**, 177-190.

SHIRAYAMA, Y. (1992): Respiration rates of bathyal meiofauna collected using a deep-sea submersible "SHINKAI 2000". Deep-Sea Res., **39**, 781-788.

SHIRAYAMA, Y. and W. D. Hope (1992): Cephalic tubercles, a new character useful for the taxonomy of Desmoscolecidae (Namatoda).Trans. Amer. Microsc. Soc., **111**, 211-212.

SMITH, K.L., Jr. and R.R. HESSLER (1974): Respiration of benthopelagic fishes: *in situ* measurements at 1230 meters. Science, **184**, 72-73.

SMITH, K.L. Jr. and N.O. BROWN (1983): Oxygen consumption of pelagic juveniles and demersal adults of the deep-sea fish *Sebastolobus altivelis*, measured at depth. Mar. Biol., **76**, 325-332.

THIEL, H. (1975): The size structure of the deep-sea benthos. Int. Revue ges. Hydrobiol., **60**, 575-606.

THIEL, H. (1979): Structural aspects of the deep-sea benthos. Ambio Spec. Rep., (**6**), 25-31.

深海産線虫類のエネルギー収支に関する予備的研究

白山　義久

パラモノヒステリダ属の一種の線虫について，深海産メイオベントスのエネルギー収支を議論するために，摂食速度と吸収速度を計測した。またその呼吸速度は別の航海で別の海域から採集した同種のデータから推定した。計測された摂食速度は非常に低く，摂食によって得られるエネルギー量は呼吸によって消費されるエネルギー量とつり合わなかった。吸収速度は摂食速度と同じ程度であった。これらの結果は溶存態有機物が粒状有機物と同様に深海産の線虫類のエネルギー源として重要であることを示唆している。

La mer 29; 174, 1991
Société franco-japonaise d'océanographie, Tokyo

Deep-sea benthic life and related biological processes as a response to organic matter fluxes in the ocean. Recent results in the North Atlantic Ocean. (Abstact)

Myriam SIBUET*

Deep-sea benthic community structure in sedimentary environment of the Atlantic ocean has been established at different levels of organization: the general level including the totality of the benthic fauna and the single organism level to describe the role of nutrition of deposit feeders like holothurians at the sediment-water interface.

Spatial variations of the trophic conditions (supply of organic matter) in six different geographic areas are compared with the quantitative distribution of the three large dimensional categories of abyssal fauna obtained from an intensive sampling strategy during 12 cruises. Meiofaunal, macrofaunal and megafaunal (mainly deposit feeders) abundances have between themselves and with the food input, significant correlations and a constant linear (for meio and macrofauna) or exponential (for megafauna) relationship between sampling sites. Therefore the general structure of the deep-sea benthic communities tends to be in equilibrium with the trophic resources.

The role of deposit feeders to consume and recycle the organic matter can be estimated from nutrition studies of holothurians. Holothurians select the richest particles and assimilate, with the help of bacterial activity, near 20% of the the ingested organic matter, mainly proteins and lipids and several tens of milliigrams of organic carbon during the intestinal transit. But time's scale studies and *in situ* experiments with manned submersibles have been developed in order to evaluate the spatial and temporal variations of the energetic needs in the deep-sea ecosystem.

*IFREMER, Centre de Brest, BP70, 29280 Plouzané, France

La mer 29: 175-179, 1991
Société franco-japonaise d'océanographie, Tokyo

Size distribution and abundance of phytoplankton in the Pacific equatorial upwelling

Aubert Le BOUTEILLER* and Jean BLANCHOT*

Abstract: In January 1991, the equatorial Pacific enrichment area covered a belt more than 11000 km long, with surface nitrate concentration up to 11 μM near the Galapagos islands, decreasing westwards and desappearing beyond 167°E. In this area, the amount of chlorophyll *a* (Chla) did not change significantly from one end of the upwelling to the other, and was very low everywhere. The size structure of chlorophyll *a* was also nearly constant from 95°W to 167° E : on the average, Chla $>3\mu$m and Chla$<1\mu$m represented 27% and 39% respectively all along the equator, with correlative uniform distributions of phycoerythrin-containing cyanobacteria (*Synechococcus* sp.) and chlorophyll-fluorescing microalgae.

Schematically, in spite of the typical longitudinal gradients of temperature and nutrients, all data of chlorophyll, size distribution and cell numbers cliarly indecate that an extreme monotony characterizes the distribution of phytoplankton all along the enrichment area due to the equatorial upwelling, covering 11 million km^2 for mean upwelling conditions.

1. Introduction

Various recent studies have shown that in the tropical open ocean, the size structure of phytoplankton seemed to be typically distributed (HERBLAND *et al.*, 1985, 1987; PEÑA *et al.*, 1990; LE BOUTEILLER *et al.*, 1992). In the nitrate depleted mixed layer of the equatorial Atlantic Ocean as well as in the one of the western Pacific Ocean, Chl a in the $<1\ \mu$m fraction was found to be always predominant.In the nutrient-rich waters, more than half of the total Chla was systematically contained within the $>1\ \mu$m fraction in which eucaryotic microalgae predominated. No major difference distinguished phytoplankton forming the deep chlorophyll maximum from phytoplankton observed in surface waters enriched by the equatorial upwelling. On the contrary, the size structure of phytoplankton usually observed in these nutrient-rich tropical waters is quite different from the size of algae in coastal upwellings (HERBLAND et al., 1987) or in temperate or cold nutrient-rich waters (STOCKNER and ANTIA, 1986; RAIMBAULT *et al.*, 1988). Therefore, the size distribution of phytoplankton would be one of the most significant properties of the Typical Tropical Structure such as defined by HERBLAND and VOITURIEZ (1979).

However, such a generalization is always risky as far as the size structure of phytoplankton is not determined everywhere in the tropical ocean, and especially in the poorly known Pacific equatorial upwelling. So, a wide study of the distribution of phytoplankton associated with physical and chemical properties, was performed during the ALIZE cruise stretching all along the equator from 95°W to 165°E.

2. Methods

All the methods used were described by REVERDIN *et al.*(1991). Total Chla (100ml) was collected on GF/F filters at 9 or 10 depths. Chla in the fractions was estimated on subsamples (260 ml) filtered on Nuclepore polycarbonate filters (1 and 3 μm), always at<30 mm of Hg vacuum pressure. Samples

*ORSTOM, B.P.A 5, Nouméa, New Caledonia

for cell counts (60 ml) were collected according to BLANCHOT *et al.*(1992) on black 0.2 μm Nuclepore filters. All filters were frozen for a later analysis at the laboratory: Chla with the methanol method and cell counts by epifluorescence microscopy.

3. Results and discussion

Position of the stations is shown on Fig. 1. The equatorial upwelling was well developed in January 1991. Nitrate was present at surface ($NO_3 > 0.1\ \mu M$) at every station from 95° W (maximum 11 μM) to 169° E and on all the meridional transects, except south of 11° S at 150° W and westwards beyond 168° E (Fig.2). Surface temperature rised from 22° 8 C at 95° W to 29° 4 at 173° E.

The amount of surface Chla (mean for the 0-20m layer) did not change significantly from one end of the upwelling to the other,

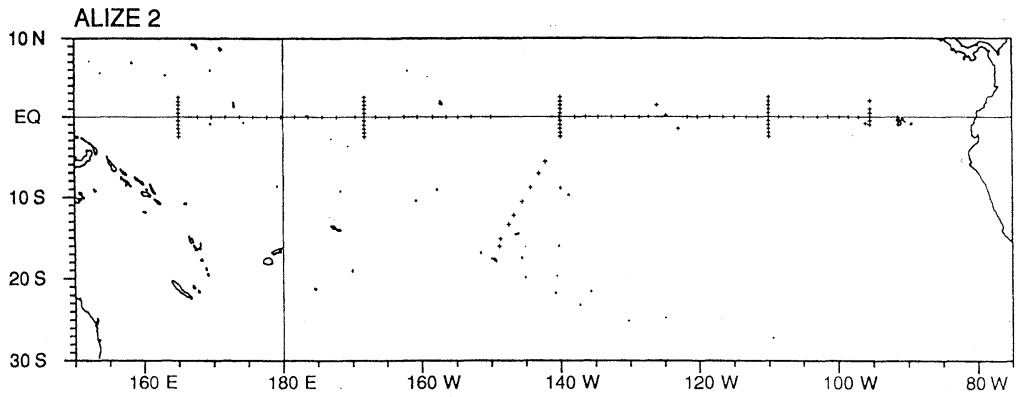


Fig. 1. ALIZE II cruise. January-Fabruary 1991. Location of stations from 95° W to 165°E

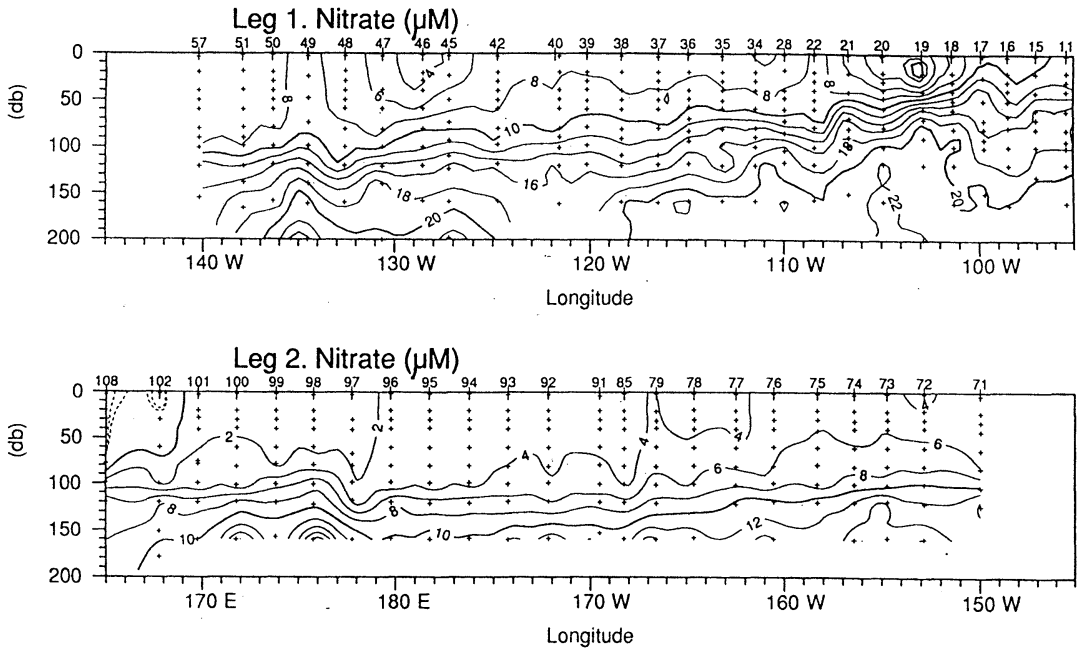


Fig. 2. Nitrate distribution (μM) along the equator.

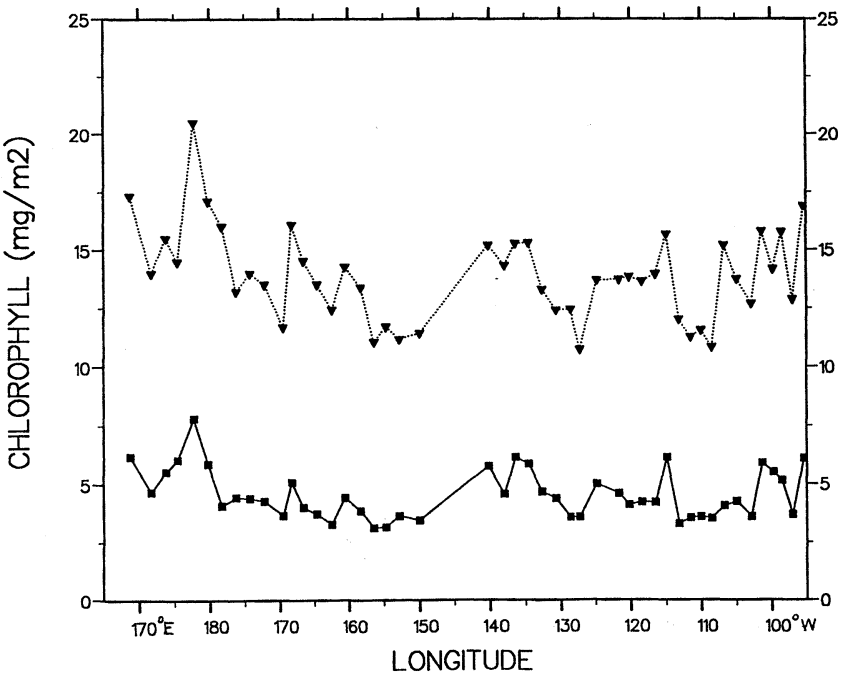


Fig. 3. Depth integrated values of chlorophyll *a* along the equator (mg m^{-2}). Squares: 0-20m layer. Triangles: euphotic layer.

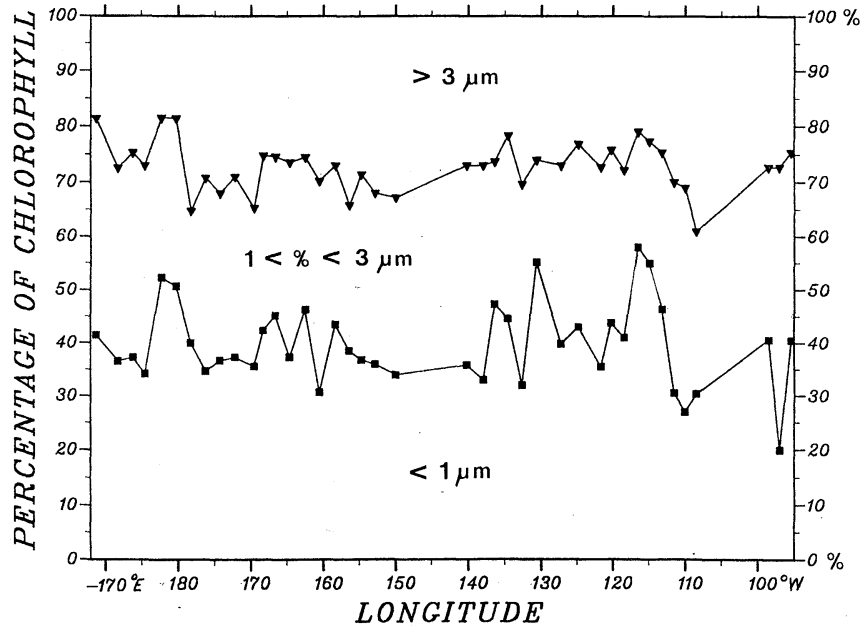


Fig. 4. Relative size distribution of Chla within the euphotic layer along the equator.

and was very low everywhere: Chla=0.215 mg m^{-3} (mean of 55 stations) from 95° W to 145° W, and Chla=0.218 mg m^{-3} (n=35 stations) from 150° W to 169° E (Fig.3). Surface Chla maximum was only 0.402 mg m^{-3}. These values are quite similar to those obtained by the same method at 165° E during the 6 transects of the ORSTOM programmes (i.e. PROPPAC and SURTROPAC) which have crossed the equatorial upwelling since 1988: surface Chla (0-20m layer)=0.231 mg m^{-3} (mean of 57 stations).

During the ALIZE I cruise in 1965, covering the same area as ALIZE II, the equatorial upwelling presented nearly the same spreading (GUEREDRAT, 1971). Chla was collected on Millipore HA 0.45 μm filters and analysed on a spectrophotometer after acetone extraction. The mean surface Chla (0-20m layer) was 0.192 mg m^{-3} (n=17) from 94° W to 140° W and 0.194 mg m^{-3} (n=13) from 146° W to 174° E, without any high Chla value in nutrient-rich waters, even when surface NO_3 was up to 13 or 14 μM at 95° W.

The Chla content of the euphotic layer was calculated according to MOREL (1988). The mean values were respectively 13.1 and 13.8 mg m^{-2} in the eastern and western parts of the Pacific in 1991 (Fig.3), and 14.3 mg m^{-2} at 165° E

These depth distributions of Chla are quite similar to those reported by CHAVEZ *et al.* (1990), showing low Chla values along the equator from 110° W to 140° W. CULLEN *et al.*(1992) also observed similar Chla profiles at 0°, 150° W. CHAVEZ and BRUSCA (1992) presented means of surface mitrate and surface Chla along the equator calculated on data collected from 1980 to 1988: surface Chla concentrations are regularly low from west of the Galapagos to the end of the upwelling, near 165° E.

The size structure of chlorophyll *a* appeared nearly constant from 95° W to 167° E: on the average, Chla > 3 μm represented 27% and 28% of total Chla in the eastern and western equatorial Pacific respectively, and never exceeded 39%. Chla <1 μm=39% (mean of 42 profiles) all along the equator (Fig.4). These size distrbutions are not different from those observed at 165° E in the western part of the equatorial upwelling by LE BOUTEILLER *et al.* (1992): Chla <1 μm=38% (n=26). PENA *et al.*(1990) also found that Chla <1 μm = 40% on the average (n=6 profiles) in the upwelling at 135° W, but CHAVEZ (1989) reported a mean Chla content of 62.4% in the < 1 μm fraction at 110° W(n=6), which seems atypically high for equatorial nutrient-rich waters.

Besides, counts of cells by epifluorescence microscopy at 48 hydrocasts distributed between 95° W and 169° E revealed that the euphotic zone contained on the average 4.2 10^{11} cyanobacteria per m^2 and 2.1 10^{11} eucaryotic microalgae per m^2, without any bloom anywhere.

Consequently, in spite of the typical longitudinal gradients of temperature and nutrients showed by the equatorial transects of both ALIZE I and ALIZE II cruises and by the analysis of historical data, all the biomass indexes available today clearly indicate that an extreme monotony characterizes the distribution of phytoplankton all along the enrichment area due to the equatorial upwelling. Exactly the same experimental procedures were used to perform the Chla fractionations and the cell enumerations during the ALIZE II cruise, so that the phytoplankton properties are described as reliably as possible from 95° W to 165° E. The relative abundance of large algal cells such as diatoms observed in the eastern equatorial Pacific by DESROSIERES (1969) and CHAVEZ *et al.* (1990) or suspected by BENDER and MCPHADEN (1990) seem to be locally and temporally restricted, and do not induce significant changes of Chla (<1 μm, >3 μm and total) or cell numbers (cyanobacteria and eucaryotic microalgae) from the west of the Galapagos to the end of the upwelling.

As a conclusion, when mean conditions prevail, the typical monotonous distribution of phyto-plankton strongly suggests that primary production, new production and

particles exportation are probably also uniformly distributed through the pacific equatorial system.This result is important to be considered in the near future, especially for global scale studies such as the JGOFS programme.

References

BENDER, M.L.and M.J. MCPHADEN (1990): Anomalous nutrient distribution in the equatorial Pacific in April 1988: evidence for rapid biological uptake. Deep-Sea Res., **37**, 1075-1084.

BLANCHOT, J., M. RODIER and A. LE BOUTEILLER (1992): Effect of El Niño Southern Oscillation events on the distribution and abundance of phytoplankton in the Western Pacific Tropical Ocean along 165° E. J. Plankton Res., **14**, 137-156.

CHAVEZ, F.P. (1989): Size distribution of phytoplankton in the central and eastern tropical Pacific. Global Biogeochem. Cycles, **3**, 27-35.

CHAVEZ, F.P., K.R. BUCK and R.T. BARBER (1990): Phytoplankton taxa in relation to primary production in the equatorial Pacific. Deep-Sea. Res. **37**, 1733-1752.

CHAVEZ, F.P. and R.C. BRUSCA (1992): The Galapagos Islands and their relation to oceanographic processes in the Tropical Pacific. **In**: Galapagos Marine Inverte brates. Topics in Geobiology. Vol.10 (M.J. James, ed.) Plenum Press, N.Y., 24pp.

CULLEN, J.J., M.R. LEWIS, C.O. DAVIS and R.T. BARBER (1992): Photosynthetic characteristics and estimated growth rates indicate grazing is the proximate control of primary production in the equatorial Pacific. J. Geophys. Res., **97**, 639-654.

DESROSIERES, R.(1669): Surface macroplankton of the Pacific Ocean along the equator. Limnol. Oceanogr., **14**, 626-632.

GUEREDRAT, J.A. (1971): Evolution d'une population de copépodes dans le systéme des courants équatoriaux de l'Océan Pacifique Zoogéographie, écologie et diversité spécifique. Mar. Biol., **9**, 300-314.

HERBLAND, A. and B.VOITURIEZ (1979): Hydrological structure analysis for estimating the primary probuction in the tropical Atlantic Ocean. J. Mar. Res., **37**, 87-101.

HERBLAND, A., A. LE BOUTEILLER and P. RAIMBAULT (1985): Size structure of phytoplankton biomass in the equatorial Atlantic Ocean. Deep-Sea Res., **32**, 819-836.

HERBLAND, A., A. LE BOUTEILLER and P. RAIMBAULT (1987): Does the nutrient enrichment of the equatorial upwelling influence the size structure of phytoplankton in the Atlantic Ocean ? Oceanol. Acta, N° Sp. proc. Internat. Sympos. on Equatorial Vertical Motion, Paris, 6-10 May 1985, p. 115-120.

LE BOUTEILLER, A., J. BLANCHOT and M. RODIER (1992): Size distribution patterns of phytoplankton in the western Pacific: towards a generalization for the tropical ocean. Deep-Sea Res., 39, 805-823.

MOREL, A. (1988): Optical modeling of the upper ocean to relation to its biogenous matter content (case ① waters). J. Geophys. Res., **93**, 10749-10768.

PEÑA, A., M.R. LEWIS and W.G.HARRISON (1990): Primary productivity and size structure phytoplankton biomass on a transect of the equator at 135° W in the Pacific Ocean. Deep-Sea., Res. **37**, 295-315.

RAIMBAULT, P., M. RODIER and I.TAUPIER-LETAGE (1988): Size fraction of phytoplankton in the Ligurian Sea and the Algerian Basin (Mediterranean Sea): size distribution versus total concentration. Mar. Microdiol. Food Webs., **3**, 1-7.

REVERDIN, G., A. MORLIERE and G. Eldin (1991) : ALIZE 2, Campagne océanographique Trans-Pacifique (Jan-vier-mars 1991). Rapport interne LODYC 91/13. Octobre 1991. Univ. P. et M. Curie, Paris V ①. 341p.

STOCKNER, J.G. and N.J.ANTIA (1986): Algal picoplankton from marine and freshwater ecosystems :a multidisciplinary perspective. Can. J. Fish. Aquat. Sci., **43**, 2472-2503.

La mer 29; 180, 1991
Société franco-japonaise d'océanographie, Tokyo

Primary production in Tokyo Bay and material flux to the open ocean (Abstract)

Takashi I SHIMARU*

Tokyo Bay is one of the most polluted Bay in the world. 110,000 ton of nitrogenous nutrients are annually loaded, and 90% of them are exported to the open sea. Growth of phytoplankton in Tokyo Bay seems to be limited not by nutrients but by physical conditions. Chlorophyll concentration is usually high in summer, but seasonal variation is not clear. Large scale fluctuation was observed in a short time by the influence of offshore water. Multidisclinary study on the water exchange and material flux at the mouth of the bay has been conducted. Intermittent outflow of surface and bottom wter occurres in summer by the intrusion of offshore water to the intermedite layer. Thermohaline front develops in cold winter and mixes the bay water and offshore water, and transports the mixed water to the bottom of Tokyo Bay and to the mid depth of the open sea. Our recent study using sediment trap shows a new mechanism of material transport by the vertical differences in tidal current velocity at the shelf edge.

*Tokyo University of Fisheries, 4-5-7
Konan, Minato-ku, Tokyo, 108 Japan

La mer 29: 181-182, 1991
Société franco-japonaise d'océanographie, Tokyo

Nitrogen cycling in the upper layer of the open ocean as an indicator of organic fluxes

B. COSTE* and G. SLAWYK*

Introduction

For a part, interest in the studies on the biogenic element cycles, and more specifically studies on nitrogen, comes from the ability these elements give to reach the flux of organic matter from the euphotic zone.

Recent advances in the studies related to the nitrogen cycle

Over the last few years, many new results contributed to a better understanding of several processes related to the nitrogen cycle in the oceans. These results led to a new insight on the role this biogenic element plays in the studies on particle flux.

According to Dugdale and Goering, "new production" represents uptake of nitrate coming up from below the seasonal thermocline. "New production" is assumed as being equivalent to the export flux out of the euphotic zone. This assumption appears valid if measurements are averaged over an appropriate period. It has been demonstrated that there is a significant correlation between new production and flux of particulate material at the basis of the euphotic zone.

Attempts to estimate "new production" at a basin scale from remotely sensed temperature and fluorescence are under investigation and there is a way (which is at its beginning) to extract "new production" from remote sensing. This new approach could be very fruitful in flux studies whose first step is to know the spatial and temporal variability of the new production (or the flux of the particulate material) on a basin scale.

From the measurements of dissolved orgamic carbon (DOC) and dissolved organic nitrogen (DON) by SUZUKI *et al.* and SUGIMURA and SUZUKI using a high temperature combustion technique it appears that the concentrations of DOC would be 4 to 5 times higher in surface waters and 2 to 3 times higher in deep waters than previously measured. Though there still remains controversy about these new data on DOC and DON, we begin to realize that dissolved organic nutrients play a significant role in nutrient cycling.

Recent studies on nitrogen cycling done in French laboratories

The nitrogen cycle in the open ocean is being studied in France by laboratories of the University of Bretagne Occidentale and of the University of Marseilles. Similar works are being conducted in the ORSTOM agency, especially in Noumea.

We have essentially been active in two fields. First, we investigated nitrate fluxes in the upper layer of the oligotrophic ocean. This has been possible thanks to the development of an automatic colorimetric method for measuring nitrate concentrations lower than 100 nM with a detection limit of about 2 nM. This new method allows us to look at very low gradients of nitrate in the upper layer (1 nM/m) and to precisely monitor the disappearance of nitrate in field and laboratory experiments (uptake of nitrate by phytoplankton).

Nitrate above the thermocline may also originate from bacterial *in situ* nitrification. Therefore, the source of nitrate above the thermocline is a fundamental question. If the source is external, from deeper water as mentioned previously, then production associated with that nitrate is

*Centre d' océanologie de Marseille. Campus de Luminy. Case 901-F 13288, Marseille, Cedex 09

new production. If it is from nitrification taking place within the mixed layer, then the resulting production is regenerated production. Very recently, we developed a procedure using the isotope dilution approach to estimate nitrification in the north-east Atlantic. With this technique, we were able to detect and to quantify nitrification activity within the euphotic zone.

The second field in which we have been involved for only a short time is the role of DON in the nitrogen cycle of the oligotrophic ocean. We significantly improved a wet-oxidation method which allows us to better describe the distribution pattern of DON in the field and include these new data into those obtained from nutrient chemistry and hydrological survey.

As far as the role of DON in nitrogen cycling is concerned we still know very little about it. Only urea has been extensively studied. Using the ^{15}N tracer, it has been clearly shown that this organic compound is a preferential nitrogen source for marine phytoplankton. However, we don't have much information about how urea is recycled in the sea. Which are the organisms responsible for urea production ? What are the rates ?

These questions led us to the development of an isotope dilution approach using the ^{15}N tracer to examine the role of microheterotrophs in urea regeneration. Similar vertcal patterns of uptake and regeneration of urea seem to indicate that these microheterotrophs probably sustain totally the urea demand of phytoplankton.

Inspecting many data on inorganic nitrogen uptake as well as urea uptake showed that the amount of ^{15}N disappearing from the dissolved fraction is very often higher than the amount of ^{15}N which appears in the particulate fraction. One hypothesis, that has been put forward by many workers, is that phytoplankton excretes ^{15}N-labelled DON. This observation strongly calls for the need of considering the DON compartment when one will obtain correct estimates of nitrogen fluxes between substrates and biomass.

This hypothesis concords fairly well with the scenario of the functioning of the food web or microbial loop in the oligotrophic ocean. According to this scenario DON, mainly excreted by phytoplankton, is consumed by bacteria which themselves become the prey of nanoplankton. Backflow of inorganic nitrogen towards autotrophs is ensured by ammonium regeneration of microheterotrophs.

From these results emerges a new conceptual scheme of the functioning of the oligotrophic ocean: surface waters can contain trace quantities of nitrogen, especially ammonium, but also nitrate; small organisms are predominant and form a very complicated food web, called microbial loop, in which DON probably plays an important role; the spatial and temporal variability of physical, chemical and biological parameters is undoubtedly higher than previously thought.

La mer 29: 183-189, 1991
Société franco-japonaise d'océanographie, Tokyo

Shelf edge exchange processes of radionuclides in the East China Sea

Yoshiyuki NOZAKI*

Abstract: Two naturally occurring radionuclides, ^{228}Ra and ^{210}Pb are very useful in the study of shelf-edge exchange processes at the ocean margins. ^{228}Ra can be used to determine the residence time of water on the continental shelf and ^{210}Pb can be used as a tracer of particle-reactive heavy metals in the water. Particular application of these nuclides to the East China and Yellow Seas yielded the shelf water residence time of 2.3 years with respect to exchange with the Kuroshio water and the ^{210}Pb scavenging residence times of ~2 months on the shelf and ~7 months in the Kuroshio surface water.

Introduction

The East Asian land-ocean boundary region probably has a significant influence on the global environment, yet detailed studies have been few. One of the unique features of this region is the existence of a series of marginal seas including the Bering Sea, Sea of Okhotsuk, Sea of Japan, the East China, and South China Sea, all of which have isolated basins deeper than 3000 meters. Therefore, materials transported from the land to the sea must be modified in this marginal region before entering to the open ocean. I describe here the exchange of water and radionuclides between the shelf water of the East China Sea and the Kuroshio Current.

The East China and the Yellow seas (Fig.1) are largely occupied by the continental shelf shallower than 200 meters. The water on the shelf has the salinities of lower than 33 PSU due to fresh water discharge from land largely through the Yangtze and Yellow rivers. A sharp front is formed along the shelf edge between the shelf water and a branch of the Kuroshio Current which flows offshore northward and enters the Japan Sea through the Tsushima Straits. The Tsushima Current, which flows along the Japanese Island and passes the Tsugaru and Soya straits to enter the Pacific, is believed to be formed by mixing the shelf water of East China Sea and the Kuroshio. Therefore, it is a major pathway by which materials are transported from East Asian continental shelf to the North Pacific.

Two natural radionuclides in the U/Th decay series are supplied to the coastal/shelf region via two distinctly different pathways. One is ^{228}Ra with a half-life of 5.75 years and supplied by diffusion from underlying sediments to the water, after its production from ^{232}Th in sediments (MOORE, 1969). Some ^{228}Ra is also transported by rivers, but it is believed that the desorption of Ra from river suspended particles is a predominant source compared to the input in dissolved form. Because of these inputs of ^{228}Ra, the shelf water contains high ^{228}Ra concentration compared to the open ocean surface water, and the ^{228}Ra is transported from the coastal regions to the offshore by lateral mixing.

The other nuclide is ^{210}Pb with a half-life of 22.3 years which is a daughter product of atmospheric ^{222}Rn, and enters to the ocean suface by dry and wet precipitation. Because of this atmospheric input, ^{210}Pb is normally present in excess relative to the in-situ production from ^{226}Ra in the surface waters and serves as a useful indicator of terrestrial materials transported through the atmosphere (NOZAKI *et al.*, 1976). This is in contrast to ^{228}Ra which is a good indicator of

*Ocean Research Institute, University of Tokyo Nakano-ku, Tokyo, 164 Japan

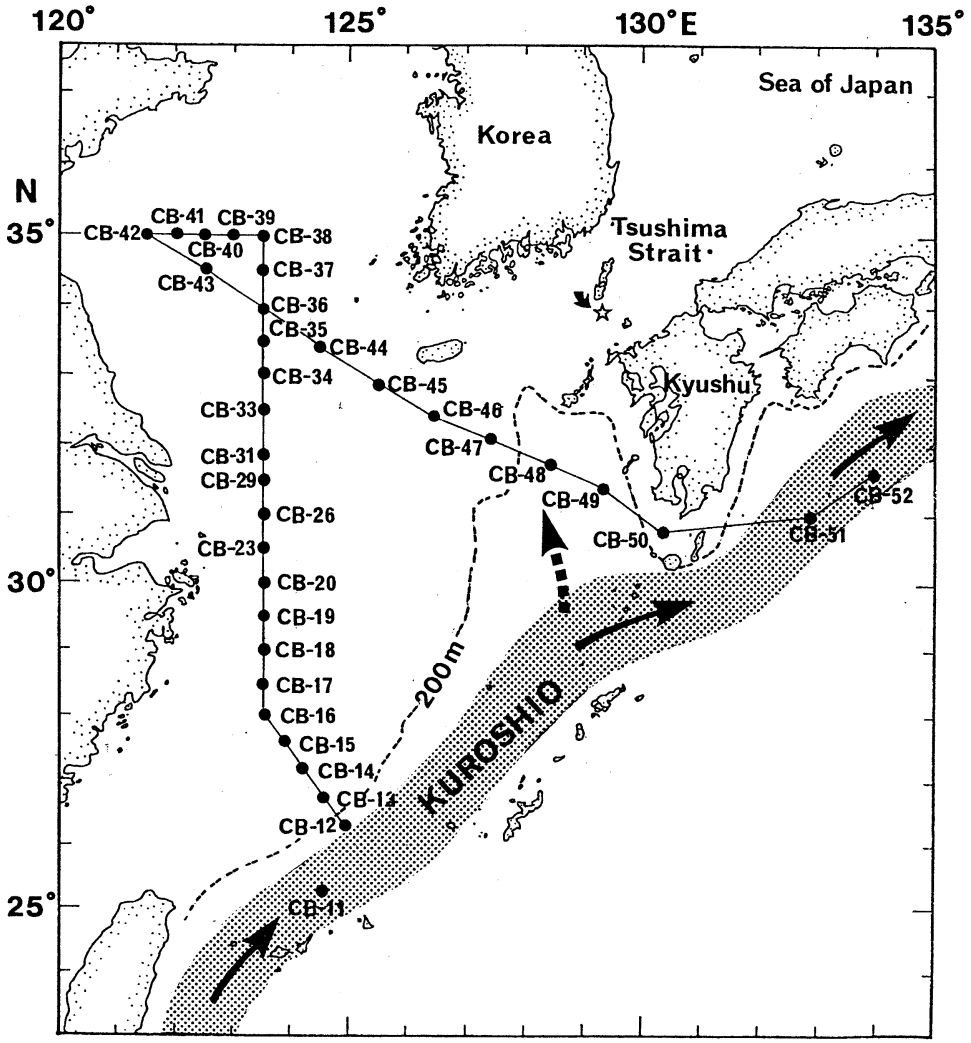


Fig. 1. Station locations of the Corona Borealis Expedition at which the surface water was sampled for radium isotope assay. The star indicates the location where Okubo's measurements are available for the Tsushima Current water.

coastally and fluvially derived substan-ces.

^{210}Pb is also particle-reactive and removed from the surface water more rapidly in the high particle flux regime of coastal waters than in the low particle flux regime of the open ocean. This would result that the concentration of ^{210}Pb is higher in the open ocean and decreases toward the coast, unlike that of ^{228}Ra which is high on the shelf and low in the open ocean. Thus, investigation of the comparative behavior of these two nuclides should help us to understand the exchange processes at the nearshore/offshore mixing zone.

Methods and Results

Fig.1 shows the station locations where the surface water was sampled. These stations were occupied by the Corona Borealis expedition of R.V. Hakuho-Maru, in 1987. The Yangtze river influences are the strongest at the station around CB-31 as indicated

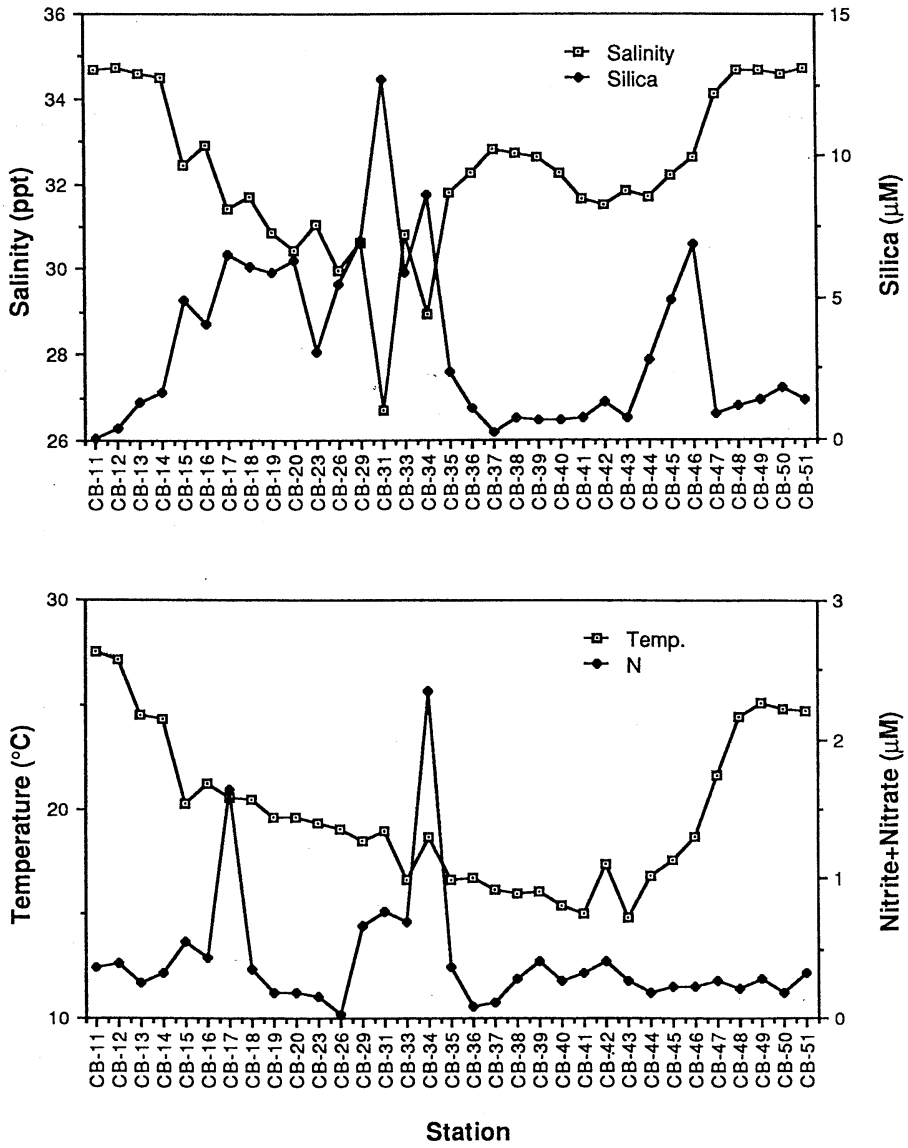


Fig. 2. The results of temperature, salinity, dissolved silica and inorganic nitrogen (nitrate+nitrite). See Fig. 1 for the station locations.

by the salinity decrease down to 26.5 PSU and the high dissolved Si concentration (Fig.2). ^{228}Ra and ^{226}Ra were analyzed by γ-spectrometry according to the method of YAMADA and NOZAKI (1984) using 250 l of seawater. ^{210}Pb and ^{210}Po were analyzed on the separate aliquots (3 l each) of water samples following the methods of NOZAKI *et al.* (1990).

The results of Ra isotopes (Fig.3) show that, as expected, ^{228}Ra concentration is very high on the shelf and the highest in the Yellow Sea, but very low in the Kuroshio Current. ^{226}Ra shows similar tendency, but because of its relatively long half-life of 1600 years, the variation is smaller than

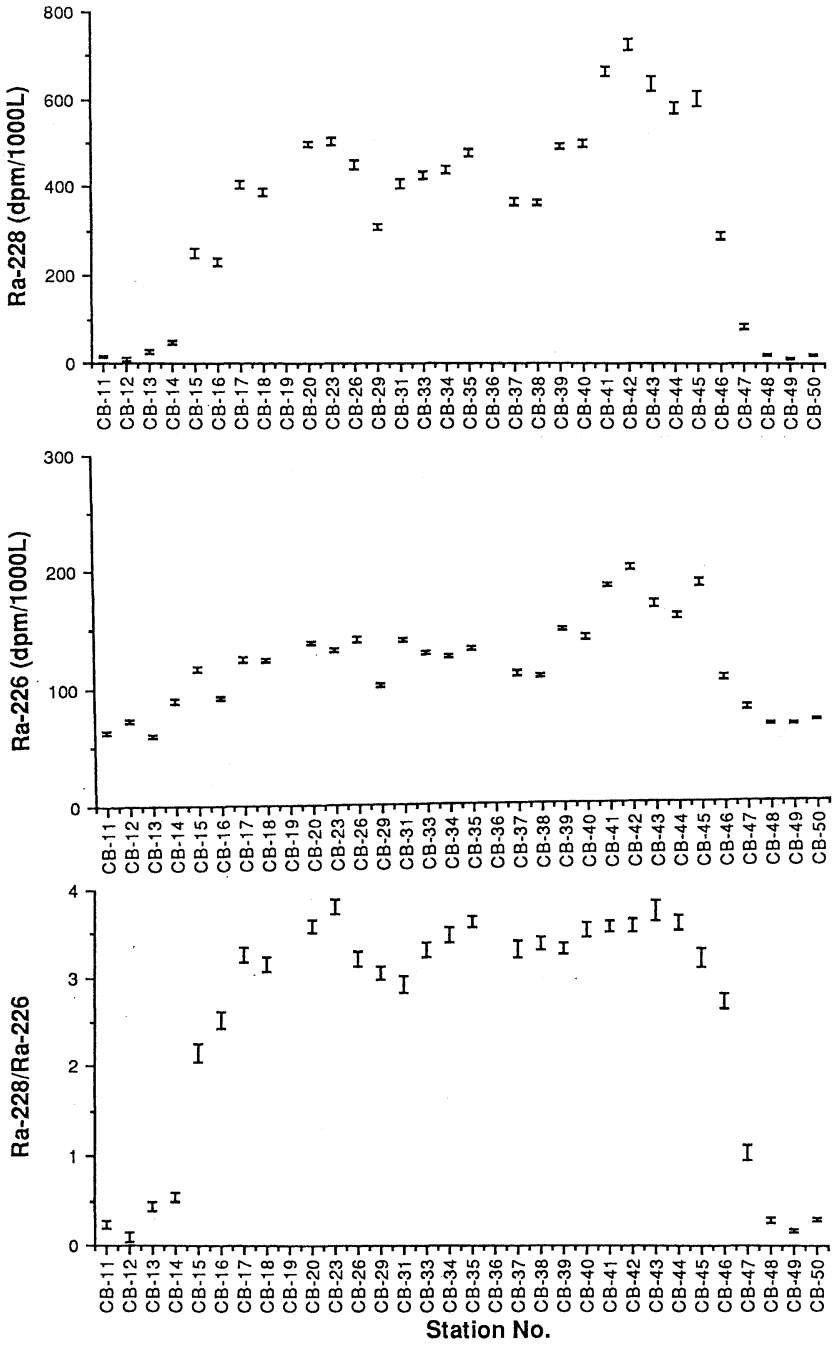


Fig. 3. The results of ^{228}Ra, ^{226}Ra and the activity ratio of $^{228}Ra/^{226}Ra$. Error bars are based on 1 sigma counting errors.

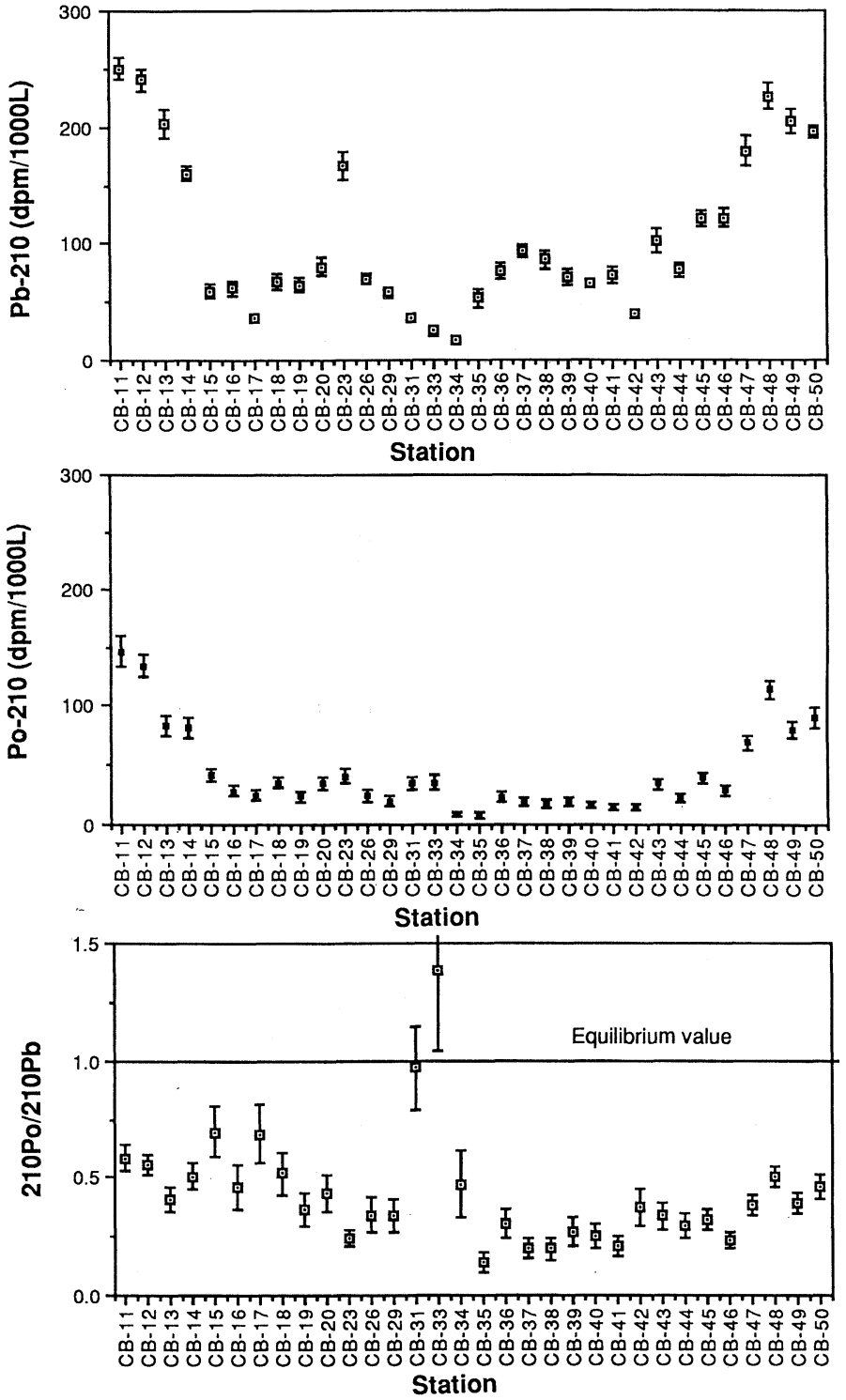


Fig. 4. The distributions of ^{210}Pb and ^{210}Po, and their activity ratio in the East China and the Yellow Seas. See Fig. 1 for the station locations.

that of ^{228}Ra. The Yangtze river influence appears to be small on the Ra distribution, which suggests that the concentrations of Ra isotopes in the river water do not significantly different from those of the shelf waters. The activity ratio of ^{228}Ra/^{226}R a, is about 3.5 on the shelf and 0.2 in the Kuroshio Current.

The distribution of ^{210}Pb is contrasting to that of ^{228}Ra, showing the higher concentrations in the Kuroshio and the lower concentrations on the continental shelf (Fig.4). The same is true for ^{210}Po. The ^{210}Po/^{210}Pb ratio is normally less than 0.5, except for the Yangtze mouth stations, where it rises to an equilibrium value presumably due to input of old detrital materials.

Discussios

Based on the Ra data, it is possible to calculate the exchange rate of water aceoss the shelf edge. One of the approaches is based on the assumption that the Tsushima Current is a mixture of the East China Sea shelf water and the Kuroshio Current. Since the flux of water passing through the Tsushima Straits is known to be $\sim 3\times10^6$ m^3/s, we can estimate the flux of water leaking out of the shelf, once the mixing ratio is known. The fraction of shelf water (f) contributed to the Tsushima Current is given by

$$f=[(\frac{^{228}Ra}{^{226}Ra})_T-(\frac{^{228}Ra}{^{226}Ra})_K]/[(\frac{^{228}Ra}{^{226}Ra})_T-(\frac{^{228}Ra}{^{226}Ra})_K + \frac{^{226}Ra_S}{^{226}Ra_K}[(\frac{^{228}Ra}{^{226}Ra_S})-(\frac{^{228}Ra}{^{226}Ra})_T]]$$

where the subscripts, K, S and T represent the Kuroshio water, the shelf water and the Tsushima Current, respectively. Equation (1) is derived from the mass balance for Ra isotopes and is represented in terms of the^{228} Ra/ ^{226}Ra activity ratio. Using the mean values for the ^{228}Ra/ ^{226}Ra ratio and ^{226}Ra concentrations given above and the data of OKUBO (1980) in the Tsushma Current, f turns out to be 0.2, i.e. approximately 20% of the Tsushima Current is originated from the East China Sea shelf water. Because total volume of the East China Seashelf water is 4.5×10^4 km^3, the mean residence time of the shelf water with respect to exchange with the Kuroshio is estimated to be 2.3 ± 0.8 years (NOZAKI *et al.*, 1989). The error assigned is based on the fluctuation of volume transport through the Tsushima Straits.

Another way of calculation is to use the Ra balance on the continental shelf and given in NOZAKI *et al.*(1991). The water on the continental shelf is assumed to be formed by mixing between freshwater derived from land and the Kuroshio surface water. Then, the mixing ratio can be calculated from the measurement of salinity. Ra in the shelf water is composed of 1) the Kuroshio component, 2) the freshwater end member and 3) excess Ra added on the shelf resulted from the combined effect of porewater diffusion, desorption from riverborne sediments and any other possible changes like the biological uptake and release and radioactive decay. This excess Ra depends upon the residence time of water on the continental shelf.

Using these assumptions and the mass balance for Ra isotopes, the water residence times can be calculated for each water. Although the values have relatively large uncertainties, they fall about 2-3 years for the East China Sea shelf and 5-6 years for the Yellow Sea (See NOZAKI *et al.*, 1991 for details). Somewhat longer residence times for the Yellow Sea waters are consistent with the general circulation pattern in which the water tends to be trapped within the inner shelf of Yellow Sea.

Now let us calculate the removal residence time of ^{210}Pb which are essentially estimated by dividing the amount of ^{210}Pb in the surface water by the atmospheric flux of 2 dpm cm^{-2}y^{-1}. For ^{210}Po, the atmospheric flux is small, so that the ^{210}Po removal residence time is estimated using the (^{210}Po/^{210}Pb) activity ratio following the manner of NOZAKI *et al.* (1990). If we compare the calculated mean residence times of ^{210}Pb and ^{210}Po, they normally agree each other and they are $\sim$7

months in the Kuroshio water and 2-3 months on the continental shelf. Exceptions are in the Yangtze river month stations, where Po residence times become extraordinary longer. This is probably due to the contribution of old detrital materials in the samples. Another exceptions are the consistently longer Po residence time at CB-14 to CB-18, which may be indication of Po regeneration from the bottom. Nevertheless, that the scavenging residence times of ^{210}Pb and ^{210}Po are very short compared to the water residence time with respect to exchange with the Kuroshio waters, implies that heavy metals with the reactivity similar to Pb and Po supplied from land through rivers must be deposited on the shelf sediments prior to the transport to the open ocean. Thus, the continental shelf is a repository of particle-reactive weathering materials and pollutants transported from land.

It should be noted that the arguments given here are all based upon the surface data obtained by the one-time survey. It may be possible to come up with better thoughts on the shelf-edge exchange processes of East China Sea, if data for the temporal and spatial variations were obtained. These measurements remain to be done in the future.

References

MOORE, W.S. (1969): Oceanic concentration, of ^{228}radium. Earth Planet. Sci. Lett., **6**, 437-446.

NOZAKI, Y., J. THOMSON and K. K. TUREKIAN (1976): The distribution of ^{210}Pb and ^{210}Po in the surface waters of the Pacific Ocean. Earth Planet. Sci. Lett., **32**, 304-312.

NOZAKI, Y., V. KASEMSUPAYA and H. TSUBOTA (1989): Mean residence time of the shelf waters in the East China and the Yellow Seas determined by ^{228}Ra/^{228}Ra measurements. Geophys. Res. Lett., **16**, 1297-1300.

NOZAKI, Y., N. IKUTA, M. YASHIMA (1990): Unusually large ^{210}Po deficiencies relative to ^{210}Pb in the upper part of the water column of the East China and Philippine Seas. J. Geophys. Res. **95**, 5321-5329.

NOZAKI, Y., H. TSUBOTA, V. KASEMSUPAYA, M. YASHIMA and N. IKUTA (1991): Residence times of surface water and of particle-reactive ^{210}Pb and ^{210}Po in the East China and Yellow Seas. Geochim. Cosmochim. Acta, **55**, 1265-1272.

OKUBO, T. (1980): ^{228}Ra in the Japan Sea. J. Oceanogr. Soc. Japan, **36**, 263-268.

YAMADA, M. and Y. NOZAKI (1986): Radium isotopes in coastal and open ocean surface waters of the western North Pacific. Mar. Chem., **19**, 379-389.

La mer 29: 190-192, 1991
Société franco-japonaise d'océanographie, Tokyo

Oxygen and carbon isotopic composition of planktonic foraminifera tests collected with sediment traps from the Japan Trench

Tadamichi OBA*

Abstract: Numerous specimens of eleven planktonic foraminiferal species were collected with sediment traps deployed at 4000 m and 9000 m water depths in the Japan Ternch. The oxygen isotopic measurements of about 700 individual foraminiferal specimens indicate that each specimen is greatly affected by the water temperaure rather than by the oxygen isotopic ratio of the sea water in which the foraminiferal specimen grew. The depth habitats of eleven planktonic foraminiferal species are estimated by comparing the oxygen isotopic ranges of these species and the seasonal change of the water temperature at the sediment trap site. The carbon isotopic values of these species are mostly controlled by the carbon isotopic ratios of the sea water. The present results provide fundamental information on the oxygen and carbon isotopic composition of individual specimens of living planktonic foramainifera. Carbon isotopic vertical profile in paleo-ocean was reconstructed by the oxygen and carbon isotopic measurements of individual specimens of surface, subsurface, deep-water dwelling species as well as benthic foraminiferal species collected from a horizon at 6000 years B.P. in a deep sea core near the sediment trap site.

Introduction

Sediment trap experiments are critical to evaluating the caerbon fluxes in the present ocean as well as obtaining fundamental information for paleoceanographic studies. In the present study, the oxygen ($^{18}O/^{16}O$) and carbon ($^{13}C/^{12}C$) isotopic ratios of the planktonic foraminiferal tests collected in sediment traps were measured in order obtain isotopic data on the ecology of individual specimens of living planktonic foraminifera. Sediment trap samples were recoveved from 4000 m and 9000 m water depths in the Japan Trench (approximately 34° 10′ N, 141° 58′ E, water depth: about 9200 m). Samples were collected at intervals of about 20 days from August, 1986 to November, 1988 using time series traps of Mark six type by Drs. NOZAKI, HANDA, and HONJO. The oxygen and carbon isotopic ratios of about 700 specimens of eleven planktonic foraminiferal species were measured individually by OBA and UOMOTO (1989) and UOMOTO (1990) with a Finnigan MAT 251 mass spectrometer possessing a small inlet system.

*Department of Geology, College of Liberal Arts, Kanazawa University, 920 Japan

Results

The oxygen isotopic results of surface dwelling species, such as *Globigeinoides sacculifer* and *Globigerinoides conglobatus*, indicate a distinct seasonal change in the isotopic values. The light oxygen isotopic values are observed in the specimens living in the surface water during summer, while heavy values occur in specimens from the subsurface water during winter. The total range of the oxygen isotopic values of *Globigerinoides sacculifer* is between −4.1‰ and −1.1‰ vs PDB. Maximum 3‰ difference in the oxygen isotopic ratios occurred in the individual measurements of 185 specimens of *Globigerinoides sacculifer*. On the other hand, the oxygen isotopic values of subsurface species, such as *Globorotalia*

truncatulinoides and *Globorotalia inflata*, remain in relatively narrow ranges, for example between −1.9‰ and +0.2‰ for *Globorotalia truncatulinoides* and between −1.2‰ and +0.6‰ for *Globorotalia inflata*. These two deep dwelling species secrete their tests mainly during winter and spring seasons, and in some cases during summer for *Globorotalia truncatulinoides*.

Since the oxygen isotopic ratio of foraminiferal tests is dependent on two factors, the temperature and the oxygen isotopic ratio of the sea water in which the foraminifera grew, the relative contributions of these two factors to the oxygen isotopic ratio of foraminiferal tests must be considered. The oxygen isotopic variation of the surface water at the sediment trap site is inferred from the seasonal change of the salinity, because a proportional relationship between the oxygen isotopic ratio and salinity of the surface water is observed in the Kuroshio region (OBA, 1990). The seasonal salinity change of the surface water is only 0.5‰ from 34.3‰ in summer to 34.8‰ in winter in this area at the present-day. It corresponds to an oxygen isotopic variation of 0.2‰ throug-hout the year. This suggests that the oxygen isotopic value of foraminiferal tests is mainly determined by the water temperature rather than the oxygen isotopic ratio of the sea water. Therefore, the depth habitat of each species can be estimated from the comparison between the oxygen isotopic range of each species and seasonal change of the water temperature at the sediment trap site. The estimated depth habitats of eleven planktonic foraminiferal species are as follows;

Species	Depth habitat
Globigerinoides sacculifer	0 - 200 m
Globigerinoides ruber	50 - 200 m
Globigerinoides conglobatus	50 - 200 m
Orbulina universa	50 - 200 m
Globigerinella siphonifera	50 - 400 m
Neogloboquadrina dutertrei	50 - 500 m
Pulleniatina obliculoculata	100 - 500 m
Globolotalia truncatulinodes	200 - 500 m
Globolotalia inflata	200 - 600 m
Globolotalia hirsuta	200 - 600 m
Globolotalia scitula	700 - 800 m

The carbon isotopic values of 700 indi vidual specimens of eleven planktonic foraminiferal species also demonstrate the seasonal change. The heavy values are found in specimens living in the surface water during summer and the light values in subsurface and deep water specimens during winter season. It is assumed that the carbon isotopic ratio of the sea water becomes heavier during summer because of increased primary productivity in the surface waters after the spring bloom. During winter season, however, the carbon isotopic ratio consists of relatively light values because of low productivity and vigorous vertical mixing of the sea water which brings isotopically light carbon from the deep. When the carbon isotopic values of the 700 specimens of the eleven species are plotted versus their oxygen isotopic values, there is a trend showing heavy carbon isotopic ratios for the specimens having light oxygen isotopic values, corresponding to shallow water depth. Specimens which have light carbon isstopic ratios also have heavy oxygen isotopic values, indicating deep water depth. These observations suggest that the carbon isotopic ratio of foraminiferal tests is essentially controlled by the carbon isotopes of the sea water, i.e. carbon isotopic ratio of the bicarbonate ion in the sea water.

It is well known that the carbon isotopic profile of sea water is closely related to the dissolved oxygen content of sea water and that depleted carbon isotopic values are observed at the dissolved oxygen minimum layer under high biological productivity areas. Therefore, the carbon isotopic profile of paleo-ocean can be reconstructed by utilizing the oxygen and carbon isotopic measurements of individual specimens of foraminifera living in different water depths. In the present study, about 30 to 50 specimens of surface (*Globigerinoides sacculifer*), subsurface (*Globorotalia inflata*), and deep-water dwelling species (*Globorotalia scitula*) as well as two benthic foraminiferal species (*Uvigerina proboscidae* and *Bulimina aculeata*) were collected from a horizon at

6000 years B.P. in a deep sea core (KH-79-3, C-6) located near the sediment trap site. The resulting isotopic data was used to construct the carbon isotopic profile of sea water at 6000 years ago (OBA, 1990). Such a reconstruction of the carbon isotopic profile is very important for paleoceanogrophic investigations especially during the last glacial age when the atmospheric carbon dioxide content was 2/3 of the Holocene age.

Acknowledgements

The author expresses his great appreciation to Drs. Y. NOZAKI, N. HANDA, and S. HONJO for providing the sediment trap samples.

References

OBA, T. (1990): Paleoceanographic information obtained by the isotopic measurement of individual foraminiferal specimens. Proceeding First International Con-ference Asian Marine Geology, Shanghai (1988), China Ocean Press, Beijing, 169-180.

OBA, T. and K. UOMOTO (1989): Oxygen and carbon isotopic ratios of planktonic foraminiferal tests in sedinent traps JT-01 and JT-02. Gekkan Kaiyo (Monthly Marine Science), **21**, 239-246, (in Japanese).

UOMOTO, K. (1990): Geochemical study of living planktonic foraminifera based on oxygen and carbon isotopes. [Master thesis], Kanazawa, Univ., 154p, (in Japanese).

La mer 29; 193, 1991
Société franco-japonaise d'océanographie, Tokyo

The French activities related to IGBP (Abstract)

Jean-Claude DUPLESSY*

French activities for Global Change include programmes related to both WCRP and IGBP, and they are jointly implemented. The main domains are:

- French Climate Research programme
  participation to GEWEX, TOGA, WOCE, Climate modelling, paleoclimatology, study of the CO_2 cycle,
- FRANCE-JGOFS
- programme on the major biogeochemical cycles
- programme on stratospheric ozone
- programme on terrestrial ecosystems

*CNRS, Centre des Faibles Radioactivités

La mer 29: 194-200, 1991
Société franco-japonaise d'océanographie, Tokyo

Preparing for ANTARÉS; Flux of biogenic silica in the SouthernOceon: Water column and sediments

Jean-François GAILLARD*

Abstract: Oceanic biogeochemical cycles exert an important control on atmospheric CO_2 concentrations. To understand past changes associated with climatic events and predict future atmospheric CO_2 levels, the role of the Southern Ocean needs to be specifically addressed. Because most the primary production occurring in the Southern Ocean is driven by diatoms, the marine cycle of silicon plays a key role in understanding the dynamics of the biological pump. The purpose of this presentation is twofold. It consists first in reviewing the current questions on the oceanic processes controlling the dynamics of silica in water masses and in surficial sediments of the Southern Ocean and, second in presenting the multidisciplinary approach undertaken by the French oceanographic community: ANTARES, in the framework of the Southern-JGOFS international program.

1. Introduction

In the Southern Ocean, primary productivity is mainly controlled by diatom species and the deep-sea sediments are the main repository of siliceous biogenic debris. This ocean plays, consequently, a major role in the global biogeochemical cycle of silicon whose dynamics, in this region of the globe, is still poorly understood. The quantification of biogenic fluxes of silica in the water column and at the sediment water interface are of prior importance to assess oceanic budgets for Si. Moreover, the dynamics of the biogeochemical transformations of silicon, in this environment, exert a direct control over the distributions and the biogeochemical cycles of C, N, S, P, and trace oligo-elements.

The South circumpolar marine province is at the confluence of the 3 major oceans: Atlantic, Indian, and Pacific, It is bounded on the north by the subtropical fronts and on the south by the Antarctic continent. The Southern Ocean has been divided into four different oceanographic regions which surrounds the Antarctic Continent. They are, from the North toward the Antarctic continent, the Polar Front (PFZ), the permanently Open Ocean Zone (POOZ), the Seasonal Ice zone (SIZ) and the Coastai Continental Shelf Zone (CCSZ). These zones are more or less corresponding geographically to concentric rings surrounding the Antarctic continent.

This ocean represents 19% of the surface of the world ocean and the circulation of the water masses is dominated by Antarctic Circumpolar Current (ACC) which has a net transport flow of 130 Sv. The heat flux across this current contributed to the formation of cold bottom waters for the entire globe. This ocean is the place of deep upwellings, seasonal sea ice formations, and low salinity waters. The cloud cover is importamt and the ecological ecosystem is under the influence of a strong seasonal forcing.

This short presentation emphasizes the role

* IPGP, 2 place Jussieu PARIS Cédex 05, France.
Present address: University of Notre Dame, Department of Civil Engineering and Geological Sciences, Notre Dame, IN, 46556-0767, USA

of the advection of water masses and the climatic forcing exerted over the Southern Ocean ecosystem. Remote sensing data have demonstrated that the Southern Ocean is a region of the world where a large level of mesoscale variability exists. The important seasonal and atmospheric forcing imposed upon the Antarctic ecosystem play certainly an important role in determining its ecological dynamics and its internal machinery. Because this ocean is still mysterious by numerous aspects and because it is though that it has played in the past an important role in the earth biogeochemical dynamics, it represents an important marine area to study.

The biological pump in the Southern Ocean is primarily under the control of the diatom population. In order to understand the importance that this ocean might have on a global scale it is consequently important to focus the study of biogeochemical processes around the cycle of silica. The following section presents some of the basic informations which are relevant in defining the French contribution to Southern-JGOFS.

2. Fluxes of biogenic silica and C_{org} in the Southern Ocean

The primary productivity of the Southern Oceanic Waters has been the focus of numerous research reports. Most of this productivity seems to occur at ocean boundaries and in frontal zones. Recently studies particularly addressed the paradigm of the existence of very low primary produtivity zones where the concentration of nutrients were never exhausted. The potential explanations of these observations are nourishing passionate debates. The main hypothesis are light inhibition, temperature influence on growth rates, strong turbulences in the upper mixed layer, important grazing activity, and/or oligo-element limitation (Fe, hypothesis, ···). The determination of the factors that control primary production when nutrients are not limiting is one of the most important scientific goal of the Southern-JGOFS program.

Although the Antarctic Ocean produces less than 5% of the global primary production of the world ocean, its production of biogenic cilica corresponds to about 20% of the entire ocean (TRÉGUER and BENNEKON; 1991), (Fig.1). The mean biogenic ratio between biogenic silica ($SiO_{2(B)}$) and organic carbon (C_{org}) in the Southern ocean diatoms is:

$$0.19 \leqq \frac{SiO_{2(B)}}{C_{ORG}} \leqq 0.65$$

In comparison, the same rame ratio for the mean oceanic diatoms is approximately 0.13. Diatoms, which are living in Antarctic regions, are consequently concentrating, on the average, more biogenic silica.

The fluxes of biogenic silica from the euphotic zone to the sea floor have been investigated in relatively few places using sediment traps (WEFER *et al.*, 1982; NORIKI and TSUNOGAI, 1986; DUMBAR *et al.*, 1991; and others). The large majority of sediment trap deployments have been performed near the continent and very little information exists on the fluxes of biogenic silica in open waters. These experiments have shown that there exists, as expected, a strong seasonal signal. The major vehicle of the biogenic silica rain to the sea floor seems to be fecal pellets in nearshore environments. This organic packaging of the diatoms frustules might reduce drastically the dissolution of diatoms frustules in the water column since they will be preserved during their descent to the sea floor.

Studies of Silica fluxes in the Southern Ocean have proposed that 2/3 of the biogenic silica production was undergoing dissolution in the water column prior to reaching the sea floor (NELSON and GORDON, 1982). If one considers that this is valid for the entire Southern Ocean, in numerous region the flux of accumulation of biogenic silica sediments can not ne explained only by the small primary productivity observed in surface waters. In some environments the sedimentary flux is even larger than the measured primary production

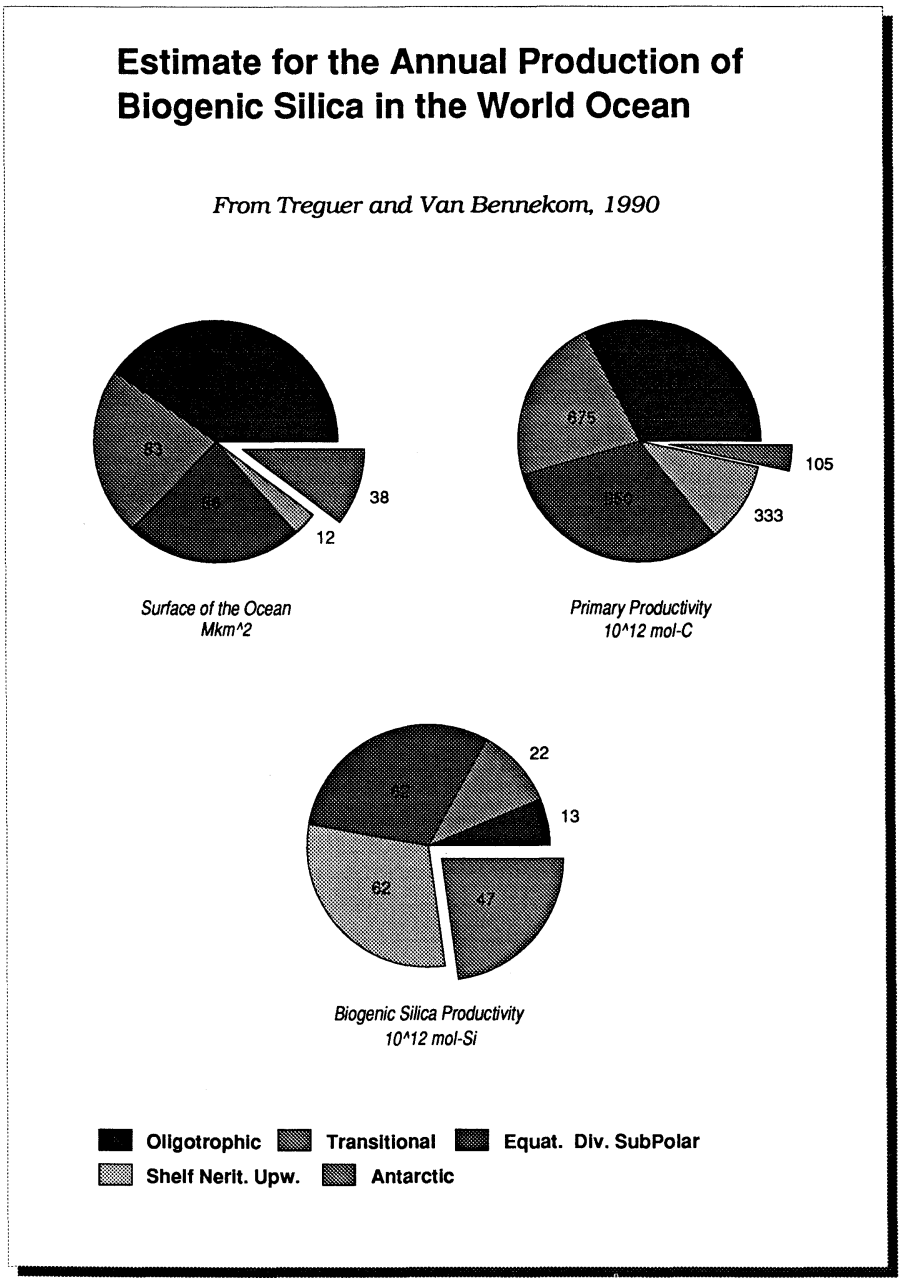


Fig. 1. The annual production of biogenic silica in the Antarctic Ocean compared to the superficies of the different oceans and their annual primary production.

of surface waters.

Consequently little is known on the recycling of silica in the open waters of the Southern Ocean. The dissolution experiments of biogenic silica performed during cruises do not always agreee with the estimates of biosilica primary productivity and the inventory of the sediment. The explanation might

reside in large transport and accumulation of sediments localized in deeper basins. Ultimately the quantification of the silica cycle should help understanding the transfer of biogenic compounds in this environment and therefore the importance of the CO_2 cycle in the Southern Ocean for the world ocean.

3. Water-sediment interface, recycling and burial

The sediments of the Southern Ocean are the repository of approximately two thirds of the total biogenic silica accumulation in marine sediments. This accumulation produces biogenic silica rich sediments which are distributed in the shape of an open ring surrounding the Antarctic continent. (DEMASTER, 1981; LEDFORD-HOFFMAN *et al.*, 1986).

The dissolution of biogenic silica debris buried in the surficial sediments generates an important flux of dissolved silica from the sea floor to the overlying bottom waters. The gradients of concentration of dissolved silica present in the interstitial waters, close to the sediment water interface, are very important. In the region of high silica accumulation the formation of silica oozes is observed. The concentration of dissolved silica increases in less than 2 cm below the sediment water interface from 100 μmoles. l^{-1} in the overlying waters to 750 μmoles. l^{-1} (GAILLARD *et al.*, 1992). Almost in all the cores, at deeper depth, diatoms frustules are well preserved whereas the concentration of dissolved silica does not reach equilibrium values with amorphous silica. Consequently it appears that the dissolution of the skeletons of the various diatom species is inhibited when buried in the sediments. The mechanism by which these frustules are protected from dissolution by a protective coating is still unknown, but it is possible to devise a theoretical model accounting for this phenomenon (Fig.2). In some benthic locations, when a geochemical mass balance is performed on the sediment, one finds that a biogenic silica rain greater than the average observed biosilica production of the surface waters is required to account for distribution of concentrations in both the

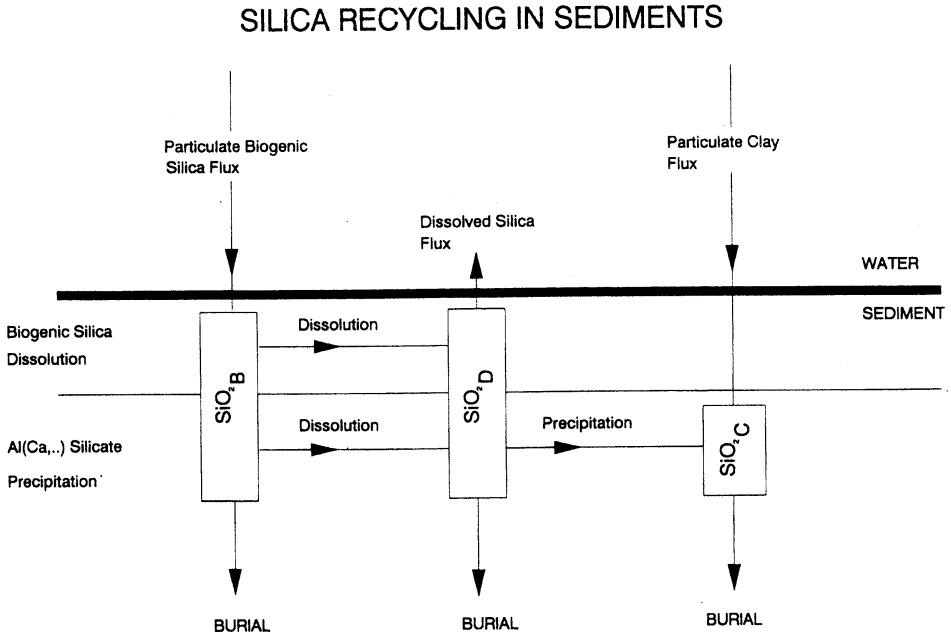


Fig. 2. A schematic diagram of the recycling and burial of biogenic silica in surficial sediments.

pore waters and the sediments.

In order to interpret more quantitatively the historical record preserved in the sediments it is necessary to obtain more information on the nature of the early diagenetic processes involved in the preservation, recycling, and transformation of bigenic silica in the Southern Ocean sediments. At the same time the paleoceanographic studies of the distribution of the diffrernt diatoms species and their different dissolution characteristics will prove to be very valuable for reconstructing past climate.

The last point to mention is the little information that one possesses on the burial and degradation of organic matter, the distribution and the diversity of the benthic fauna, and the metabolic activity of the organisms at the sea floor. All these aspects are important in assessing the role of the benthic environment in the cycle of the chemical elements. The Southern Ocean is a region of the globe where large volumes of bottom waters are formed and consequently all these benthic processes affect their chemical composition and are important to consider.

4. ANTARES 1 Cruise

The program ANTARES is the Frech contribution to Southern-JGOFS. This program is organized by Dr. P. TRÉGUER. The first cruise is presently in its planning stage and should take place during the month of March and April 1993. Its principal goal is the study of the benthic environment along a transect following 55° E. This expedition will survey this route by providing sea floor information, using conventional techniques such as bathymetry, acoustic properties of the sediments, and on board determination of the sedimentology of surficial sediments and piston cores. With the help of these geophysical and sedimentological informations three study zones will be defined. These study sites have to be characterized by a constant pelagic sedimentation in order to extend the present knowledge of oceanic processes to the historical record. These 3 zones will be situated at the northern and southern limits of the POOZ, and in a region of the SIZ accessible by ship during austral summers. After the survey and the precise choice of the locations, the sampling of the benthic environment will focus on the surficial sediments and deep waters physics and chemistry. It is expected to obtain at each site a frame of box cores for biological and geochemical studies, surficial sediments using a multitube corer, and deep sediment cores for paleoceanographic studies. A benthic chamber, operating as a free vehicle, will be launched at each site for determining benthic fluxes of O_2 and dissolved silica. Deep water sampling using a rosette and CTD will be performed in order to determine the chemical composition of the water column. Before leaving the site, sediment trap arrays, consisting of 3 traps and 3 current meters, (which can be detected in case of an unexpected release by a satellite detection device: ARGOS buoy), will be moored. The last aspect of this expedition is the study and the characterization of the circulation of Oceanic Waters in order to understand the transfer of material of material within the water column. On the 55° E route back to port, several XBTs and hydrocasts will be performed on a mesh following a precise timing. The next cruises of the ANTARES program will principally focus on upper ocean processes with a continuous hydrological survey.

Along with the teams devoted to the mooring of sediment trap arrays and hydrological studies the participants of this cruise are for the most part involved in benthic studies. These studies will encompass the fields of biology, geochemistry, and microbiology. The different aspects that will be developed during the cruise are the following:

- Benthic populations:
  Survey of Species, Numbering, Biomass
- Sedimentology (Recent Sediments):
  Find recent depostis, determine sedimentology on board the ship. Benthic photogra-

phy, Acoustic Information.
•Sediment Geochemistry:
+Bulk Sediment Analysis: C_{org}, Opal, $CaCO_3$, Metals, ···
+Sedimentation Rates Estimation: Using Radioisotopes
+Pore Water Chemistry: O_2, Nutrients, Metals, SiO_2, Electron Accerptors.
+Experimental Kinetic Studies of $Si_{(B)}$ Dissolution/Precipitation
+Organic Geochemistry: Lipids as Tracers.
•Sediment Microbiology:
+ETS, O_2, Sediment Oxygen Demand.
+Bacterial activity: using ^{14}C and ^{35}S-SO_4
•Benthic Fluxes:
+Benthic Chamber Experiments:
Determination of O_2 benthic demand.
Fluxes of Dissolved Silica to the Overlying Waters.

The scientists involved in the study of the circulation of deep oceanic waters and their chemical/physical characterizations will particularly concentrate on the following aspects:
•Antarctic Circumpolar Current
+Baroclinic Flux from the Polar Front to the Antarctic Continent.
•Isotopic Composition of Water Masses
+ ^{18}O and ^{13}C tracers.
•Water Column Chemistry
+Dissolved Silica Variations
+Iron and Nd chemistries.

Finally the paleoceanography team will address two issues. The first issue will focus on the definition of past hydrological conditions using the isotopic records of ^{18}O and ^{13}C of the sediments, and the second on the long term sedimentary record. This last aspect will particularly look at past planktonic assemblages in the sediments and assess the variations of the biogenic silica flux and biogenic carbonate flux over the last glaciations periods.

ANTARES 1 Participants:

Benthic Studes: G. STORA and P. ARNAUD. (COM, Marseille), C. RABOUILLE and J. L. REYSS (CFR, GIF/Yvette), J. F. GAILLARD (IPGP, Paris and UND, USA), A. SALIOT and J. LAUREILLARD (LPCM, Paris), P. VANCAPPELLEN (Georgia Tech., USA), A. J. VANBENNEKOM (NIOZ, NL), P. CAUMETTE, J. C. RELEXANS, and P. LABORDE (Univ.Bordeaux), and G. ROWE (TAMU, USA). A. DINET (Banuyls) M. BIANCHI (Marseille).

Circulation and Characterization of Deep Oceanic Waters: Y. PARK (MNHM, Paris), P. TRÉGUER (IEM&UBO, Brest), C. JEANDEL (UMR 39 & IPG, Toulouse), C. PIERRE (LODYC, Paris).

Paleoceanograohy: C. VERGNAUD-GRAZZINI and C. PIERRE (LODYC, Paris), M. LABRACHERIE, J. J. PICHON, and G. BAREILLE (Univ. Bordeaux) and L. LABEYRIE (CFR, GIF/Yvette).

References

DE MASTER, D. J. (1981): The supply and accumulation of silica in the marine environment. Geochim. Cosmochim. Acta, **45**, 1715-1732.

DUMBAR, R. B. ,D. A. MUCCIARONE, and A. R. LEVENTER (1991): Biogenic and Lithogenic Sedimentation in the Western Ross Sea, Antarctic: Results from Seasonal and Annual Sediment Trap Experments. EOS, Vol 72 N° 44, 235.

GAILLARD, J-F., C. RABOUILLE, and L. PHILIPPE(1992):The Diagenesis and Recyling of Silica in the Scotia Sea and the Southern Atlantic Ocean. Deep-Sea Res., (submitted)

LEDFORD-HOFFMAN, P., A. D. J. DE MASTER, and C. A. NITTROUER (1986): Biogenic-silica accumulation in the Ross Sea and the importance of Antarctic continental shelf deposits in the marine silica budget. Geochim. Cosmochim. Acta. **50**, 2099-2110.

NELSON, D. M. and L. I. GORDON (1982): Production and pelagic dissolution of biogenic silica in the Southern Ocean. Geochim. Cosmochim. Acta, **46**, 491-501.

NORIKI, S. and S. TSUNOGAI (1986): Particulate fluxes and major components from sediment trap experments in the Pacific Ocean. Deep-Sea Res., **33**, 7 903-912.

TRÉGUER P. and A. J. VAN BENNEKOM(1991): The annual production of biogenic silica in the Antarctic Ocean. Mar. Chem. **35**, 477-487.

WEFER, G., E. SUESS, W. BALZER, G. LIEBEZEIT, P. J. MULLER, C. A. UNGERER, and W. ZENK (1982): Fluxes of biogenic components from sediment trap deployment in circumpolar waters of the Drake Passage. Nature, **299**, 145-147.

La mer 29; 201-205, 1991
Société franco-japonaise d'océanographie, Tokyo

Sedimentation processes in the Antarctic coastal area

Hiroshi HATTORI* and Osamu MATSUDA**

Abstract: A party of 27th Japanese Antarctic Resarch Expedition during 1985 and 1987, designed a moored system for monitoring temporal variation in phytoplankton standing stocks and downward flux at Breid Bay in the Antarctic Ocean. A total of 1127 hourly data sets of water temperature, chlorophyll conentration and current at 52 m depth as well as every 3.5 day period of 12 trap samples at 120 m depth were obtained. Integrated chlorophyll *a* standing stock in the upper 200 m water column were higher in December reaching 400 mg m^{-2} than in February of 330 mg m^{-2}. Lager than 20 μm fraction of chlorophyll *a* was dominant in the water column in December and February. Vertical flux of particulate pigments, total cell volume and POC increased to the mid-January and each peak of pigment, cell volume and POC fluxes were observed 4.7 mgm^{-2} day^{-1}, 450 μl m^{-2} day^{-1} and 105mg C m^{-2} day^{-1}, respectively. A marked increase of pigment flux and cell volume flux in mid-January was observed 3.5 to 10.5 days after an increase in the upper layer chlorophyll. Thus sinking rate was calculated as about 6.5 to 19.4 m day^{-1}. Sediment samples were dominated by intact cells of *Thalassiosira antarctica* throughout the period of observation. Large diatom, *T.antarctica* blooming may represent typical Antarctic blooms and this species may be an important source of food for benthic and planktonic animals.

Introduction

There are vast areas covered with seasonal sea ice in both polar oceans. Their maximum areas are generally 15 and 20 million km^2 in the Arctic and Antarctic, respectively (GLOERSEN and CAMBELL, 1988). Marginal ice zones in the Antarctic and Arctic are known to be major area of high production through several tropic levels of organisms (MCROY and GOERING, 1974, SMITH *et al.*, 1988). Biological investigations in these polar areas are very limited partly because of the logistic difficulties. Mooring systems are considered to be useful devices for overcoming the logistic difficulties.

* Department of Marine Sciences and Technology, Hokkaido Tokai University, Minami-ku, Sapporo, 005 Japan
** Faculty of Applied Biological Science, Hiroshima University, Kagamiyama, Higashi-Hiroshima, 724 Japan

In the Southern Ocean, particularly in the Antarctic Ocean during austral summer, average values of downward organic carbon flux are reaching around 100 mg m^{-2} day^{-1} (FUKUCHI and SASAKI, 1981; WEFER *et al.*, 1982). These values of organic carbon flux are much higher than those obtained in other temperate and tropical waters (HONJO *et al.*, 1982). However, higher values of the flux in the Antarctic Ocean have been observed in the bloom season in austral summer, particularly higher flux was observed around vanish of the seasonal ice (MATSUDA *et al.*, 1987; WEFER *et al.*, 1988).

Time-series investigation, such as temporal changes in phytoplankton stading stocks in the euphotic layer and the downward flux from the surface is necessary to clarify and evaluate biological processes about energy flow from the surface to the deeper layer. This investigation has been carried out in Breid Bay, Antarctic polynya, during December 1985 and Fedruary 1986 (FUKUCHI *et al.*,

1988).

In this paper, we would like to introduce the results obtained in Breid Bay by FUKUCHI *et al.* (1988) and some other results to consider the sedimentation processes in the Antarctic coastal water.

Materials and methods

A party of 27th Japanese Antarctic Research Expedition (JARE-27) during 1985 and 1987, designed a moored system for monitoring both long-and short-term temporal variation in phytoplankton standing stocks and downward flux at Breid Bay Antarctic Ocean. The objectives of this study are 1) to develop long-term mooring system for polar marine biology, particularly chlorophyll in the upper productive layer and its sedimentation into deeper layer, 2) to analyze blooming process in the Antarctic water, 3) to evaluate the process of downward flux in the blooming period.

Mooring array of the system consisted of a continuous chlorophyll measuring buoy, a current meter and a time-series sediment trap were set at depths of 52, 57, and 120 m, respectively. The system was deployed in the Antarctic polynya in Breid Bay from 28 December 1985 to 13 February 1986. Further details of the moored system were shown in FUKUCHI *et al.* (1988).

Results and discussion

A total of 1127 hourly data sets of water temperature, chlorophyll concentration and current as well as every 3.5 day period of 12 trap samples were obtained.

The bloom had already started before the start of the mooring experiment in late December and had not yet terminated when the experiment ended in mid-February.

Vertical profile of size fractionated chlorophyll *a* observed just before deployment of the system and after recovering it were shown in Fig.1. Subsurface chlorophyll maximum was reaching about 6 mg m^{-3} at the beginning and end of the study. Larger than 20 μm fraction was abundant throughout the period. The bloom in the coastal polynya continues for more than 2 to 3 months when favorable conditions persist in summer. Integrated chlorophyll *a* standing stock in the upper 200 m water column were higher in December reaching 400 mg m^{-2} than in February of 330 mg m^{-2}. However, the stocks above the pycnocline were higher in February than in December.

Water temperature was higher in December. Thermocline deepened in February (Fig. 1). Salinity profile in December was uniform

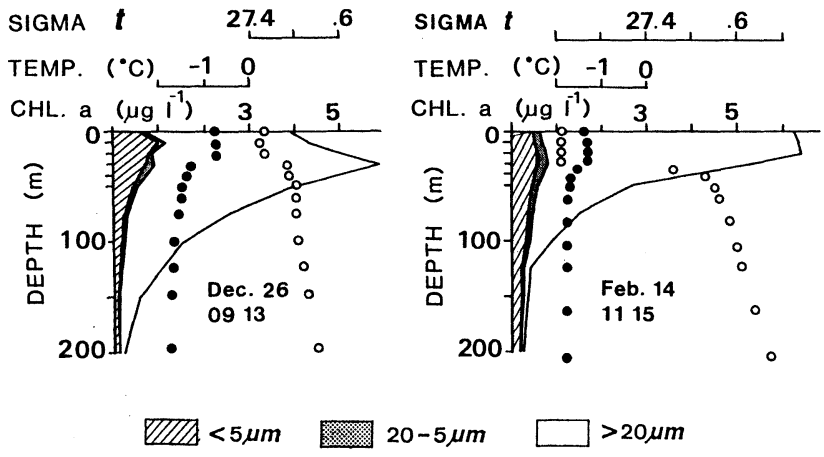


Fig. 1. Vertical profiles of size fractionated chlorophyll *a* in Breid Bay in December (left) and February (right). Temperature and Sigma-t profiles also shown by filled and open circles, respectively.

and higher than 34.00. In February, however, salinity in the surface layer decreased to less than 33.80 and a strong halocline was formed between 30 to 50 m. Sigma-t profiles were similar to salinity profiles in December and February. A strong pycnocline between 30 and 50 m was formed in February (Fig.1).

The chlorophyll-measuring buoy was set just below the pycnocline and below the subsurface chlorophyll *a* maximum. The sediment trap was set in vertically uniform water having temperatures below −1.7℃ and salinities above 34.10. Euphotic depths are around 20 m depth in December and February.

Figure 2 shows the schematic representation of results obtained from the continuous chlorophyll measuring buoy and the time series sediment trap. Chlorophyll *a* concentration in the upper layer fluctuated mainly in the range of 0.7 to 5.6 mg m^{-3}, and the values tended to decrease toward mid-February. Highest value was observed in the period of No. 3 at 52 m depth.

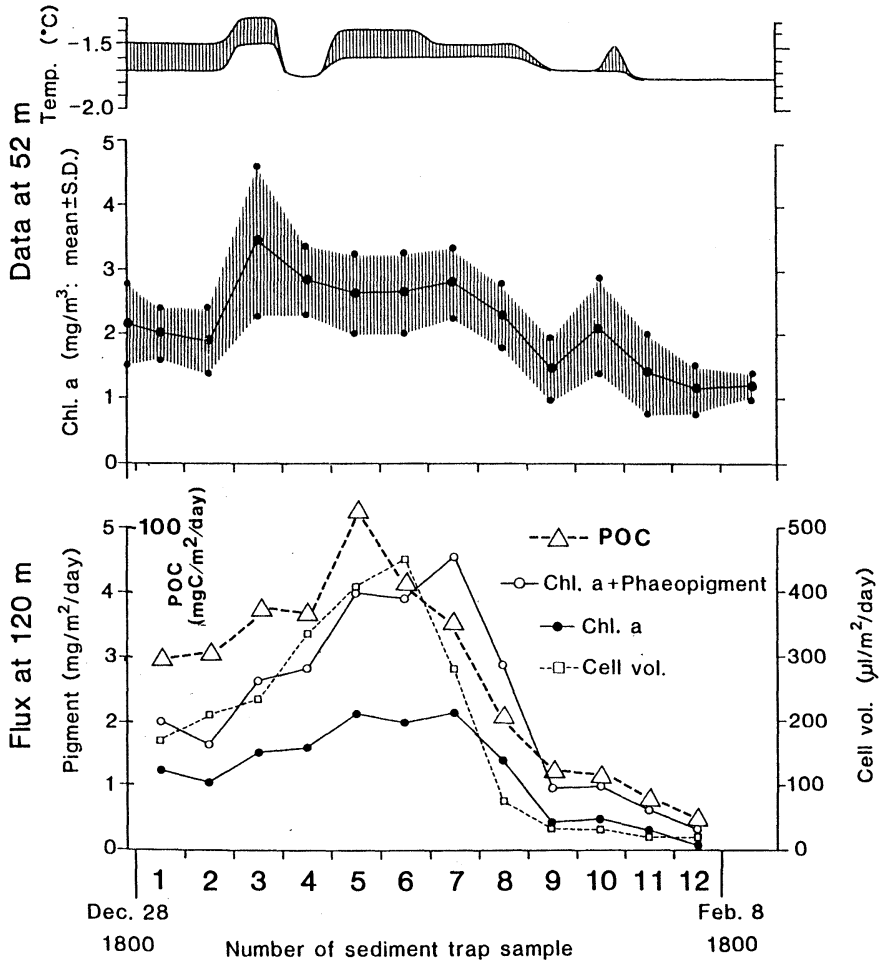


Fig. 2. Schematic representation of results obtained from the continuous chlorophyll measuring buoy at 52 m depth and the time series sediment trap at 120 m depth from Decemder 1985 to February 1986. Temperature and chlorophyll *a* data from 47 days of 1 hour interval are averaged to correspond to every 3.5 day period of the intervals of trap samples. Shaded area in the chlorophyll *a* is standard deviation of the 3.5 day period and a line means mean chlorophyll *a* concentration.

Vertical flux of particulate pigments, total cell volume and POC increased to the mid-January and each peak of pigment, cell volume and POC fluxes were observed in the period of No.7 (4.7 mg m^{-2} day^{-1}), No.6 (450 μl m^{-2} day^{-1}) and No. 5 (105 mgC m^{-2} day^{-1}), respectively. A marked increase of pigment flux and cell volume flux in mid-January was observed 3.5 to 10.5 days after an increase in the 52 m layer chlorophyll. If the increase from sample No.1 to sample No.7 in flux at 120 m depth was due to the rapid increase in chlorophyll *a* from sample No.2 to No.3 at 52 m depth, then an estimate of the sinking rate of particles can be made. The increase in pigment flux followed the increase in chlorophyll *a* by 3.5 to 10.5 days. Thus sinking rate was calculated as about 6.5 to 19.4 m day^{-1}.

Particles sinking down from the upper layer to the 120 m depth were intact diatom, *Thalassiosira antarctica*. Trap samples were dominated by intact cells of this species throughout the period of observation. In the Antarctic Peninsula region, main constituent of the trap sample was also intact and apparently viable cells of *T.antarctica* (BODUNGEN *et al.*, 1986). Size of this species is about 20 μm in diameter. In Fig.1, size fraction larger than 20 μm was abundant in the whole water column during December and February. Abundance of this size in the trap samples was also observed by an Elzone Particle Counter. About 18 μm (equivalent spherical diameter) particles were dominant throughout the study. These results reveal that the sinking rate of 6.5-19.4 m day^{-1} is that of *T. antarctica*. This rate is higher than those of single phytoplankton cells (e. g. SMAYDA, 1970). Probably, sinking cells of *T. antarctica* are chain-forming and the sinking rates become large.

It is not known why the peaks of the pigment, cell volume and POC fluxes differed by one sampling period of the trap samples. But, once these fluxes reached their peak in the mid-Junuary, those values were rapidly decreasing. These were apparent in the cell volume and pigment fluxes. In the vertical profiles of Sigma-t in Fig.1, pycnocline became larger in February. In general, when water stability in the surface become higher, phytoplankton remains longer in the upper layer of pycnocline. Hence it appears that the decreasing of fluxes in the mid-January represents beginning of higher water stability in the surface.

Smaller size, of fecal pellets less than 200 μm long were found in the trap samples. And their estimated volume were similar to that of sinking cells. SEM observations of the pellets revealed that *T. antarctica* was main food source for organisms inhabiting in the upper layer. Based on the results, large diatom, *T.antarctica* blooming may represent typical Antarctic blooms and this species may be an important source of food for benthic and planktonic animals.

To observe that the temporal variability of downward particulate flux using time-series sediment traps with reference to the sersonal variation of ice coverage in the Antarctic Ocean, we will deploy similar mooring systems in Prydz Bay and Antarctic polynya near Syowa Station in coming austral summer. After successfull recovering of these system, the sedimentation process in the Antarctic Ocean will become clearer.

Acknowledgment

We express our gratitude to Profs. M. FUKUCHI, T. HOSHIAI, Y. Yoshida and Y. NAITO, National Institute of Polar Research, for their support of this study. We thank captain, the officers and the crews of the icebreaker Shirase for their cooperation on board.

References

BODUNGEN, B. V., V. SMETACEK, M. M. TIZER and B. ZEITZSCHEL (1986) : Primary production and sedimentation during spring in the Antarctic Peninsura region. Deep-Sea Res., **33**, 177-194.

FUKUCHI, M. and H. SASAKI (1981) : Phytopl ankton and zooplankton standing stoks and downward flux of particulate material around fast ice edge of Lützow-

Holm Bay, Antarctica. Mem. Natl Inst. Polar Res. Ser. E, **13-36.**

FUKUCHI, M., H. HATTORI, H. SASAKI and T. HOSHIAI (1988): A Phyto-plankton bloom and associated processes observed with a long-term moored system in antarctic water. Mar.Ecol.Prog. Ser., **45**, 279-288.

GLOERSEN, P. and W. J. CAMBELL (1988): Variations in the Arctic, Antarctic, and global sea ice covers during 1978-1987 as observed with the Nimbus 7 scanning multichannel microwave radiometer. J.Geophys. Res., **93 (C9)**, 10, 666-10, 674.

HONJO, S., S. MANGANINI and J. COLE (1982): Sedimentation of biogenic matter in the deep ocean. Deep-Sea Res., 29, 606-625.

MATSUDA, O., S. ISHIKAWA and K. KAWA-GUCHI (1987): Seasonal variation of downward flux of particulate organic matter under the Antarctic fast ice. Proc. NIPR Symp. Polar Biol., **1**, 23-34.

MCROY, C.P. and J.J. GOERING (1974): The influence of ice on the primary productivity of the Bering Sea. *In* HOOD, D.W. and E.J. KELLY (eds), Oceanography of the Bering Sea. Institute of Marine Science, University of Alaska, p 403-421.

SMAYDA, T.J. (1972): The suspension and sinking of phytoplankton in the sea. Oceanogr. Mar. Biol. A. Rev., **8**, 535-414.

SMITH, W. O. Jr., N. K. KEENE and J. C. COMISO (1988): Inter-annual variability in estimated primary productivity of the Antarctic marginal ice zone. *In* Sahrhage, D. (ed.), Antarctic Ocean and Resources Variabirity. Springer-Verlag, Berlin Heidelberg, p 131-139.

WEFER, G., G. FISHER, D. FÜETTERER and R. GERSONDE (1988): Seasonal particle flux in the Bransfield Strait, Antarctica. Deep-Sea Res., **35**, 891-898.

WEFER, G., E. SUESS, W. BALZER, G. LIEBEZEIT, P. J. MÜLLER, C. A. UNGERER an dW. ZENK (1982): Fluxes of biogenic components from sediment trap deployment in circumpolar waters of the Drake Passage. Nature, London, **299**, 145-147.

南極沿海域における粒子の沈降過程

服部　寛・松田　治

表層での植物プランクトン現存量と下層での沈降粒子量の系列変化を観察するための繋留ブイシステムを用い，南極のブライド湾において1985年12月から1986年２月の期間測定を行なった。52m水深における3.5日毎の12本の沈降粒子試料を得ることが出来た。200m 以浅の水柱内におけるクロロフィル現存量は12月，２月共に高く，それぞれ400，330mg m^{-2} に達し，20μm 以上のサイズの植物プランクトンが優占していた。沈降粒子量は１月中旬に多く，１日当たり，単位面積(m^{-2})当たりの色素，植物プランクトン細胞量とPOC量はそれぞれ，4.7mg，450μl と105mgC に達した。１月中旬における色素と細胞量のピークは，上層でのクロロフィル量のピークが：現れた後3.5から10.5日後に得られた。このことから粒子の沈降速度は，１日当たり6.5から19.4mと推定された。珪藻の *Thalassiosira antarctica* は沈降粒子の中で観測期間を通し優占していた上，トラップで採集された糞粒内にも非常に多かった。これらのことから，*T. antarctica* の増殖は南極海沿岸の夏期における大増殖を形成し，なおかつ底棲生物や浮遊生物にとっても重要な餌生物であると考えられた。

La mer 29: 206-208, 1991
Société franco-japonaise d'océanographie, Tokyo

Size structure of the primary producers, food webs and fluxes in the Southern Ocean

Guy JACQUES*

A rapid change in the community structure in the Weddell/Scotia Sea as an example of a no-diatom community in the Southern Ocean

During the EPOS cruise in the Weddell/Scotia Confluence area, a rapid change was observed in the chlorophyll concentration and in the community structure. During the last days of November, a chlorophyll-rich area reaching 4 mg m^{-3} and spreading over more than 90 km was observed. In the heart of this bloom, more than 80% of the biomass was provided by a diatom community >10 μm.

Three weeks later, the total biomass was decreasing to values close to 1 mg Chl *a*. m^{-3}, owing to a strong decrease of the diatom stock very due to grazing by krill. The biomass of the autotrophic nanoplankton community increased during the same time, the cryptophyceans being the main contributors. After this event, the relative mean biomass of the size fraction >10 μm remained at a level below 20% for the rest of the cruise, and very often below 10% of the total phytoplankton biomass in the area.

The evolution occurring in the Weddell/Scotia system during early summer point out a change from a new production-based ecosystem with a large fraction of the organic matter produced by large diatoms (exported into the deep water through their rapid sinking or by way of fecal pellets) towards a regenerated system which is a weak exporter of organic matter (Fig.1). Do these results modify the classical concept of the predominating position of large diatoms at the basis of Antarctic marine food chains in he Seasonal Ice Zone (SIZ) and the Permanently Open Oceanic Zone (POOZ) ?

Size structure of the food weds and fluxes in the SIZ and the Pooz

Some features clearly identify the Seasonal Ice Zone:

- the zone beside the ice is a site of enhanced primary production and concentration of living resources : the average production should be of 1 gC m^{-2} d^{-1} in the Ross Sea and 0.6 gC m^{-2} d^{-1} in the Weddell Sea.
- the Marginal Ice Zone (MIZ) extends for a distance of 150 to 250 km from the edge of the ice with a bloom persisting for 1-2 months, which is no longer lasting and surface limited when compared to other regions of high production in the world. In spite of this, the role of this phenomenon in total production could represent approximately 70% of the annual production, or respectively : 100 gT C in the Ross Sea and 85 gT C in the Weddell Sea.
- the onset of the bloom is linked to the speed of pack ice retreat and is almost srecific to the spring period. These blooms are dominated by diatoms generally with a size $>$ 10 μm among which *Nitzschia curt*a, which is equally an epontic species, is predominant. But as the summer season progress, the food web frequently toppled towards a microbial loop based regenerated system (see before).
- the *f* ratio of new production/total production is high: above 0.4, even, at times, above 0.6. Accordingly, a large fraction of the primary biomass is exported towards higher trophic levels and, especially, directly to the sediment. Due to the diatom dominance during the spring bloom, this aspect is even

*Observatoire Océanologique de Banyuis, F666 50, Banyuls-sur-Mer (France)

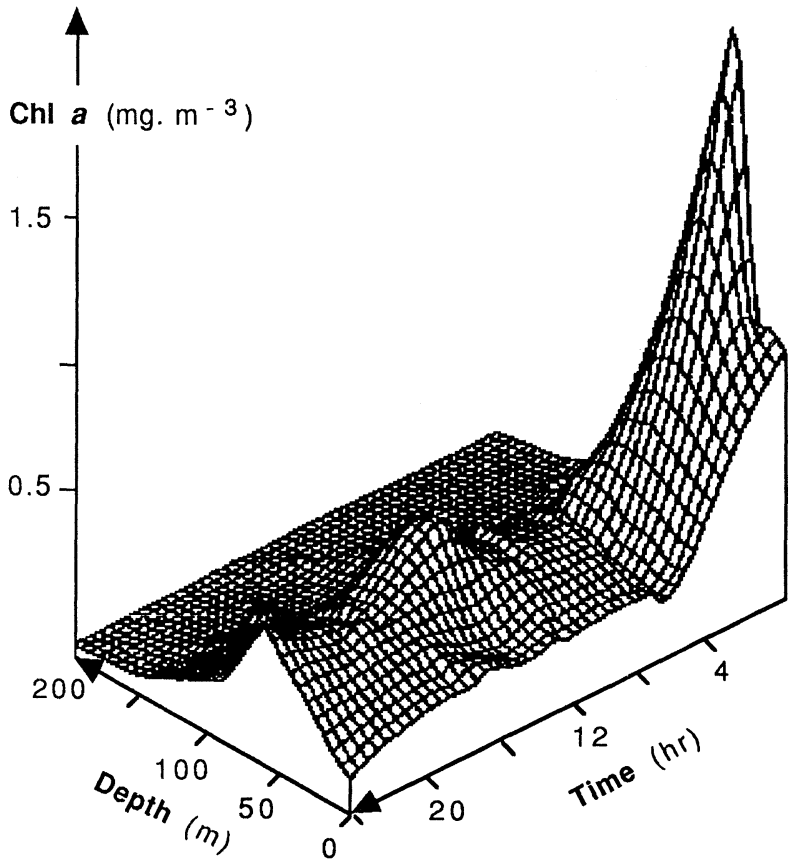


Fig. 1. Evolution of a diatom bloom at the Station 157 in the Weddell Sea. The diatom bloom vanished in less than 20 h and the phytoplankton community toppled towards a flagellate-dominated system.

more evident for silica: from 25% to 50% of the silica produced ends up at the water-sediment interface.

The Permanently Open Oceanic Zone is a typical well-mixed system of the Antarctic Ocean, first identified as an almost "oligotrophic" area although nutrient rich. Even if some data showed that nanoplankton largely contributed to the total phytoplankton stocks, most of the recent results reinforce the classical concept giving diatoms a predominating position in the POOZ; then, the regional variation of total phytoplankton chlorophyll biomass approximately reflects the change of >20 μm diatoms. Sometimes, the dominant diatom assemblage is <10 μm in size, which may explain some discrepencies in the size fraction data:

•dominant "nanoplanktonic-weakly silicified" diatoms are : *Nitzschia nana" (N. cylindrus, N. pseudonana), Chaetoceros dichaeta, C. atlanticum* v. *gracilis, C. simplex, D. tenuijunctus, N. prolongatoides, N. subcurvata.*

• dominant microplanktonic-heavy silicified diatoms are: *N. kerguelensis, N. turgiduloides, Dactylisolen antarcticus, Asteromphalus hookeri, A.parvulus, A.hyalinus, Chaetoceros criophilum, Thalassiosira antarctica.* At times, *F. kerguelensis* is by far the most abundant species.

What is the importance of the POOZ compared to the other subsystems in terms of vertical fluxes ? The unproductive open ocean generates only a small vertical carbon

flux towards the sea bottom. However, it is becoming more and more obvious that diatom accumulation in the sediment does not necessarily imply a high level of production. The best present estimates indicate that the Southern Ocean accounts for $\leq$ 5% of global organic matter production in the upper ocean (annual primary production $\neq$ 15 $gC\,m^{-2}$?) and subsequent accumulation of organic matter in the sediment, but it is the site of about 75% of the global-scale transfer of biogenic silica to the seabed. This particularity can be explained by two characteristice: biogenic silica may be pro-duced in higher proportion to organic carbon in the surface waters and/or unusu-ally high fractions of that silica may be delivered to the seabed rather than dissoled in the water column.

The POOZ appears to be therefore a system where the large amount of intact frustules in the sediment indicate a predominance of large diatoms in the pelagic system and their subsequent rapid sedimentation. It is now evident that the so-called "microbial loop" is not as important in the POOZ as in the others systems.

La mer 29: 209-211, 1991
Société franco-japonaise d'océanographie, Tokyo

Carbon and nitrogen isotope composition of organic matters in the Arctic food webs

Masao MINAGAWA*, Kazuo ISEKI** and R. W. MACDONALD***

Abstract: During the last decade, the isotope compositions of carbon and nitrogen have been used to describe the behavior of organic matter in sea water. As both elements are bioactive, the isotope composition can provide insight into primary production,decomposition and the food chain. The nitrogen isotope ratio in particulate matters is considered an especially good tracer for new production. However this isotope cannot be directly applied without taking in account both the variation in source materials and isotopic fractionations arising from chemical or biochemical reactions.

Here, we focus the C and N trophodynamics in the Arctic,especially the western Canadian continental shelf which has a strong input from the Mackenzie River. The Beaufort sea ecosystem shows a relatively high ^{15}N content when compared with other oceans. We assign this difference to terrestrial organic matters which appears to be an important source to the ecosystem and sediments. Implications of this to the regional particle dynamics will be discussed.

The direct determination of carbon and nitrogen isotope abundances in the various components of marine ecosystem have neen used,in recent years, to clarify nutrient dynamics. Carbon isotope ratios in marine organic matter are essentially governed by the isotope discrimination associated with primary production in the euphotic layer. Previous work has shown that the $\delta^{13}C$ values for most plankton range between -19 to -21 ‰, except for polar seas. In the Antarctic Ocean, low $\delta^{13}C$ (up to -28 ‰) values are widely observed and have been attributed to the cold water temperature. Low $\delta^{13}C$ values have also been measured in plankton from Bering Sea (MCCONNAUGHEY and MCROY, 1979) and the western Beaufort Sea (SAUPE *et al.*, 1989). Three factors are thought to control ^{13}C distribution; variation of isotope fractioation with water temperature, physiological discrimination by marine plants, and variations in pCO_2 in surfac water. However, the relationship between $\delta^{13}C$ and the environmental conditions has still poorly defined.

From this point of view, carbon isotopic distribution in the Arctic requires further study. The Arctic Ocean differs fundamentally from the Antarctic Ocean. First, the interior Arctic Ocean surface is covered by permanent ice which limits the CO_2 exchange. Second, the Arctic Ocean has extensive continental shelves which are seasonally covered by ice and receive large inputs of land-derived matter may play an important role in the material cycle in the Arctic Ocean especially over the shelves.

The nitrogen isotope ratio in marine organic matter is controlled mainly by the balance between nitrogen fixation, denitification and supply of nitrate from the deep ocean. The $\delta^{15}N$ of the organic matter can provide a good proxy of the various proce-

* Mitsubishi Kasei Institute of Life Sciences, 11 Minami-Oya Machida-Shi, Tokyo, 194 Japan
** Seikai National Fisheries Research Institute 49 Kokubu-Machi, Nagasaki, 850 Japan
*** Ocean Chemistry Division,Institute of Ocean Science P.O.Box 6000, Sidney, B.C.V8L 4B2 Canada

sses which produce the balance, and previous studies have traced the movement of nitrogen between marine plankton, suspended particles and sediment trap particles. The $\delta^{15}N$ of pelagic plankton varied from −2 to 10 ‰ in the North pacific (MINAGAWA and WADA, 1986). This wide variation suggests that $\delta^{15}N$ of marine organic matter provides a sensitive indicator of the nitrogen source and metabolisms in ocean ecosystems. Overall fractionation factors have been measured for nitrogen fixation (1.002: MINAGAWA and WADA 1986) and for nitrate uptake (1.006: Wada, 1980). these results suggest that new production should be characterized by relatively lower delta values in primary producers. In contrast, ^{15}N enrichment along the food chain (MINAGAWA and WADA, 1984) will be reflected in the Particulate organic matters which sinks from the euphotic zone into deeper water. Denitrification, which occurs for example in the oxygen minimum layer of the eastern tropical Pacific Ocean (CLINE and KAPLAN, 1976; LIU and KAPLAN, 1989; SAINO and HATTORI, 1989) also tends to increase the $\delta^{15}N$. Except for this region, the $\delta^{15}N$ of pelagic plankton falls in the range of 6 to 7 ‰, which is almost the same range measured for nitrate in surface water.

The nitrogen isotope abundances and distridutions in Arctic marine ecosystems are poorly. The shelves receive some terrestrial nitrate (e.g., MACDONAL DA *et al.*, 1987) and have new production of perhaps 20-60 gC m^{-2} yr^{-1} (ANDERSON *et al.*, 1990). Incontrast, the productivity of the Arctic interior ocean appears to be very low (SUBBA RAO and PLATT, 1984; MACDONALD and CARMACK, 1991). The lack of new production there may therefore result in higher ^{15}N abundane in recycled nitrogen when compared to marginal or other seas.

In recent investigations of material budgets in the Canadian Beaufort Sea (NOGAPB. 6 project), we have attempted to identify the carbon and nitrogen ispotope ratios of organic matters in the Arctic shelf ecosystem. The first detailed analyses of $\delta^{15}N$ and $\delta^{13}C$ have been made for plankton, fish, sediments and sediment trap particles. Since detailed results of this study will be published in elsewhere, we describe the results only briefly here.

The $\delta^{13}C$ of zooplankton and trap particles was found to be near −23 ‰ and −25 ‰, respectively, indicating slightly lower ^{13}C content compared to plankton in other seas. On the other hand, sediments from the Mackenzie River estuary and the Mackenzie Shelf 150 km away from the coast show in their isotopic composition a substantial addition of land-delived organic material, for which the $\delta^{13}C$ is −28 ‰. Therefore, we believe that significant quantities of terrestrial organic carbon is added into the carbon cycle in this ecosystem and that it alters the $\delta^{13}C$ of both plankton and sinking particles. The temperature effect, which produces low $\delta^{13}C$, is relatively unimportant for the Beaufort sea.

The $\delta^{15}N$ of plankton, fish and trap particles varied from 7 to 12 ‰, which is within the normal range found for other oceans. However, if we subtract the $\delta^{15}N$ dilution caused by mixing with terrestial organic matter (about 1‰), the results indicate a significant enrichment of ^{15}N. Further, the $\delta^{15}N$ of sediment samples also shows relative enrichment of ^{15}N compared to $\delta^{13}C$ - $\delta^{15}N$ relationships reported for other seas. These results suggest that the nitrogen isotope in the Beaufort Sea are defined by a balance between selective fixation of ^{14}N into are sediment and the addition of river-delived terrestrial nitrogen which is ^{14}N rich.

References

ANDERSON, L. G., D. DYRSSEN, and E. P. JONES (1990): An assessment of the transport of atmospheric CO_2 into the Arctic Ocean, J. Geophys. Res., **95**, 1073-1711.

CLINE, J. D. and I. R. KAPLAN (1975): Isotopic fractionation of dissolved nitrate during denitrofication in the eastern tropical South Pacific Ocean. Mar. Chem. **3**, 271-299.

FISCHER, G. (1991): Stable carbon isotope ratios of plankton carbon and sinking organic matter from the Atlantic sector of the Southern Ocean Marine Chem. **35**, 581-596.

LIU K.K and I.R.KAPLAN (1989): The eastern tropical Pacific as a source of ^{15}N-enriched nitrate in seawater off southern California. Limnol. Oceanogr. **29**, 361-364.

MACDONALD, R.W. and E.C.CARMACK (1991): Age of Canada basin deep waters—A way to estimate primary production for the Arctic Ocean. Science, **254**, 1348-1350.

MACDONALD, R.M., C.S. WONG. and P. ERICKSON (1987): The distribution of nutrients in the Southeastern Beaufort Sea: implications for water circulation and primary production. J.Geophys. Res. **92**, 2939-2952.

MCCONNAUGHY, T. and C.P.MCROY (1979): Food-web structure and the fractionation of carbon isotopes in the Bering sea. Marine Biol. **53**, 257-262.

MINAGAWA, M. and E.WADA (1984): Stepwise enrichment of ^{15}N along food chains: further evidence and the relation between $\delta^{15}N$ and animal age. Geochim. Cosmochim. Acta **48**, 1135-1140.

MINAGAWA, M. and E. WADA (1986): Nitrogen isotope ration of red tide organisms in the East China Sea: a characterization of biological nitrogen fixation. Marine Chem. **19**, 245-259.

SAINO, T. and A.HATTORI (1987): Geographical variation of the water column distribution of suspended particulate organic nitrogen and its ^{15}N natural abundance in the Pacific and its marginal seas. Deep-Sea Res. **34**, 807-827.

SAUPE, S., D.M. SCHELL and W.B.GRIFFITHS (1989): Carbon-isotope ratio gradients in western arctic zooplankton Marine Biology **103**, 427-432.

WADA, E. (1980): Nitorgen isotope fractionation and its significance in biogeo-chemical processes occurring in marine environments. *In* Isotope Marine Chemstry. (eds. GOLDBERG, E. D., Y. HORIBE, and K. SARUHASHI, Uchida Rokakuho, Tokyo, 375-398.

PARTICIPANTS

France

CADET, Daniel L.	Institute National des Sciences de l'Univers
CECCALDI, Hubert J.	Maison Franco-Japonaise, EPHE
COSTE, Bernard	CNRS, Observatoire océanologique de Marseille
DINET, Alain	CNRS, Observatoire océanologique de Banyuls
DUPLESSY, Jean-Claude	CNRS, Centre des Faibles Radioactivités
GAILLARD, Jean-François	Université de Paris 7
JACQUES, Guy	CNRS, Observatoire océanologique de Banyuls
JARRIGE, Fraçois	ORSTOM, Départment Terre-Ocean-Atomosphère
Le BOUTEILLER, Aubert	ORSTOM, Centre de Nouméa
SEMPERE, Richard	Unversité de Perpignan-Université de Tokyo
SIBUET, Myriam	IFREMER, Centre de Brest

Japan

ARUGA Yusho	Tokyo University of Fisheries
HANDA Nobuhiko	Nagoya University
HATTORI Hiroshi	Hokkaido-Tokai University
IIYAMA Toshimichi	Chiba University
ISEKI Kazuo	Seikai National Fisheries Research Institute
ISHIKAWA Kimitoshi	Natural Institute for Resources and Environment
ISHIMARU Takashi	Tokyo University of Fisheries
ISHIZAKA Joji	Natural Institute for Resources and Environment
KOIKE Isao	University of Tokyo
MATSUDA Osamu	Hiroshima University
MINAGAWA Masao	Mitsubishi-Kasei Institute for Life Science
NAITO Yasuhiko	National Institute of Polar research
NOZAKI Yoshiyuki	University of Tokyo
OBA Tadamichi	Kanazawa University
SHIRAYAMA Yoshihisa	University of Tokyo
TAKAHASHI Masayuki	University of Tokyo
TAKAYANAGI Kazufumi	National Research Institute of Fisheries Science
TANIGUCHI Akira	Tohoku University
TSUJI Yoshihiko	JAMSTEC

La mer 29: 213-218, 1991
Société franco-japonaise d'océanographie, Tokyo

JECSS/PAMS NEWS No. 11

JECSS/PAMS VII in China in 1993, Chinese Research in JECSS area, Japanese Research in JECSS area, A New Journal "Research of Sea".

(December, 1991)

1. Preface

It seems that JECSS/PAMS News will be published quarterly in La mer hereafter. The only hindrance to the regular appearance of the News is lack of any new items worthy of a newsletter. We need reports on start and developement in research either in theory, concept or experiment. The items to be published do not need completed materials which have many ample outlets in regular journals. Conceptual models or seemingly controversial subjects are accepted if these are not published elsewhere. It is important for the news to be published regularly to keep the Editorial Board and the readers of La mer alert. This arrangement is realized through the efforts of Professor Hideo Sudo of Tokyo University of Fisheries.

2. First Announcement of 7th JECSS/PAMS Workshop and call for papers.

The Seventh JECSS/PAMS Workshop will be held in Qingdao (China) on May 9-15, 1993. For further information, contact Zhang Fagao, Secretary of the local organizing committee, Institute of Oceanography, Academia Sinica, 7 Nanhai Road, Qingdao, China.

Local Organizing Committee:

Yunshan Qin (IOAS), chair; Dunxin Hu (IOAS), vice-chair; Fagao Zhang (IOAS), secretary; Zeshi Chen (1st IO, SOA), Yuanbing Fan (NNSFC), Guohong Fang (IOAS), Xiuwen Han (Dept. of Resources and Environment, AS), Ronghui Huang (IAPAS), Yusong Su (OUQ), Tianhong Yang (SCSIOAS), Yaochu Yuan (2nd IO, SOA), Shijin Zhao (IOAS)

Secretariat of LOC:

Institute of Oceanology, Academia Sinica 7 Nan-Hai Road, Qingdao 266071, People's Republic of China

Telephone: 86-532-279062 ext.377

Telex: 32222 ISS CN

FAX: 86-532-270882

Steering Committee of JECSS/PAMS:

Kenzo Takano (University of Tsukuba), chair; Kuong Lung Fan (National Taiwan University), Ya Hsueh (Florida State University), Kazuo Kawatate (Kyushu University), Kuh Kim (Seoul National University), Gil Jacinto (University of Philippines), Absornsuda Siripong (Chulalongkorn University), Gennady I. Yurasov (Academy of Science, Russian Federation), Fagao Zhang (IOAS), Takashi Ichiye (Texas A&M University), honorary chair

Objective:

JECSS/PAMS is a forum for and by marine scientists who have interest in the Japan Sea, the East China Sea and other marginal seas of the Pacific Ocean. Its objectives are (1) to exchange information of research activities, (2) to discuss research results and (3) to plan cooperative studies. Emphasis is on physical oceanography; however, geological, chemical and biological oceanography are included as well.

Invitation:

Participants will be invited to this international workshop. Invited participants will be accommodated lodgings during the workshop without charge. A registration fee of US$100 is charged to cover the cost of proceedings. There are limited funds for participants who will be unable to pay for their registration fee from their own source. Those who need support should indicate this in a separate letter for application to the secretary of the workshop.

Abstract Preparation:

The abstract deadline is December 31, 1992. All abstracts submitted must be in English. The abstract must be typed on paper of 21×

29.5 cm with abstract text in 16×24 cm. Leave blanks at the top 3 cm, at the bottom 2.5 cm, on the left side 3 cm and on the right 2 cm.

It is advisable to contact Fagao Zhang, secretary of the Workshop for turther information on invitation and abstract preparation.

Qingdao is located at the coast of the Yellow Sea. It is well known for its textile and light industries, its sea port for foreign trade and oceanographic research at IOAS, 1st IO, SOA and OUQ. It is an ideal. place to vacation, with beautiful, natural scenery and a pleasant climate. The beach and Mount Laoshan are regarded as one of the best national beauties of China. Climate in May of Qingdao is good with average temperature of about 16° C and many flowers are in bloom. (By Qin Yunshan, Professor and Director of IOAS and chair of 7th JECSS/PAMS Workshop LOC).

The secretary of 7th JECSS/PAMS Workshop requests an early reply to him by mail or by fax with intention of presenting paper or not. Those who respond by August 31 will receive the second circular. He also request that any person may notify others who are potential participants of this announcement. Those who wish to have an original announcement and application forms for participation will be supplied by writing to the secretary listed above.

3. Chinese research in JECSS/PAMS area

Marine Sciences (quarterly) published by International Academic Publishers (at Academia Sinica, Institute of Oceanology) appeared from vol. 3(1) to vol. 4(1) in February 1992. The following are excerpts of articles which may be of interest to the News readers.

In vol 3(1), 15-19, M. Cui and D. Hu (IOAS) discussed staircase structures of temperature and salinity profiles collected with the SBE-CTD system in October 1988 during the hydrographic cruise in the western Pacific Ocean west of 130° E and between 5°N and 27° N. Among more than 80 hydrographic stations only eight stations showed conspicuous staircase profiles at 200-600 db below the thermocline, south of and close to Taiwan and close to Mindanao. They derived a time scale of formation from energy conversion and estimated the time as 1 day and space scale as 1 to 10 km. They speculated the salt fingering as a cause, but also included internal waves breaking as another.

In vol. 3(2), 19-21, C. Wang and X. Weng of IOAS treated interannual variabilities in strength of the Taiwan Warm Current (TWC) in 1959-1986, and its relationships with volume transports of the Kuroshio at latitudes from 17°N to 25°N in 1965-66. Also they found that the following year of strong EI Niño in the equator, TWC became weak.

In pages 16-17, M. Cui and D. Hu (IOAS) discussed application of an inverse calculation to determine velocity field with grid data base by use of geostrophic relations. There is no example of the calculation.

In pages 27-33, Y. Zhao (IOAS) and G. A. McBean (UBC) discussed EOF of seasonal SST anomalies of the North Pacific Ocean from 1950 to 1979 and their relations to the Sea Level Pressure (SLP) anomalies over the whole hemisphere between 15°S and 15°N of the same period. SST's EOF has first component of 19.1% amplitude and second component 10.7%. SLP anomalies have strong telecommunication of Pacific/North America. This is shown in winter between the first component of SST's EOF and SLP. In summer, significant positive and negative correlations between SST and SLP anomalies over the south of the North Pacific and over Siberia and Bering Sea, respectively.

In vol. 3(3), pages 29-35, Y. Lin (2nd IO, SOA) discussed flux of sediment transport based on the time integrated flux of suspended sediment concentration multiplied by fluctuating current. The net transport was derived by use of cospectrum between fluctuations of current and suspended sediment. The procedure is applied to data of current and suspended sediment in the Jintang inlet of the Chanjiang Estuary. He derived the longitudinal diffusion coefficient of 10^3 $m^2 s^{-1}$ for a frequency range covering both low and high frequencies.

In vol. 3(4) pages 27-29, M. Feng, D. Ha and Y. Li of IOAS presented an analytical solution

of the circulation in the Huanghai (Yellow) Sea that is thermally driven. They simplified the current and density field in two dimensions of vertical and horizontal along the line crossing the center with east and west boundaries and with constant eddy viscosity and eddy diffusivity. The results indicate that the central area temperature is higher than on both sides and the vertical section has double cell structure with the upper layer of downwelling center and with the lower layers of upwelling center. However, without a few examples of circulation patterns and temperature distributions, it is hard to visualize the model.

In pages 30-32, D. Yuan and D. Hu presented an analytical solution of time-dependent, linear momentum equations of the reduced gravity ocean on the equatorial beta plane driven by the wind and horizontal eddy viscosi-ty with a linear and vertically integrated continuity equation. They modeled the formation of the equatorial "warm pool" in the western Pacific by use of the isolated zonal wind stress. They concluded that the geometry of the western boundary is important for the formation of the pool and also that the intensity of the Mindanao Current contributes significantly to the evolution of the pool. The latter seems to be insensitive to the isolated easterly wind stress in the central part in comparison to the one in the western part. However, without a few numerical examples the conclusion is difficult to assess.

4. Japanese research in JECSS/PAMS areas.

In spring annual meeting of 1992 of the Ocenographical Society of Japan on April 2-6, about 21 papers in physical oceanography sessions dealt with topics in JECSS/PAMS areas. This is almost one third of total physical oceanography papers (71) in that meeting. I did not record statistics of this kind and thus it is difficult to say that this is an increase or decrease from previous years. But I see a trend that more of these papers dealt with data collected for special processes and not by routine hydrographic surveys. I am not sure whether the number of the papers and conceived tendency reflected the JECSS VI in Kyushu University in 1992. Still I am very much heartened by the significant number of papers and the change in the content of the papers.

In the following I explain abstracts of some papers that were sent to me by Professor Sudo and also that might be of interest to non-Japanese JECSS scientists. The order is from south of ECS to Japan Sea.

K. Muneyama et. al. (JAMSTEC and Sanyo Techno-Marine Co.) presented a preliminary hydrographic study of east of the Philippines between 8°N and 2°N and west of about 130°E with 1° latitude-longitude CTD stations and 0.5°interval XBT with 10 drifters dropped in NECC, NEC, and Mindanao C from December 1991 to January 1992. It was found that the New Guinea Submersiblel Flow transported low salinity-high temperature water northwestward from southeast and turned to north or northeast off the northwest end of New Guinea. Drifter tracks indicated that the Mindanao C flowed westward in the Molucca Sea.

R. C. Wajsowicz of Hokkaido U. and T. Yamagata and Y. Masumoto of U. of Tokyo discussed seasonal change in the baroclinic circulation in the Indonesian archipelago based on a multilevel GCM of $0.5° \times 0.5°$ grid of the equatorial Indian and Pacific Oceans with explicit island representation. The narrow straits and high sills reduce the net heat transport based on a Sverdrup model.

H. Nakajima *et al.* (Hiroshima U. and Kyushu U.) analyzed and discussed current data at a meteorological buoy station (126-20E, 27-10N) in the ECS collected with ADCP during August 29 - Sept. 1 in 1990 during passage of Typhoon No. 15. The mean direction at eight layers down to 425 m during one year, 1990 was 40°. The station seemed within the Kuroshio. When the typhoon was closest to the station, the inertial oscillations started and seemed to end about six days later. The initial thirty hours they propagated downward from the surface but later upward from the deep layers. The data will provide an example of the generation of inertial motions due to an atmospheric disturbance. O. Kato *et al.* (Seikai Natl. Fish. Res. Inst.) described the

current in the sea west of Kyushu based on ADCP measurements of five sections crossing the Tsushima Current from 31.5°N to East Tsushima Channel. On the southern two sections there was no strong current zone, whereas on the northern sections western side showed a strong current zone.

S. Mizuno et al. (Kyushu U. and Hiroshima U.) discussed 1991 measurements of the flow at five stations crossing a core of the Kuroshio northwest of Okinawa with ADCP, Aandera RCM8 and electromagnetic type meters. The data were collected when Typhoon 17 passed near the stations on September 23. The data indicated that the effect lasted more than one month with shifting of a Kuroshio core eastward resulting in vanishing speed at some stations. This may present an interesting example of an effect of a meteorological disturbance on a western boundary current. K. Eda et al. (Hiroshima U. and Kyushu U.) used the data of current collected at one ADCP station at 27-17.62N and 126-3.80E at 20 n miles SE of it on the line of stations described by Mizuno et al. above. The former was on a continental slope at 400 m deep and the latter is the core of the Kuroshio. They applied a method of Bryden H. (1980), JGR **85**, 2825, to determine vertical velocity and found that the method was valid when the flow crossing the isopaths was intensified and that the upper layer flowed to the shelf with upwelling and the lower layer to the ocean side with downwelling.

S. Kanari, Ch. Kobayashi (Hokkaido U.) and K. Matsuno (Nagasaki U.) measured parameters in the mixed layer near the bottom by profiling with CTD, XBT and MSP on the line crossing the isobaths with depths 150-500 m northwest of Okinawa and collected time-series current data at three layers above the bottom. Estimation of eddy diffusivity is of order of 1 $cm^2 s^{-1}$ near 100-180 m, but becomes 10 to $10^2 cm^2 s^{-1}$ near the bottom where the mixed layer existed. Eddy viscosity is 10 to 10^2 $cm^2 s^{-1}$ and increases as the station nears the coast. K. Matsuno, S. Kanari and Ch. Kobayashi discussed the internal tides from current data collected with three RCM-4. As with the barotropic tides semidiurnal components were predominant in the baroclinic tides and the vertical structures of the latter depend on the movement of the Kuroshio core.

A. Iso (Fisheries U.) modeled seasonal change of the transport of the Tsushima Current through Tsushima Strait with maximum in summer to fall. He confirmed this with bimonthly ADCP and CTD measurements. He considered that the cold bottom water outflowed from the Japan Sea to Tsushima Strait close to the western coast in late summer, generating a strong current zone near the coast, whereas in winter the cold water flowed out in the central portion without causing the intensified baroclinic flow. This dynamics was treated as geostrophic adjustment problems in three and two layer seas for the former and two layer sea for the latter.

M. Sakurai et al. (Kagoshima U.) presented a presliminary report on current data in the Tokara Strait 29-31N, 129-51E at 760 m depth, south of Kyushu measured from November 1990 - July 1991. In the upper layer in the first 40 days, the current flowed NW in reverse to the Kuroshio, then up to 70 days oscillated between E and W and after 100 days E with the Kuroshio. In the lower layer it always flowed south. In average, the upper layer flow directed 70° with 11 cm s^{-1} and the lower one 170° with 9 cm s^{-1}. Ferry boat surface temperature measurements indicated movement of the front that suggests a possibility of locating the Kuroshio from historical SST records on ferry boats.

Y. Isoda, M. Ebara (Ehime U.) and T. Murayama (Shimane Pref. Fish. Exper. St.) discussed seasonal change of the Tsushima Current along 26 transects at 133°E in August 1988 - July 1989 with ADCP and CTD. They eliminated tide and wind driven components from observed currents and also estimated baroclinic components by use of the density field. The barotropic components thus determined showed large values on the slope and nearshore where bottom slope was large. Seasonal change resulted mainly from shift of maximum baroclinic flows. During the stratification period maximum flow of 20 cm s^{-1}

was near the center of the shelf, whereas in winter the maximum with 10 cm s^{-1} moved to the edge of the shelf.

M. Hirai and H. Yamada (Japan Sea Natl. Fish. Res. I) and H. Toju (9th Mar. Safety Agency St.) described two ships' hydrographic cruises in August - September 1991 with CTD and ADCP northwest from the coast of Japan on six transects to about 250 n. miles between 134°E and 139°E and 37°N and 40°N. Temperature at 200 m showed an isolated warm anticyclonic eddy with the center at 136°E and 38.5°N of diameter of 150 n. miles.

T. Senjyu and H. Sudo (Tokyo U. of Fish.) discussed water characteristics of temperature, salinity, oxygen and nutrients in the Japan Sea between 300-1000 m from historical data of 1964-1985. They classified the upper part of the Japan Sea Proper Water in four segments in their location and two northern and southern segments represent rich and poor oxygen areas separated at 40°N, respectively. They speculated that the proper water is formed in Segment I west of the central line of the JS and north of 40°N and then advected to the west and south and converging into the Segment III west of Japanese coastline and south of 40°N. It is more challenging to confirm sinking mechanism in Segment I and deep circulation to bring the sunken water to segment III.

S. Martin (U. of Wash.), M. Wakatsuchi (Hokkaido U.) and N. Ono (Nat. Inst. Pol. Research) discussed the formation of the Japan Sea Bottom Water in the Mamiya Strait using ice-cover data with microwave image. They estimated the ice growth as 25 km^2 per season 25% of which severe storms provide. This may produce $5-12 \times 10^2$ km^2 of JSBW consisting 50-100 % of the renewal rate estimated from carbon-14 data. Oxygen bottom boundary layer thickness decreased between 1966-1985 corresponding to a decrease in frequency in severe storms during the same period, suggesting that severe storms contributed ice formation and the bottom water formation.

Through the Office of Institute for Pacific Asia, TAMU (Director, D. Hall) came to my attention the 17th conference of US/Japan Cooperation program in Natural Resources, Marine Facility Panel convened in May 1991 in Tokyo. This meeting was not reported in JOSJ, since most of the papers were devoted to marine technology and its application. One paper by M. Takamatsu (3rd Port Construction B. of MOT) might be of some interest to the readers, since it described recovery by *Seiryu Maru* of spilled oil off Tango Pen. in the Japan Sea in the winter of 1990. It seemed that January 1990 "Maritime Gardenia" 7027 D.T. cargo ship of Hong Kong spilled 863 ton bunker C oil, of which only 20 ton was recovered in February. The environmental impact is unknown, though the coastline is one of the scenic beaches of Japan. Also the paper stated that 934 marine pollution incidents occurred around Japan during 1990, of which 605 involved oil pollution.

Though these numbers significantly decreased from 1581 and 1228, respectively in 1981, the curves of the numbers plotted against years show that both numbers were almost static since 1986. We would like to know how these incidents occurred and how they were managed, as marine scientists who are conscious of marine environmental problems.

5. Miscellaneous

Due to an editorial policy change of the OSJ (Oceangraphical Sciety of Japan) mentioned in the preface, the miscellaneous sections of the JOSJ (Journal of OSJ) were completely abolished and instead bi-monthly Japanese journal "*Umi no Kenkyu*" (UNK, Research of Sea) was started in February, 1992 as volume 1 No. 1 (229 pages). The first issue include fifty year history of OSJ, descriptions of marine research and developement organizations of Japan as well as recent (mainly since 1970s) history of development in reseach on different branches of oceanography and ocean engineering both in Japan and all over the world . The different sections of research developements were written by scientists who are currently active in research of their respective field, unlike previous publications in Japan of this kind which used to include perfunctory resumes of researches at each organization

written by mainly management personnel.

I find this part very useful for information on research efforts by the Japanese scientists which did not always publish in coventional journals including JOSJ. The only inconvenience I felt is the complete lack of reference lists. At least references of Japanese papers will be helpful if included. For most of the foreign journals contents of which are cited, abbreviated journal names, volume, year and the first page number do not take much space.

The UNK seems to accept manuscripts only in Japanese. Therefore "Forum" of the old JOSJ that was initiated by Dr. H. Sudo was abolished. However, Sudo, who is a member of La mer Editorial Board, assured me that La mer has an unofficial Forum section with due editorial process. Thus the readers are encouraged to submit their manuscripts in English either to be included in future JECSS /PAMS News or Forum of La mer.

In this issue of UnK, K. Muneyama of JAMSTEC contributed one section on JECSS (page 214) in a chapter describing international cooperative programs in oceanography in Japan. In a section of marginal seas and shelves of chapter on physical oceanography, A. Maeda of Kagoshima U. mentioned JECSS. He also raised a question that researchers of China (B. Guan of IOAS and others since 1982) had a different concept from the one commonly accepted by the Japanese researchers on circulation in the Yellow Sea, particularly the presence of the Yellow Sea Warm Current only in winter. He attributed this difference to interpretation of circulation by use of fields of water properties only and advocated wide use of ADCP. I concur with him completely.

Acknowledgements

Publication and distribution of JECSS / PAMS No.11 is supported by U.S. WOCE Office (Director, P. Chapman) at Texas A&M University. Distribution to Asian countries including former USSR is helped by Kei Muneyama of JAMSTEC.

(*Editor*, Takashi ICHIYE, *Department of Oceanography, Texas A&M University, College Station, Texas 77843-3146, USA*)

La mer 29: 219-222, 1991
Société franco-japonaise d'océanographie, Tokyo

Faits divers

Comments on Oceanographical Society of Japan and its 50th Anniversary*

Takashi ICHIYE**

1. Introduction

The Oceanographical Society of Japan (OSJ) celebrated its 50th Anniversary in October, 1991. As far as I know OSJ is the oldest learned society (LS) in the world, solely dedicated to oceanography. I have been a member, since about 1947 or 1948 and I congratulated its longevity together with other members.

This short note is the outcome of my rather random thinking about problems related to OSJ, some of which were already expressed in my recent correspondence with my colleagues in Japan and also in JECSS Newsletter published in the Journal of the Oceanographic Society of Japan (JOSJ).

This is not systematic critics on conduct of OSJ. Consider it as a view from a member who was long associated with OSJ, but quite detached from its operation or influences. Submittal of this note to "La mer" is through encouragement of Professor Hideo Sudo, a member of the Editorial Board of La mer.

I remember some time ago, some editors in the U.S. stated that a LS may not be sustained without heavy subsidies from private or government sources with memberships less than 2,000 if the LS publishes a journal at regular decent intervals and provides one or two general meetings every year with an affordable membership charge. Thus it is considered a great achievement to sustain OSJ for fifty years. (For that matter it is beyond my comprehension how the French-Japanese Oceanographical Society did not go under with membership, perhaps below 500.)

2. LS's services to its members

Any LS's professed purposes include promotion of its specified academic discipline and dissemination of information and knowledge related to its discipline in order to improve scientific skill and status of its members.

After perusal of many back issues of JOSJ, where most of the information on activities of OSJ were described in "News" items in Japanese, I come upon the following comments. These are in comparison with publications such as EOS, Bulletin of American Meteorological Society and Physics Today, respectively representing service sectors of American Geophysical Union, American Meterological Society and Amerlcan Institute of Physics. Of course for strict comparisons in statistical sense and in social science rigors, it should be taken into account of membership size, hierarchy of status of each discipline within academic and social standings at each country. Howevery, I stated at the beginning that this note is not the result of regorous study, but only a cursory impression of one overseas member of OSJ.

As far as Vol. 47, No. 4, August 1991, every number of JOSJ contained "News" as a service to members of OSJ, excapt Forum which started in Vol. 46 to include contributions from members, but seemed to have been dropped within a year. The "News" includes minutes of monthly meetings of the OSJ executives, announcements with paper titles of annual society meetings of spring and fall, change of the society directories with new members, their addresses, reports

* Received Novenber 20, 1991
**Department of Oceanography, Texas A&M Universyty, College Station, TX 77843-3146 USA

of national and international scientific meetings related closely or barely to oceanography and occasionally book reviews and lecture or a summary of researches by Okada Prize Awardees.

However, we are reminded that the Editorial Board of the OSJ does not adopt the principle of the New York Times that "all the news fit for printing is printed".

Therefore perusal of "News" items does not give any picture of the Japanese oceanographic community nor the trend of its scientific orientation unlike other U.S. publications mentioned above. Even constituents of OSJ membership are not pictured clearly in the "News". I suggest that a first step of upgrading the service of OSJ is to make a census of its members through a little bit more penetrating questionaires, for example on the status of employment, job classification, salary and other compensation levels, academic training and highest degrees, past job experiences, current and past (in previous several year) work categories, job satisfaction, etc. Of course responders could be anonymous.

The result of these questionnaires may be handled by a group including sociologists as well as oceanographers besides a primary processing of the data. The actual mechanism may be left to a committee to be set up for this purpose. This kind of census might be updated every two or three years and could be used for promotion of marine sciences among the general public or for that matter for lobbying them to Japanese Science Congress (Nippon Gakujutsu Kaigi) or even to the Japanese Parliament.

The second, relatively easy step is to make a list of organizations and institutes of Japan which conduct research, developement, services and education related to marine sciences. This list may include mainly those supported by local and central governments, but also those supported by industries. It should list numbers of scientific and supportive staffs, possibly project descriptions and typical or average annual budgets. Such data always seems to be available for much wider disciplines in science and technology in Japan as seen by several kinds of promotional brochures prepared by MITI (Ministry of International Trade and Industries)and other ministries for propaganda purposes in order to deflect sharp criticisms from overseas against Japan's lack of effors on research versus her predatory trade practices. It seems that OSJ may be limited to much narrower fields of marine science and thus does not need extensive search for information nor extravaganza of luxuriant format of these brochures. (a new Japanese jouvnal of "Umi no Kenkyu"of OSJ in its first issue included a chapter listing institutes and their research projects except budgets and stuff members.)

In conjunction with or in consequence to this second step, OSJ should publish annual statistics of total budgets for marine sciences at different agencies and perhaps man power statistics of working marine scientists and those who are in preparation, that is, graduated and undergraduate students. These statistics could be updated yearly or every other year. They could be used for marine science/marine services planners for their efforts in immediate future plan of their projects or capital assessment, man power recruitment and budget negotiations with government and other funding sources.

3. Respectability of OSJ

One of the basic deficiencies in OSJ may not have originated in itself, but in the cultural background of Japan, where the up- and above have all the responsibilities, even in the field of science. In practice, the LS in Japan seems to have little voice in framing and implementing policies in science even if they are closely related to advancements of national welfare. This is in great contrast to the Western nations, notably in the U.S. and Britain, though in recent decades, influences of the academic on policy matters seemed to wane. Still there are some examples where Congresses or Parliaments listened to voices of scientists through LSs, for example in the US for global warming the Congresses and

the Administration paid attention to opinions by scientists through the American Meteorological Society or AGU or for Space Station to discussions summarized by a dozen of LSs.

On the other hand, OSJ seems to be mute in any subjects when the Japanese oceanographic community was requested to participate in global projects or considered as responsible for Japan as a nation such as marine environmental problems.

Global aspects aside, I heard many grumblings by Japanese marine scientists about the shortcomings of the current system. Strong voices were aired against the concentration of reserach budgets in some government agencies in contrast to universities with rigid mobility of personnel and restrictions in usage of research infrastructures. I believe that many of these may be alleviated through vigorous actions on the part of OSJ. But first of all, the society should start to establish itself as an impartial arbiter of the shortcomings on the basis of the science. This process will take time, but OSJ should start in its direction with education of its members.

A few years ago, in relation to the JECSS (Japan and East China Sea Study) Program a Chinese scientist asked me about the possibility of joint field experiment with Japanese universities and agencies. This is a preliminary plan and his institute could not present official requests to the Japanese side. He considered OSJ might be a suitable channel for such a proposal. When I discussed this with several Japanese colleagues, they categorically dismissed the idea, because OSJ has no standing with universities or agencies. In this particular case, there was almost no budgetwise problem, since the field work involved would use instruments and personnel provided by the Chinese side or even ship time might be also provided. Therefore it seemed that OSJ could not play as an intermediary between two scientific parties nor to advocate or judge on scientific merits of the plan.

There are other subjects that OSJ could consider its own capacity as an impartial arbiter. For example, Japanese government allocated ship time apparently is not distributed according to needs of different organizations nor to achievements performed previous year. Of course uneven allocations of ship time as well as that of reserach budgets are themselves not to be worried at all for healthy growth of marine sciences. However, in Japan, many marine scientists employed at some agencies complained that they were engaged so busily in cruise after cuise, there was no time to consider the data from scientific points of view. One the other extreme, many university marine scientists had a hard time making field experiments, thus were forced to deal with purely theoretical problems or only subjects without field data.

The key point that there is very little review process on use of ship time in general leading to a result of some mission oriented agencies continuing routine field work without taking account of developements of technology or improvement of understanding the processes to be measured in the field.

The LSs of U.S. are very conscious about the recruitment of the next generation of scientists of each discipline. Most of the LSs publish status of the graduate students and potential undergraduates who are expected to join the work force. Also some LSs mobilize student chapters on campus for recruitment. In the same fashion, many U.S. LSs have been trying to recruit female and minority scientists to remedy unbalanced representation in science and engineering by these groups. It seems strange for outsiders that OSJ did nothing of that sort in spite of the statistics that showed miniscule percentage of female marine scientists.

Although perhaps Japan does not have a serious problem for minorities, its oceanographic community needs support and cooperation by those of neighboring nations if it wants to extend research scope beyond its adjacent seas. As I became more conscious about this problem while I started JECSS more than ten years ago and kept it going

since then, I have been surprised and a little bit disappointed at lukewarm response of oceanographic community as manifested in overall attitude of OSJ towards JECSS. If the Japanese oceanographic community wants to work in the Western Pacific including its adjacent seas, both scientifically and economically,cooperation and support of neighboring nations are mandatory and should be sought vigourously.

OSJ seems to be almost inactive in attracting industries to oceanography or marine sciences in general. This is incomprehensible, since many industries which are land oriented in other countries are affected by the seas or affect them in many ways. OSJ should take a lead in public relations and education of the public as well as the industrial sectors. This does not mean fund rasing or something like that. Rather OSJ should fulfill its obligation by enlightening the public. In this connection, OSJ should act positively and explicitly on environmental problems related to seas and oceans from different aspects of bureaucracies or industries. Again it could serve as impartial arbiter in its scientific judgement.

There might be many other initiatives OSJ could take. These mentioned are only a starting point from which future executives of OSJ may make big forward movement.

3. Conclusion

The first president of OSJ (from 1948-1967), late Professor Koji Hidaka, mentioned his vision more than twenty years ago in "Forty Years with Oceanography" (1968, Japan Broadcasing Publication Co.).

In his statement he said that Japanese oceanographers suffered poor support from the government for their efforts on field experiments and were forced on relying mainly theoretical studies and that they could not take initiatives in global research of the ocean, following the itiniatives started by U.S. and other European nations because of uncertainties of support from lack of funds. Also he mentioned that the only Japanese initiated international program, CSK (Cooperative Study of the Kuroshio), languished because only the bureaucrats were involved. Perhaps many of these remarks are no more valid bacause of amazing advancement of economic status of Japan. It has extremely good infrastructures in marine sciences, capable man power and improvement of the political situation around the western rim of the Pacific Ocean. I hope OSJ will play a key role in this decade and beyond in the 21st century.

La mer (Bulletin de la Société franco-japonaise d'océanographie)

Tome 29 (1991)

Sommaire

Numéro 1

Numéro 2

うみ（日仏海洋学会誌）

第29巻（1991年）

総 目 次

第1号

第2号

Numéro 3

Notes originales

第3号

原　著

Numéro 4

資　料

第4号

日仏ワークショップ「オーシャンフラックス」

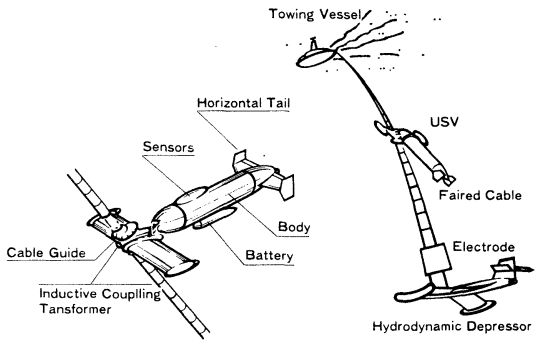
賛　助　会　員

旭化成工業株式会社	東京都千代田区有楽町 1-1-2　三井ビル
株式会社旭潜研	東京都北区栄町 9-2
阿部嘉方	東京都練馬区春日町 2-15-6
株式会社内田老鶴圃　内田悟	東京都文京区大塚 3-34-3
有限会社英和出版印刷社	東京都北区中里 2-7-7
株式会社カイジョウ	東京都西多摩郡羽村町栄町 3-1-5
(財)海洋生物環境研究所	東京都千代田区内神田 1-18-12　北原ビル内
株式会社川合海苔店	東京都大田区大森本町 2-31-8
三信船舶電具株式会社	東京都千代田区神田 1-16-8
株式会社　自然・情報環境研究所	横浜市栄区桂町 1-1, 3-401
昭和電装株式会社	高松市寺井町 1079
新日本気象海洋株式会社	東京都世田谷区玉川 3-14-5
全日本爬虫類皮革産業連合会	東京都足立区梅田 4-3-18
株式会社高岡屋	東京都台東区上野 6-7-22
株式会社鶴見精機	横浜市鶴見区鶴見中央 2-2-20
株式会社東京久栄技術センター	埼玉県川口市芝鶴ケ丸 6906-10
株式会社　東急フーズミート	東京都品川区東品川 4-10-21
株式会社西日本流体技研	長崎県佐世保市棚方町 283
日本アクアラング株式会社	神奈川県厚木市温水 2229-4
株式会社　日立造船技術研究所 バイオ研究センター	大阪市此花区桜島1-3-22
宮本悟	東京都中央区かきどき 3-3-5　かちどきビル　㈱本地郷
株式会社読売広告社	東京都中央区銀座 1-8-14
渡辺機開工業株式会社	愛知県渥美郡田原町神戸大坪 230
株式会社渡部計器製作所	東京都文京区向丘 1-7-17

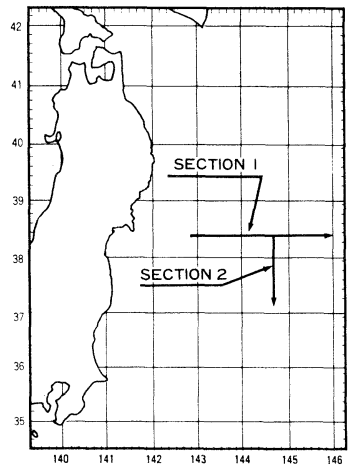
スライド式高速曳航体 JAMSTEC TSK方式

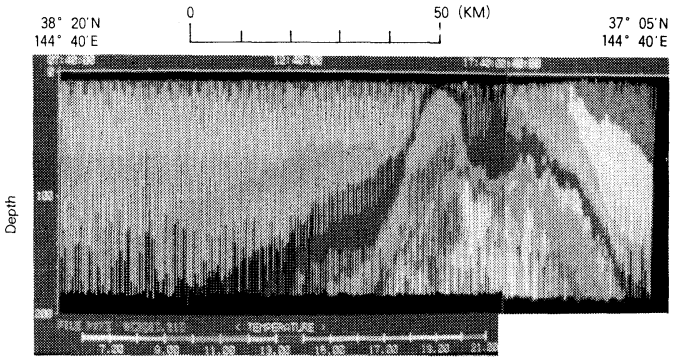
Underwater Sliding Vehicle System (USV)

○本システムは海洋科学技術センター殿の御指導によって開発されました。
○USVは小型かつ軽量で極めて優れた水中運動性能を有しております。
○電磁誘導伝送方式を使うことにより船上からのUSVの昇降運動制御及びリアルタイム信号モニターリングを行うことができます。
○取得データはFD及びハードディスクに記録し２次電算機処理に供します。



The USV system

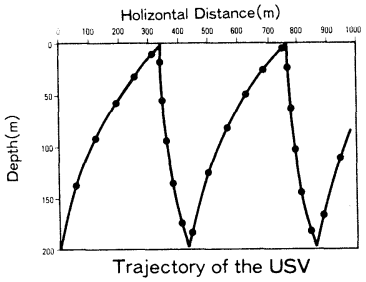




T.Sスライド式高速曳航体によって得られた三陸沖の水温鉛直分布のカラー画像。
（海洋科学技術センター殿から資料を御提供頂きました。）

SPECIFICATIONS

Towing Speed	:0～8knots	
Operation Dapth	:Max.400m	
Tow Cable	:8mm hydrodynamically fared stainless steel wire rope with polyurethane coating	
Sensor	Range	Accuracy
Conductivity	20～70ms	±0.05ms
Temperatune	−2～35C	±0.05C
Depth	0～400dbar	0.5%FS
Data Transport	:Inductive Coupling Data Communication System	
Sempling Rate	:5times per second	
Sensor Battery Life	:50hours	



Trajectory of the USV

T.S.K

株式会社 鶴見精機

本　　社　〒230 神奈川県横浜市鶴見区鶴見中央2-2-20
TEL.(045)521-5252　FAX.(045)521-1717

白河工場　〒969-03 福島県西白河郡大信村大字中新城字弥平田
TEL.(0248)46-3131　FAX.(0248)46-2288

TSK AMERICA INC.
828 MILLS PL.N.E. NORTH BEND, WA. 98045, U.S.A.
TEL.206-888-3404 TLX.230754235 TSKA SEA UD

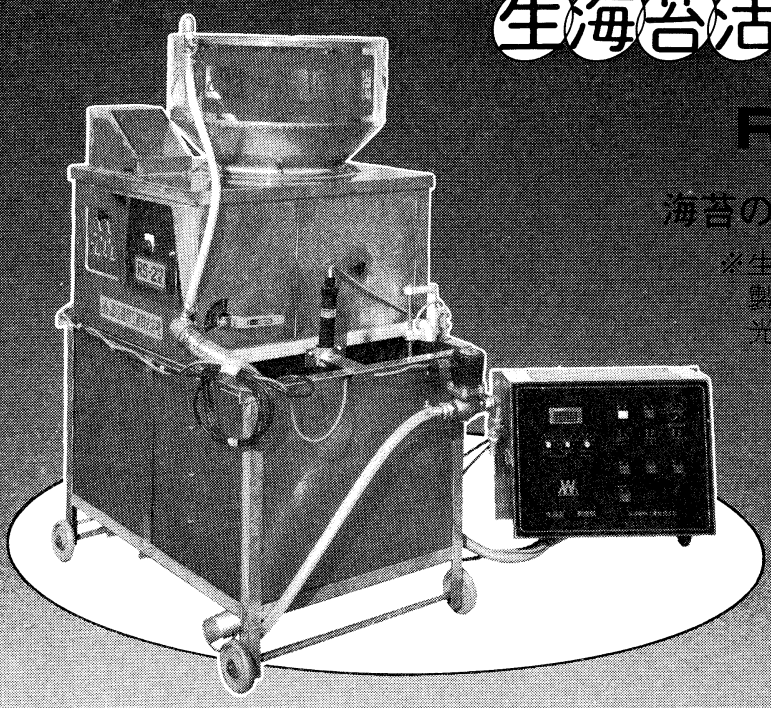
応援します。
良い海苔づくり—

生海苔活性調整機

RS-2型

海苔の等級が数段あがる

※生海苔を活性化し、海苔製品の表面をなめらかに光沢よく仕上げます。



	RS-1型	RS-2型
寸法	770㎜	1,300㎜
幅	990㎜	950㎜
高	680㎜	760㎜
重量	65kg	180kg
モートル	40W 1台 100W 1台	40W 2台 60W 1台 100W 1台 150W 1台

渡辺機開工業株式会社

愛知県渥美郡田原町神戸大坪230

電話 05312(2)1121(代表)

日仏海洋学会入会申込書

（正　会　員）

	年度より入会	年　月　日申込
氏　名 ローマ字		年　月　日生
住　所　〒 勤務先　機関名 電　話		
自　宅　住　所　〒 電　話		
紹介会員氏名		
送付金額　円	送金方法	
会誌の送り先（希望する方に○をつける）	勤務先　自　宅	

（以下は学会事務局用）

受付	名簿 原簿	会費 原簿	あて名 カード	学会 記事

入会申込書送付先：　〒101　東京都千代田区神田駿河台 2-3

(財)日仏会館内

日仏海洋学会

郵便振替番号：　東京 5-96503

第29巻　第4号

目　　次

投稿の手引

1. 「うみ」（日仏海洋学会機関誌；欧文誌名 La mer）は，日仏海洋学会正会員およびそれに準ずる非会員からの投稿（依頼稿を含む）を，委員会の審査により掲載する。
2. 原稿は海洋学および水産学両分野の原著論文，原著短報，総説，書評，資料などとする。すべての投稿は，本文，原図とも正副2通とする。副本は複写でよい。本文原稿用紙はすべてA4判とし，400字詰原稿用紙（和文）に，または厚手白紙にダブル・スペース（和文ワープロでは相当間隔）で記入する。表原稿および図説明原稿は，それぞれ本文原稿とは別紙とする。
3. 用語は日，仏，英3カ国語の何れかとする。ただし，表および図説明の用語は仏文または英文に限る。原著論文（前項）には約200語の英文または仏文の要旨を，別紙として必ず添える。なお，欧文論文には，上記要旨の外に，約500字の和文要旨をも添える。ただし，日本語圏外からの投稿の和文要旨については編集委員会の責任とする。
4. 投稿原稿の体裁形式は最近号掲載記事のそれに従う。著者名は略記しない。記号略号の表記は委員会の基準に従う。引用文献の提示形式は，雑誌論文，単行本分載論文(単行本の一部引用を含む)，単行本などの別による基準に従う。
5. 原図は版下用として鮮明で，縮尺（版幅または1/2版幅）に耐えられるものとする。
6. 初校に限り著者の校正を受ける。
7. 正会員に対しては7印刷ページまでの掲載を無料とする。ただし，この範囲内であっても色彩印刷を含む場合などには，別に所定の費用を著者負担とすることがある。正会員の投稿で上記限度を超える分および非会員投稿の印刷実費はすべて著者負担とする。
8. すべての投稿記事について，1篇あたり別刷50部を無料で請求できる。50部を超える分は請求により，50部単位で作製される。別刷請求用紙は初校と同時に配布される。
9. 原稿の送り先は下記の通り。

〒108 東京都港区港南4-5-7 東京水産大学　村野正昭 気付
日仏海洋学会編集委員会

1991年12月25日 印刷
1991年12月28日 発行

うみ　第29巻 第4号

定価 ¥1,600

編集者　村野正昭
発行所　日仏海洋学会
財団法人 日仏会館内
東京都千代田区神田駿河台2-3
郵便番号：101
電話：03(3291)1141
振替番号：東京 5-96503
印刷者　佐藤一二
印刷所　有限会社英和出版印刷社
東京都北区中里2—7—7
郵便番号：114
電話：03(5934)4856

Tome 29 N° 4

SOMMAIRE

Proceedings of the French-Japanese Workshop for Ocean Flux Studies