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Note pour la présentation des manuscrits

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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.

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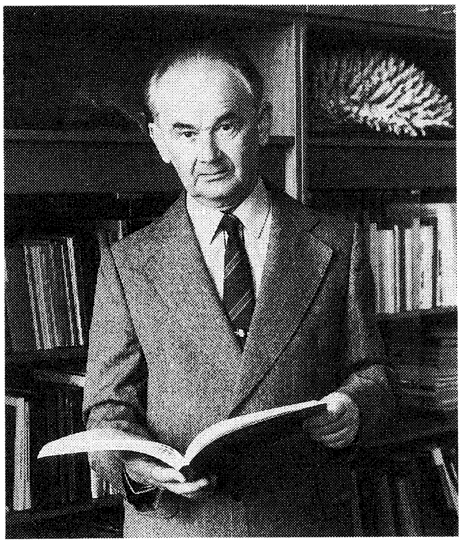
Article spécial n°7

Cultural eutrophication of the Black Sea and other South European Seas*

Yu. P. ZAITSEV**



The increasing influx of nutritive substances both mineral and organic ranks first among different forms of man-made impact on seas and oceans. This process, having received the name of eutrophication, promotes in natural water bodies a series of interrelated phenomena united under the title "Syndrome of eutrophication" (GOMOIU, 1985). These include algal blooming or a according to E. ODUM (1975) cancerous rates of production, oxygen deficiency in near bottom layers (hypoxia), mass mortality of bottom and near bottom organisms, and the production as a result of protein desintegration of hydrogen sulfide, decrease in water transparency etc.

Eutrophication of coastal waters of seas and oceans has been rapidly developing in the last 20-30 years as a result of intensive agricultural, industrial and other human activity. Besides, the degree of eutrophication for each water body depends on certain geographical, physical, chemical and biological conditions.

The Black Sea as an object of the cultural or anthropogenic eutrophication has attracted the attention of specialists yet in the late 60's. In the north-western part of the Black Sea into which three of the largest rivers-Danube, Dnesrt, Dnepr flow, an increase in concentrations of nutrients and in phytoplankton, especially peridinian algae was observed. These processes quickly enhanced, and in the 1970's a distinct "syndrome of eutrophication", including " red tides" (NESTEROVA, 1979) and mass mortality of bottom organisms (ZAITSEV, 1977) took place. Literature references included many reports on the complex and even critical conditions of the ecosystem of the Black Sea especially on the north-western shelf, where the state of the pelagic and benthic zones in comparison to the 1960's has changed greatly.

For a more complete and objective evaluation of the ecological situation in the region, it was necessary to make comparative investigations of different areas of the Mediterranean Sea Basin, where during the same period the same changes were developing. This paper is the first attempt to comparatively evaluate the level of trophicity of marine waters according to chlorophyll "*a*" content in wide spaces from the Alboran Sea in the west to the Sea of Azov in the east. Chlorophyll "*a*" is found in all live cells, and its concentration thus reflects the amount of phytoplankton on the sea surface.

The system of intercontinental seas connected by the Mediterranean Sea Basin, communicates with the Atlantic Ocean through the Strait of Gibraltar, and with the Indian Ocean through the Suez Canal and Red Sea. The water surface, including the Black and

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Azov Seas makes up to 2,960,000 square kilometres. The drainage area of all these seas on the territory of Europe, Asia and Africa exceeds 7,000,000 square kilometres. Thus the relation of the surface of terrestrial drainage area to sea surface is close to 2.4. However, for certain seas of this basin this index varies markedly.

Thus, for the Sea of Azov it exceeds 19.0, for the Black Sea- 5.6, for the Agean Sea- 0.7, Adriatic- 2.1, Ionian- 0.3, Tyrrhenian- 0.4. For the rest of the Mediterranean Sea it is 2.6. However, it should be noted that almost 80% pertains to Nile River Basin which after the building of the Aswan dam has greatly decreased its influence on the Mediterranean Sea.

But, this index is non-absolute and not the only criterion for the assessment of the degree of dependence of the land on the sea through surface run-off. However, at present, namely the river waters represent the main source of anthropogenic influence on marine ecosystems. Drainage areas of different seas in the Mediterranean Sea Basin are illustrated in Fig.1.

The term cultural (known as man-made, anthropogenic, accelerated, forced) (ODUM, 1971) eutrophication in special literature has been a widely used syntagm for distinguishing nutrient and organic water pollution caused by human activity.

Data of remote measurements from satellites (ARNONE, LA VIOLETTE, 1986, Ocean Color from Space, 1989) and materials from trditional methods obtained by using ship and buoy measurements (SERBANESCU *et al.*, 1978, FORTESA *et al.*, 1980, BOLOGA *et al.*, 1985, ESTRADA, 1986, VEDERNIKOV, 1987 COSTE, 1987, Dynamics of water, 1988, KOVALEVA *et al.*, 1988, SOUVERMEZOGLOU *et al.*, 1988) have been used for making up schematic maps of the seas of the Mediterranean Sea Basin according to the concentration of chlorophyll "*a*" in the surface water layer (Fig.2.)

Each of these methods has its advantages and disavantages. Thus, contact ship and buoy measurement help in obtaining a wide range of information not only on chlorophyll content, but on the carriers of this pigment-pelagic unicellular algae, on their specific and size composition, number, biomass on other biotic and abiotic parameters of the marine

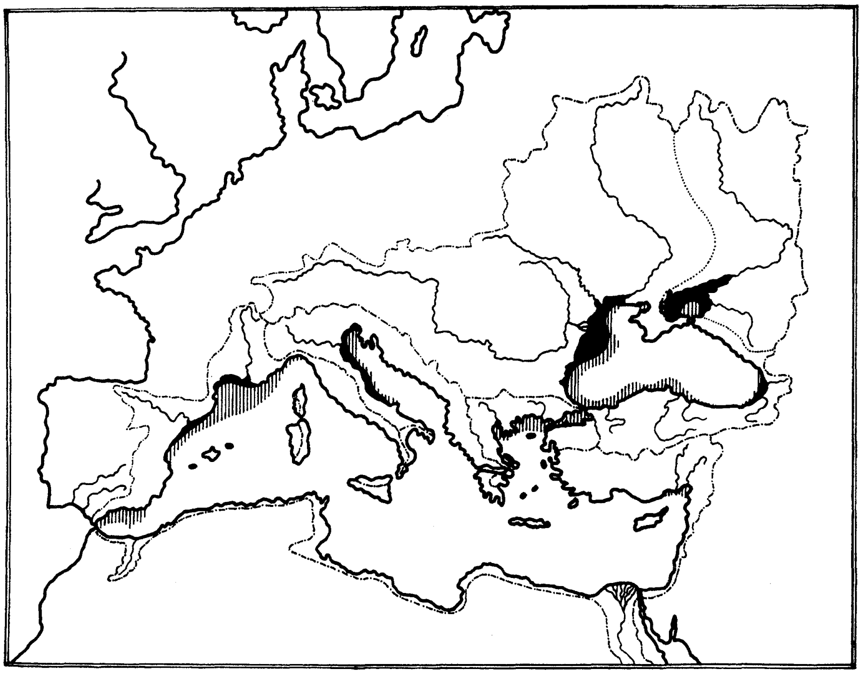

Fig. 1. Drainage basins (—·—·—·) of different seas of the Mediterranean basin

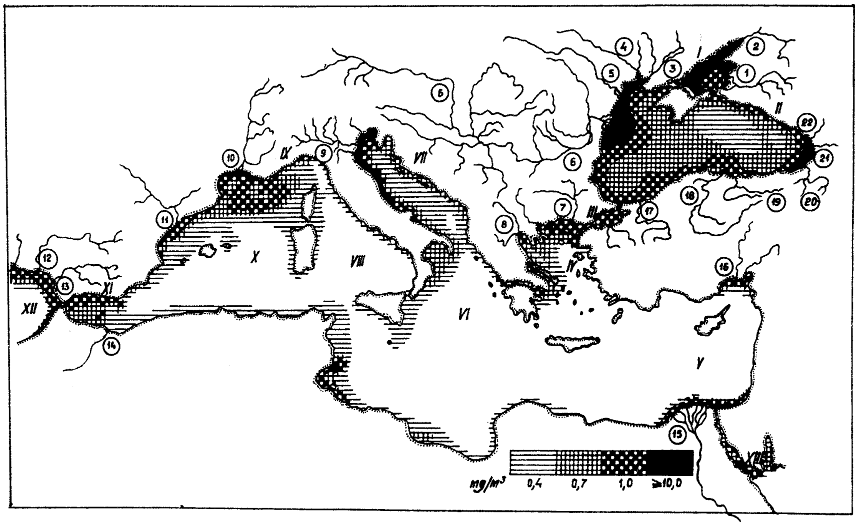

Fig. 2. Cultural eutrophication of the Mediterranean basin

Seas:
I. Sea of Azov
II. Black Sea
III. Sea of Marmara
IV. Aegean Sea
V. Levantine Sea
VI. Ionian Sea
VII. Adriatic Sea
VIII. Tyrrhenian Sea
IX. Ligurian Sea
X. Algero-Provencal Basin
XI. Alboran Sea
XII. Atlantic Ocean
XIII. Red Sea

Main Rivers:
1. Kuban
2. Don
3. Dnepr
4. Southern Bug
5. Dnestr
6. Danube
7. Maritza
8. Vardar
9. Po
10. Rhône
11. Ebro
12. Guadiana
13. Guadalquivir
14. Moulouya
15. Nile
16. Ceyhan
17. Sakarya
18. Kizil Irmak
19. Yesil Irmak
20. Coruh
21. Rioni
22. Inguri

environment. However, for this purpose lengthy expedition are necessary. During this period of time the parameters of the marine environment may change, and then the data on the maps may prove to be tentative.

Information received from satellites is practically instant. For example, a two minute satellite scene with help of a CZCS (Coastal Zone Color Scanner) from Nimbus 7 contains two million pixels that cover an area of two million square kilometres. If the same measurements were carried out on board ship, (speed- 11 knots), it would have taken more than 11 years (Ocean Color from Space, 1989).

That is why when using modern methods for studying seas and oceans and man-made changes in their ecosystems, best results may be obtained by combining the data of remote and contact measurements.

The space survey of the whole Mediterranean Sea which served as the basis for making up the map, indicating eutrophicated areas, was fulfilled in May, 1980 (Ocean Color from Space, 1989). In the following 10 years, in certain areas this process has been progressing markedly. That is why materials obtained from expeditions in many countries in the last decade have been considered in the map.

From Fig.2 it is clear that the greater part of the Mediterranean Sea proper until the present time remains oligotrophic with minimum amounts of phytoplankton. This is especially noted for the eastern part of the sea. In spite of that the Nile enters at this point with its drainage area exceeding 2,800,000 square kilometres and annual run-off of 73 cubic kilometres, the influence of this river on the Mediterranean Sea, after the building of the Aswan dam, in 1970, was greatly diminished. It has had a negative effect on biological productivity and fisheries in this region (SESTRINI *et al.*, 1989) and on solid river load.

Large rivers such as the Ebro, Rhone and Po with annual river run-off about 120 cubic kilometres flow into the Adriatic and northwestern part of the Mediterranean Sea. As a result highly trophic areas have been created lately along the coast line of South Europe (Catalonia, Provence, Coté d'Azur, Italian Riviera). From the middle of the 1980's hypertrophic areas have been formed along the north and west coast line of the Adriatic Sea causing a critical situation in these areas in coastal waters and on the shore. The Po River proved to be the main source of eutrophication in the Adriatic. Although it has a compratively small drainage basin (75,000 square kilometres). It flows through a territory having intensive farming, animal raising and industrial enterprises.

Mineral and organic nutrients enter the Alboran Sea with surface and current waters from adjacent Atlantic Ocean areas, where the Guadalquivir, Guadiana and Tagus Rivers enter from the Pyreneen peninsula.

On the opposite north-eastern line of the Mediterranean, the highly trophic waters in the region of the Iskenderun Bay are created by waters of the Ceyhan and Seyhan Rivers.

Thus, it becomes clear that the most widely eutrophic areas of the Mediterranean Sea are near the estuarine river regions and adjacent waters which carry nutrients of agricultural and industrial origin, fortified with sewage waters from largely populated habitats located along the lower river currents.

The Mediterranean Sea with its area of 2,500,000 km^2 and volume of 3,700,000 km^3 has 473 km^3 of river water entering annually (SESTRINI *et al.*, 1989). The Black Sea with a surface area of 422,000 km^2, with a slow vertical turbulence of water masses, and limited water exchange through the Bosphorus Strait has about 350 km^3 of river run-off entering, including 203 km^3 from the Danube, annually (SKOPINTSEV, 1975). That is why the surface of the water of all the Black sea pertains to mesotrophic and eutrophic, while the zone of Danube water influence- to hypertrophic (ZAITSEV *et al.*, 1989).

Finally, the Sea of Azov with its area of 39,000 km^2 and a maximum depth of 13 metres, in years of hevy rainfall receives more than 40 km^3 of river waters (BRONFMAN, KHLEBNIKOV, 1985). For this reason the Sea of Azov has undergo an "eutrophication syndrome", including mass mortality of bottom organisms, many decades prior to the present period of total eutrophication of coastal marine waters (ZENKEVICH, 1963).

Thus space and ship measurements shows that antropogenic eutrophication at present is widely spread in coastal marine waters of the South Europe. Its main source is river water or according to Odum (1971)- outwelling.

As to degree of cultural eutrophication some seas and areas of the Mediterranean Sea Basin can be arranged in the following order, decreasing: Sea of Azov, Black Sea, Adriatic Sea, Sea of Marmara, Gulf of Lyon, Aegean

Sea, Balearic, Alboran, Ligurian, Tyrrhenian, Ionian and Levantine Seas, and central parts of the Algero-Provencal Basin, and the eastern half of the Mediterranean Sea.

The whole area of the Sea of Azov, almost one-quarter of the Black Sea surface, the northern half of the Marmara Sea, almost one-fifth of the Adriatic Sea and others are subjected to algal blooming.

The largest hypertrophic area in the Mediterranean Sea Basin is located in the north-western part of the Black Sea opposite the USSR, Roumania and Bulgaria in the zone of influence of the Danube, Dnestr and Dnepr rivers. It takes up an area of 100,000 km^2. The largest abundance and biomass of plankton organisms, which react positively to marine water eutrophication, have been noted here. Thus the number of phytoplankton cells (with peridinians predominating) reaches up to 800,000,000 / 1 with biomass of $1000 g/m^3$ (SUKHANOVA *et al.*, 1988), while the infusorian *Mezodinium rubrum*- 4,600,000 / 1 and $280 g/m^3$, correspondingly (TUMANTSEVA, 1985). As to *Noctiluca miliaris* in neuston layer (0-5cm) it may attain extreme indices for the Seas and oceans, exceeding $6,800,000,000/m^3$ and 500 kg/m^3 (ZAITSEV *et al.*, 1988). The highest number of the new ctenophore species introduced from the Atlantic Ocean *Mnemiopsis leidyi* was also noted in the north-western part of the Black Sea. The abundance of this animal in coastal waters may exceed 500 specimens per cubic metre.

Mass mortalities of bottom organisms which at beginning of the 1970's have been observed in large areas of the north-western Black Sea shelf, take up to 10,000 km^2 in the economic zone of the USSR alone (ZAITSEV, 1989). Due to hypoxia, from 100 to 200 tons of aquatic organisms die per one kilometre of sea bottom. This includes 10-15 tons of fish-both commercial and non-commercial, adult and juvenile forms. Mass mortalities cease when homothermal autumn sets in with enhancement of turbulent water mixying. Larvae begin to inhabit the bare shelf zones. They are carried by water currents from marginal biotops and shelf zones which do to not undergo mass mortalities. Benthic populations are renewed, and this process continues until the next period of oxygen deficiency, the cycle repeating once more.

Besides harming fisheries, cultural eutrophication of marine waters causes great losses in other fields of economy. This is expecially noted where coast zones are used for recreative and tourist purposes. Algal blooms changes the usual organoleptic quality of the water. It becomes brownish in colour, slimy an unpleasant smell. Aerosol particlels enter the atmosphere from blooming marine waters containing toxic substances and microorganisms. The decrease of water transparency due to mass phytoplankton production lowers the penetration of solar radiation to the bottom, and hinders or exclude the development of benthic macrophites. Mass mortality of benthic organisms creates conditions for intensive reproduction of pathogenic microorganisms and this is a direct hazard to human health.

All these phenomena are more or less characteristic for many coastal waters of the South Europe in the Black and Azov Seas, on the northern shores of the Sea of Marmara and Prince Islands, some bays of the Aegean Sea, the north and westhern shores of the Adriatic, the shores from Marseilles in France to Valencia in Spain and others.

This man-made ecological situation occurring along the densely populated coast of Southern Europe reflects the necessity for more close international cooperation. Only with combined efforts can a multilateral study of "the eutrophication syndrome" be acheved, and as a result joint practical measures can be taken for improving the condition of coastal waters in the Mediterranean Basin.

Due to widely spreading eutrophicated marine areas in the World Ocean, it should be taken into consideration that surface water containing large amounts of plankton and neuston organisms has a temperature till 2-3 degrees higher than water depleted of suspended hydrobionts. It is known also that many plant and animal planktonic organisms aids in evaporating water up to 2-3 times more intensively with the help of flagella movements.

Such an influence on the mechanism of climate forming processes is also a very important ecological consequence of eutrophication of seas and oceans. However, this problem is beyond the scope of this paper.

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The eels of French Polynesia: Taxonomy, distribution and biomass*

Gérard MARQUET** and René GALZIN**

Abstract: Electric fishing carried out in the inland waters of the five archipelagos that constitute French Polynesia has corroborated the presence of three species of eels: *Anguilla marmorata, A. megastoma* and *A. obscura.* Meanwhile the altitudinal distribution of those three species in the visited island has been established and their biomass assessed.

1. Introduction

French Polynesia (Fig. 1) covers a vast oceanic region located at the eastern limit of the Indo-Pacific province. The land masses of Polynesia spread over an area situated between 134°W and 154°W longitude and 8°S and 28°S latitude.

French Polynesia is made up of 118 islands and islets, high volcanic islands (35) and low coral islands or atolls (83) that represent, together, an emerged area of 4000 km^2 scattered over 2,500,000 km^2 of ocean.

These islands form five archipelagos dispersed along a general north-west, south-east axis:

* The Austral Archipelago (141 km^2) includes 7 islands, one of which is an atoll.

* The Gambier Archipelago (23 km^2) is made up of 9 volcanic islands, surrounded to the north and east by a barrier reef.

* The Marquesas Archipelago (997 km^2) contains 12 islands, one of which is an atoll.

* The Society Archipelago (1618 km^2) is composed of 14 islands: 9 high volcanic islands and 5 atolls.

* The Tuamotu Archipelago (850 km^2) includes 76 atolls.

Apart from the SCHMIDT's (1927) publication on the eels of Tahiti, the other publications deal with ichthyological fauna with few references to freshwater fauna.

The Society Archipelago is the best known so far. Its ichthyological fauna have been described by KENDALL and GOLDSBOROUGH (1911), SCHMIDT (1927), FOWLER (1932), HERRE (1931,1932), POLL (1942), EGE(1939) and RANDALL (1973).

The other archipelagos have been less investigated owing to their isolated situation. However, the Marquesas Archipelago has been studied by FOWLER (1932), PLESSIS and MAUGE (1978) and RANDALL (1985). The Gambier Archipelago has been prospected by SEURAT (1934) and FOURMANOIR *et al.*(1974). The Austral Archipelago has been particularly neglected to the exception of Rapa Island. Tubuai has been visited by PLESSIS (1980). The brackish waters of the Tuamotu atolls are still to be prospected, yet SEURAT (1906) has reported the sighting of eels in Fakarava.

This lack of information about freshwater fauna especially where Anguillidae are concerned is all the more regrettable that it affects a zone of great geographical specificity; indeed, French Polynesia is situated at the eastern limit of presence of the genus *Anguilla* in the Indo-Pacific province.

2. Islands choice criteria

On account of their easy access and the presence of a logistic support provided by the Department of Rural Economy, 11 islands (Fig. 1) have been investigated as part of this study: Rurutu and Tubuai in the Austral Archipelago, Mangareva and Taravai in the Gambier Archipelago, Hiva Oa, Nuku Hiva, Ua Huka and Ua Pou in the Marquesas Archipelago, Moorea and Tahiti in the Society Archipelago and finally Rangiroa in the Tuamotu Archipelago.

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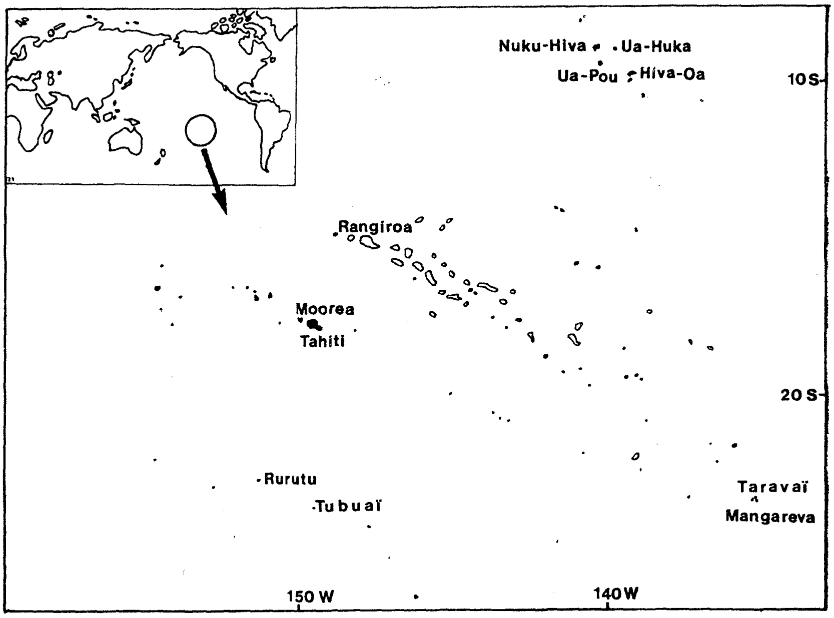

Fig. 1. General map of French Polynesia showing the position of the eleven relevant islands.

3. Materials and methods

Taxonomy

Eels' identification is based on the best defined characters, as specified by SCHMIDT (1927), EGE (1939), MARQUET and LAMARQUE (1986) and MARQUET (1987).

Catching methods

Two methods of capture have been used: electric fishing mainly and rotenone poisoning occasionally. Various generators have been used: the "Cormoran" (GOSSET, 1975), the "Martin-Pêcheur" (GOSSET *et al.*,1971) and an electrogen group "Cadmit Super Champ" (220 V AC, 300 Hz).

The "Cormoran" gives a polarised rectangular impulsions output, at 100 and 400 Hz, with a cyclic ratio adjustable between 10 and 50%. Five tensions are available between 100 and 400V. The power output is 1000 W. This apparatus has been designed for brackish waters within a 500 to 5000 μS cm^{-1} conductivity range.

The "Martin-Pêcheur" is a portable, battery operated apparatus, with a 180 W output, weighing 12 kg, battery included. It gives polarised rectangular impulsions with a choice of two frequencies: 100 or 400 Hz with a cyclic ratio continuously adjustable between 5 and 25%. Three tensions are available: 150, 200 and 300 V. This apparatus has been designed for waters within a 50 and 1000 μS cm^{-1} conductivity range.

Rotenone poisoning was used only where the above generators were not suitable to the conductivity of the investigated waters.

Stock assessment method

The DE LURY method (1947) has been chosen for its quickness and easy use. It consists in performing several consecutive fishing operations without returning the captured eels to the river. The regression of the number of catches allows the definition of a 'constant of efficiency', which is necessary for the computation of the initial stock. In the present study, the fishing efficiencies were always very high, especially for large sized eels which constitute the main part of the biomass. Therefore two consecutive fishing sessions were more than sufficient to obtain reliable results. Moreover, the constancy of the fishing efficiencies found in this way in the various habitats allows, to a certain extent, the extrapolation of the results obtained from a single fishing session. In effect, two kinds of operations have been performed.

a) Operations involving two consecutive fishing sessions. They have allowed not only the estimation of the stock on each location but also the calculation of the fishing efficiency according to species and size classes.

b) Operations involving a single fishing session. The efficiencies calculated previously have been re-used here. To make up for the efficiency variations from one site to another, the operator was led to introduce a correcting factor based on experience. In that case, the word 'appreciated' stock will be used in opposition to the word 'estimated' stock utilised for results obtained by the more reliable 'two fishing sessions' operations.

The first method has been used in the Society Archipelago but the second method had to be used in the other archipelagos owing to lack of time.

At first a stop net (0.5-cm mesh) was used at both ends of the fishing site to prevent any emigration or immigration during the fishing sessions. As it appeared that this precaution could be dispensed with, stop nets were not used in the later fishing operations.

Prospection of the various types of habitat

In Tahiti island, numerous streams have been investigated (Marquet, (1988): the Ahonu, the Faatautia, the Fautaua, the Moaroa, the Onohea, the Papeiti, the pk = 14,5 km rivulet, the Punaruu, the Puorooro, the Tiirahi, the Tuauru, the Vaihiria, the Vaipuu, the Vaitaara, the Vaite and the Vaitoare.

On the other hand, stagnant waters have been insufficiently prospected because, as a rule, their high conductivity makes the use of electric fishing impossible. Lake Vaihiria has been visited three times: in May 1982, May 1983 and October 1984.

In Moorea island, much attention has been devoted to the study of the Niuroa and Opunohu rivers.

For the other islands, the prospected streams are given below: Rurutu island: the Puputa, the Tevaavai, the Tevaipa, the Vaioivi, the Vaipapa and the Vaipurua.

Tubuaï island: the Hautara, the Taahuaai, the Tamatoa, the Tehaunatieva, the Vaiohuru, the Vairani and the Matavahi swamp.

Mangareva island: the water catchment rivulet and Gatavake rivulet.

Taravai island: the water catchment rivulet.

Hiva Oa island: the Faakuaa, the Taaoaa, the Vaioa, the Vaipaee and the Vaiutu.

Nuku Hiva island: the Taiohae, the Taipivai, the Tapueaho and the Vaipupui.

Ua Huka island: the Hane, the Vaikivi and the Vaipae.

Ua Pou island: the Anakooma, the Mereka, the Paaumea and the Paeoa.

In the Rangiroa atoll, rotenone poisoning has been employed on the Hoa Vaimate laguna and on the site of the disused fish breeding station of Pavete.

Rivers' zonation

A three zone river partition has been retained to study and explain eels distribution in French polynesian rivers: lower course, middle course and upper course.

The lower course is short, being limited to the littoral area. The estuary area, submitted to marine influence, must be distinguished from the river upstream with low conductivity waters.

The middle and upper courses run down the original volcanic cone. The average slope of the middle course is less than 10%. The upper course has a steeper gradient, inducing strong currents, a scarce aquatic vegetation and a bottom of rocks and boulders. The transition between the middle and upper courses is often materialized by a high waterfall.

Main physical features of Polynesian eels' habitats

Those features have been exhaustively described, for the first time, in a study giving rise to a Doctorate thesis (Marquet, 1988).

The high islands sometimes have numerous rivers and rivulets. This is the result of heavy rainfalls and of intensive erosion of the volcanic cones constituting these islands.

There were no hydrometric stations in French Polynesia before the creation and development of a network in Tahiti, in the early seventies, by the O.R.S.T.O.M. The measurements made by that office have shown that the main streams have a typically torrential rate of flow.

Apart from running waters, there are stagnant waters chiefly in the usually narrow bands of littoral plains. In Tahiti island, an altitudinal lake can be found: Lake Vaihiria (470m).

The importance of the hydrographic system in the various high islands depends on their altitude and their surface area. The ratio of flowing water to stagnant waters varies from one island to another. Tubuaï in the Austral Archipelago shows an exceptionally important amount of stagnant waters.

Physical and chemical data about the rivers are few and mainly recent. The lack of geological diversity of high islands explains the fairly uniform composition of their waters.

The waters of streams originating in basaltic rocks are weakly mineralised. Their conductivity varies from 40 to 150 $\mu S\ cm^{-1}$. Their pH is comprised between 7 and 8 rather nearer 8 than 7. Oxygenation is very good, especially in high ground waters (9 mg ℓ^{-1} on average). Waters are mainly bicarbonated, and the main cations are calcium, magnesium and sodium. The nitrate content is low, and silicate content varies according to the rivers.

Howevr on low ground, stagnant waters are highly mineralised, owing to saline intrusions. Obviously, in contrast with high islands, atolls can have no hydrographic network but only shallow lagunas and ponds of highly conductive brackish waters.

4. Results

Taxonomy

Among the 16 eel species recorded by EGE (1939), three can be found in the French Polynesian inland waters: *Anguilla marmorata* (QUOY and GAIMARD, 1824), *Anguilla megastoma* (KAUP, 1856) and *Anguilla obscura* (GÜNTHER, 1871).

Geographic distribution

A. marmorata (Table 1) is established everywhere except in the Taravai islet.

A. megastoma does not occur in the Marquesas Archipelago, in the most southern part of French Polynesia and in the Rangiroa atoll.

A. obscura does not inhabit the Marquesas Archipelago and the Taravai islet.

Table 1. Presence (1) or absence (0) of eel species in the eleven studied islands.

	A. marmorata	*A. megastoma*	*A. obscura*
Austral Archipelago			
Rurutu	1	1	1
Tubuaï	1	0	1
Gambier Archipelago			
Mangareva	1	1	1
Taravaï	0	1	0
Marquesas Archipelago			
Hiva Oa	1	0	0
Nuku Hiva	1	0	0
Ua Huka	1	0	0
Ua Pou	1	0	0
Society Archipelago			
Moorea	1	1	1
Tahiti	1	1	1
Tuamotu Archipelago			
Rangiroa	1	0	1

Altitudinal distribution

In the Society Archipelago (SCHMIDT, 1927; MARQUET and LAMARQUE 1986), *A. marmorata* and *A. megastoma* occur in running waters. The dominant species are *A. marmorata* below the waterfalls and *A. megastoma* above. *A. megastoma* is established in the Vaihiria lake. *A. obscura* is restricted to estuaries and shallow stagnant waters.

The altitudinal distribution in other archipelagos is mainly the same (Table 2). However, in some archipelagos one species becomes ubiquitous. Such is the case for *A. obscura* in the Austral Archipelago and for *A. marmorata* in the Society Archipelago.

A. marmorata cannot be found in the upper course when the waterfall that separates it from the middle course is too high. Such high waterfalls occur in the Marquesas islands.

Biomass

The various species of eels are not distributed uniformly throughout French Polynesia (Table 3).

In the Austral Archipelago, *A. obscura* colonizes both running and stagnant waters. Therefore, its biomass is relatively high (from 142 to 92 kg ha^{-1}). In running waters, where *A. megastoma* is present, its biomass is high (291 kg ha^{-1} in Rurutu). *A. marmorata* is moderately abundant (80 kg ha^{-1} on average).

In the Gambier Archipelago, the three species are present. In running waters, the con-

Table 2. Distribution of the three eel species in the studied islands.

	Running waters				Stagnant waters		
	High islands				High islands		Atoll
	Lower course		Middle course	Upper course	Littoral area	Lac Vaihiria	
	Estuary	Upstream					
Anguilla marmorata							
Rurutu		+	+	+	+		
Tubuai		+	+				
Mangareva		+					
Hiva Oa	+	+	+	+			
Nuku Hiva,	+	+	+	+			
Ua Huka	+	+	+	+			
Ua Pou	+	+	+	+			
Tahiti	+	+	+	+	+		
Moorea	+	+	+	+	+		
Rangiroa							+
A. megastoma							
Rurutu			+	+			
Mangareva			+	+			
Taravai			+				
Tahiti			+	+		+	
Moorea			+	+			
A. obscura							
Rurutu	+	+	+	+	+		
Tubuai	+	+	+	+	+		
Mangareva	+				+		
Moorea	+				+		
Tahiti	+				+		
Rangiroa							+

Table 3. 'Appreciated' biomasses (kg ha^{-1}) for the three eel species in the five archipelagos.

	Austral		Gambier		Marquesas				Society	Tuamotu
	Rurutu	Tubuai	Mangareva	Taravai	Hiva Oa	Nuku Hiva	Ua Huka	Ua Pou	Moorea and Tahiti together	Rangiroa
A. marmorata	96	65	54	0	221	94	226	291	261	+
A. megastoma	291	0	559	267	0	0	0	0	264	0
A. obscura	98	142	129	0	0	0	0	0	13.5	+

Table 4. Estimated biomass (kg ha^{-1}) of the three eel species in Tahiti-Moorea rivers.

	Lower course		Middle course	Upper course
	Estuary	Upper waters		
Number of investigated rivers	4	6	6	4
A. marmorata	191	424	139	60
A. megastoma	0	0	2	397
A. obscura	7	0	0	0

cept of biomass, as expressed in kg ha^{-1}, is not very significant because of the scarcity and narrowness of the rivulets that make up the hydrographic system. The dominant species is *A. megastoma* with a high biomass (559 kg ha^{-1} in Mangareva). *A. marmorata* is much rarer (54 kg ha^{-1}). In stagnant waters, *A. obscura* is well established with a biomass of 129 kg ha^{-1} in Mangareva.

In the Marquesas islands, the only species that can be found is *A. marmorata*. Its average biomass over the four studied islands is 208 kg ha^{-1}.

In the Society islands, the three species are present. *A. marmorata* and *A. megastoma* are predominant with a biomass of 261 and 264 kg ha^{-1} respectively. *A. obscura* has shown a much lower biomass (13.5 kg ha^{-1}).

In the Rangiroa atoll, the generators available were not suited to the conductivity of the water. Therefore, it was not possible to appreciate the biomass of the two species that were found, namely *A. marmorata* and *A. obscura*.

Owing to the greater number of data concerning the Society Archipelago, it has been possible to 'estimate' the biomass of the three species in the Tahiti-Moorea rivers (Table 4).

In the lower course and the middle course, *A. marmorata* is by far predominant with a biomass varying from 139 kg ha^{-1} to 424 kg ha^{-1}. In the upper course, its biomass drops to 60 kg ha^{-1}.

A. megastoma, scarcely present in the lower and middle courses, becomes predominant in the upper course with a biomass of 397 kg ha^{-1}.

A. obscura is restricted to estuaries with a low biomass (7 kg ha^{-1}).

5. Discussion and conclusion

Taxonomy

The presence of three eel species in French Polynesia is consistent with SCHMIDT's results (1927), taken up by EGE (1939) for the Society Archipelago only.

However, EGE (1939) mentions that specimen of a fourth species, captured in Tahiti and labeled *A. australis*, belongs indeed to the subspecies *A. australis schmidti*. No such eel has been found among the few thousands that were caught in the course of this study. In fact the known distribution of that species, limited to New Zealand and New Caledonia, suggests that French Polynesia is situated too far from its usual habitat. Nevertheless, it may be that the eel mentioned by EGE (1939) became lost by accident, just like *A. anguilla* bas been reported by EGE (1939) in Kenya and *A. obscura* in South Africa by JUBB (1957). However,it remains possible that the eel seen by EGE (1939) in the Hamburg Museum had been wrongly labelled as coming from Tahiti.

Geographic distribution

A. marmorata

In French Polynesia: The presence of this species has long been known in Tahiti as well as in the Marquesas islands (EGE, 1939; FOWLER, 1932; HERRE, 1936). The present survey has extended the known distribution area of *A. marmorata* towards the east as far as Mangareva (135°W). *A. marmorata* may now be considered as ubiquitous in French Polynesia. Its absence from the Taravai islet can be explained by the lack of any significant river. In any case, the Taravaï islet can be considered as part of the nearby Mangareva where *A. marmorata* is present.

In the Indo-Pacific province: This ubiquity in French Polynesia is in agreement with the wide Indo-Pacifique distribution of *A. marmorata*. In the Indian Ocean: It has been recorded in South Africa by JUBB (1964), in Madagascar by KIENER (1965) and in the Reunion island also by KIENER (1981). In the Pacific Ocean, it can be found from the Philippines (EGE, 1939) to Japan (NISHI and IMAI, 1969) and from New Guinea to Polynesia (EGE, 1939).

A. megastoma

In French Polynesia: This species has been observed (EGE, 1939) in the Society Archipelago (Tahiti, Moorea and Raiatea) and in the Gambier Archipelago (Mangareva). The present work has shown that *A. megastoma* does not occur in the Marquesas Archipelago and in the Tubuaï island. This means that the distribution of this species is restricted to a narrow range of latitude.

In the Indo-Pacific province: This distribution in French Polynesia can be paralleled with the general distribution of *A. megastoma* in the Indo-Pacifique province. Indeed, *A. megastoma* is known from the Solomon islands to Pitcairn island (EGE, 1939).

A. obscura

In French Polynesia: The presence of this species has been recorded (EGE, 1939) in Tahiti island and in the Austral Archipelago (Tubuaï and Rapa). The present work shows that *A. obscura* is absent from the Marquesas Archipelago. The distribution of this species is roughly that of *A. marmorata*, minus the Marquesas islands.

In the Indo-Pacific province: This distribution in French Polynesia again can be paralleled with a relatively wide distribution of *A. obscura* in the Indo-Pacifique area. Indeed, *A. obscura* is known in Australia (BEUMER *et al.*, 1981) and from New Guinea to Polynesia (EGE, 1939).

The present paper advances the knowledge of the Polynesian eel distribution in an area of scientifing interest. Indeed, it is situated at the eastern limit of presence of the genus *Anguilla* in the Indo-Pacific province (Fig.2).

In that area, the number of eel species decreases sharply to the north. In the Marquesas islands (9°S), a single species (*A. marmorata*) has been captured, and in Hawaï (24° N) no eel has ever been reported (SCHMIDT, 1925).

Conversely, to the south, three species have been captured in Rurutu (22° S), two in Tubuaï island (23°S) and the same number (PLESSIS, 1987) in the Rapa island (27°S). Rurutu and Tubuaï are two neighboring island, however the former has a more precipitous character. This difference could explain the absence of *A. megastoma* in Tubuaï. On the other hand, Rapa similar to Rurutu in its relief shows no trace of *A. megastoma*. Since the absence of this species cannot be attributed to the morphology of the island, it is likely to be related to its more southerly latitude.

At the extreme east of French Polynesia, three species can be found in Mangareva

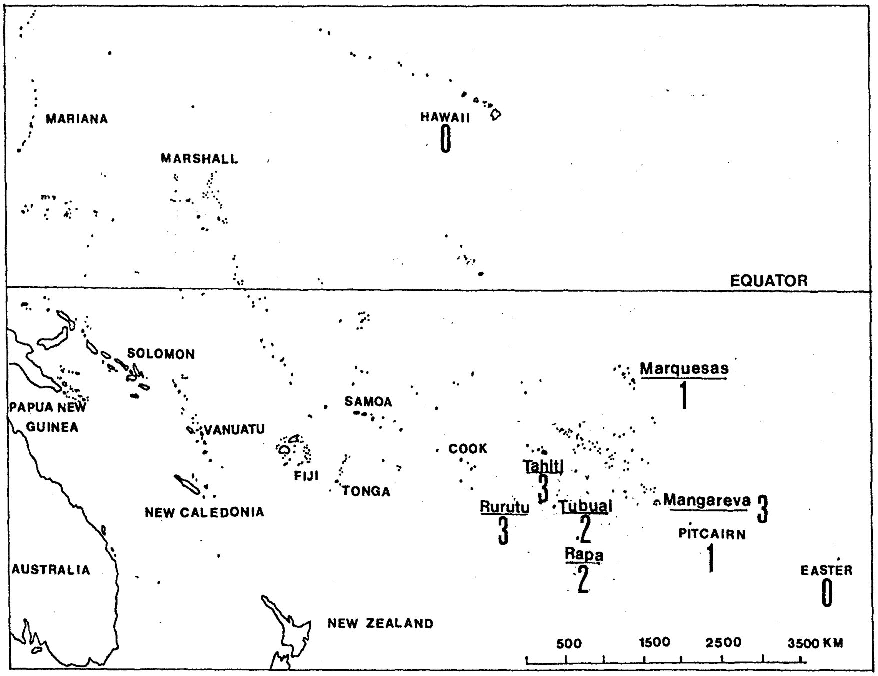

Fig. 2. Number of eel species in the East Pacific Ocean.

(135° W), a single species (EGE, 1939), *A. megastoma*, in the Pitcairn island (130°W) and none (SCHMIDT, 1925) in Easter island (109°W). The precipitous character of the Pitcairn shoreline could explain the absence of *A. marmorata* and *A. obscura* from this island. The absence of any species of eels in the Easter island must be attributed to its state of isolation.

Altitudinal distribution

The present research has shown, for the first time, the presence of *A. marmorata* and *A. obscura* in a Polynesian atoll. This result was foreseeable because eels are euryhaline.

A. marmorata: As a rule, in high islands, it can be found in stagnant waters, as well as in running waters. In the latter case, it is present all the way from estuary to upper course. This adaptability is specific of that species. In Madagascar, it settles within 500m from the sea (KIENER, 1965). In South Africa, it occurs in coastal areas (JUBB, 1964). However, it has been seen in Rhodesia as far as 1000 km from the estuary (FROST, 1957) and in the Philippines at more than 1530 m above the sea (SCHMIDT, 1927).

A. megastoma: In high islands, it inhabits the upper course of streams. No reference has been found about the distribution of *A. megastoma* in territories other than French Polynesia.

A. obscura: In high islands, it is usually restricted to lower freshwater reaches and to estuaries. This distribution seems to characterize short finned eels; for instance *A. bicolor bicolor* in Madagascar (KIENER, 1965) and *A. australis schmidti* in New Zealand (BURNET, 1968).

Biomass

A. marmorata: The biomass is very high in the Society Archipelago, and to a lesser degree in the Marquesas islands though *A. marmorata* has no other species to compete with in that archipelago. In the east, the biomass drops considerably, and to the south it decreases gradually. Out of the three species, *A. marmorata* spreads the most to the north; on the other hand, its extension eastwards and southwards is limited.

A. megastoma: Wherever it exists, its biomass is always high. This result is in conformity with the fact that where ecological conditions are difficult, the surviving species meet few competitors.

A. obscura: The biomass of this species is certainely undervalued because it lives in strongly conductive waters. Therefore, electring fishing was too often impossible with the available generators. Out of the three species, *A. obscura* seems to reach furthest to he south.

The 'appreciated' or 'estimated' biomasses are generally high. By way of comparison, BURNET (1952) gives average values in the range of 100 kg ha^{-1} for *A. dieffenbachi* in New Zealand rivers. TESCH (1977) finds variation from 3 to 50 kg ha^{-1} for *A. anguilla* in German rivers. SLOANE (1984) gives a range of 0.4 kg ha^{-1} to 230 kg ha^{-1} for the biomass of *A. a. australis* in Tasmanian rivers.

Several reasons explain the high values obtained in Polynesian rivers:

– The rate of growth seems higher for species living in tropical conditions than for those in temperate countries.

– The practice of eel fishing is little spread in French Polynesia and elvers are not fished at all.

– There is little or no competition from other fish, especially for bigger specimens.

The importance of the existing stock of Polynesian eels is such that the possibility of drawing a moderate amount of elvers or young eels with fish farming in view could be envisaged without the risk of affecting the overall population. The atolls would furnish a suitable site for aquaculture.

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フランス領ポリネシアのウナギ類：その分類，分布および現存量

Gérard MARQUET and René GALZIN

要旨：フランス領ポリネシアを構成する５つの群島の内水面で，電気漁法による調査を行った結果，３種のウナギ類；*Anguilla marmorata*, *A. megastoma* および *A. obscura* の存在が確認された。調査した島における，これら３種のウナギ類の高度分布を調査するとともに，その現存量を評価した。

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Abundance and Growth Characteristics of the Bacterioplankton inside and outside the Hydrothermal Vent Plumes in the North Fiji Basin*

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Abstract: Bacterioplankton were studied from the deep waters near the boundaries of hydrothermal vent plumes in the North Fiji Basin with special reference to their chemosynthetic sulfur-utilization. The bacterial abundance inside the plumes was greater than that outside the plumes. However,no clear difference in their growth rate was evident for samples collected inside and outside the plumes. The addition of thiosulfate had little influence on growth rate, because the population density of thiosulfate-utilizers near the boundary of hydrothermal plumes occupied only a small fraction of the bacterioplankton community.

1. Introduction

Active hydrothermalism in the rift of the North Fiji Basin has been intensively studied (KAIYO 87 Shipboard Party, 1988; HONZA *et al.*, 1989),and typical vent fauna composed of *Bathymodiolus, Alviniconcha, Munidopsis, Bythograea,* etc. were observed by the deep-towed TV camera (HASHIMOTO *et al.*, 1989), and the long-term observation system (MITSUZAWA *et al.*, 1989) both developed by Japan Marine Science and Technology Center. An active "white smoker" chimney and other vents in the area were carefully observed by the French submersible *Nautile* in 1989 (URABE *et al.*, 1990). Chemical studies show the vent plumes rising up to hundreds of metres and the occurrence of a "megaplume" in the North Fiji Basin (NOJIRI *et al.*, 1989). The occurrence of chemolithotrophic sulfur bacteria in the vent plumes was determined, with their active growth and CO_2 - uptake being certified experimentally (NAGANUMA *et al.*, 1989; SEKI and NAGANUMA , 1989; SEKI *et al.*, 1991).

This study aims at evaluating the abundance and growth characteristics of bacterioplankton communities inside and outside the boundary of vent plumes,with reference to their chemosynthetic sulfur-utilization. This research was part of "The Joint Research Program on the Rift System in the Pacific Ocean" funded by the Special Cooperation Fund of the Science and Technology Agency of Japan (STA) and the Institut Francais de Recherche pour l'Exploitation de la Mer of France (IFREMER) in cooperation with the Committee for the Coordination of Joint Prospecting for Mining Resources in South Pacific Offshore Areas (CCOP/SOPAC).

2. Materials and Methods

In November and December 1988, an integrated research program of geophysics, geology, geochemistry and biology was conducted along the rift axis during the KAIYO 88 cruise with R.V. *Kaiyo* (HONZA *et al.*, 1989). Bacteriological samples were collected at 12 sites along the rift axis by using Go-flo bottles and sterile Niskin bags (Go-flo samples and Niskin samples; SEKI *et al.*, 1991). The sample depths were from the bottom to more than 1000 m above the bottom. The sample locality, i. e. inside or outside plumes, could be precisely indicated by manganese concentration.

Immediately after collection, portions of the Go-flo samples for counting bacterial cells were fixed with 0.2 μm-filtered formalin at a final concentration of 2%. Bacterial cells in each 5-50 ml of the samples were counted by the combination fo membrane-filtration and epifluorescence microscopy (NAGANUMA *et al.*, 1989). Separate counts were made for: the

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total cells, growing cells (with diameter larger than 0.3 μm; MORITA, 1982), and dividing cells. The frequency of dividing cells (FDC; HAGSTROM *et al.*, 1979) was also estimated from the separate counts; this FDC value gives the *in situ* FDC.

The number of thiosulfate-utilizers was counted by the spread-plate method using 1.5%-agar plates (of TB medium; TUTTLE and JANNASCH, 1972). The agar plates were inoculated with the Niskin samples, and kept in a cold room (at about 4℃) in the dark for more than 4 weeks. The number of colonies counted represents in principle the abundance of thiosulfate-utilizers.

Growth rates of the bacterioplankton were determined immediately after the sampling, from the changing rate of bacterial cell numbers during the chemostat culture (JANNASCH, 1969). Vent plumes should be associated with chemosynthetic activity by sulfur oxidation; thus two media with reference to sulfur-utilization were used for the chemostat culture. The media for this purpose were: 1) thiosulfate-enriched TB medium, a liquid medium containing 1% of sodium thiosulfate in 75% aged seawater diluted with distilled water (TUTTLE and JANNASCH, 1972); and 2) thiosulfate-free TB medium. The chemostat cultures with two media were conducted in parallel at 1-2℃, in the dark at 1 atm and with a dilution rate of 0.2-0.3 hr^{-1}. The FDC, as well as growth, was determined during the first 12 hours of the chemostat culture. Thus the FDC-growth relationship in the chemostat culture was determined and converted to *in situ* FDC values which were used to calculate the in situ growth rate.

3. Results and Discussion

3.1. Bacterial abundance

Total cell counts were within the range of $\times 10^3 - 10^4$ cells ml^{-1} throughout the water column in the bottom 1000 m, and no obvious relationships between depths and counts were shown (Fig. 1). Higher counts, however, were mostly found for the samples collected inside vent plumes, where the manganese concentrations were higher than the background concentration of 1-2 nM. Actually, the highest manganese concentrations of 5-16 nM were associated with the highest total bacterial counts of $1.0\text{-}2.1 \times 10^4$ cells ml^{-1}. A relationship between manganese concentration and total cell counts was evident for the bottom-most samples. and was expressed as follows (Fig. 2):

$$\log[\text{cells ml}^{-1}] = 3.74 + 0.54 \log[\text{manganese nM}]$$

with a statistical significance of $r^2 = 0.74$ ($n = 10$, significant at 2.5% level). Hence, the bacterioplankton densities greater than $5.5\text{-}8.0 \times 10^3$ cells ml^{-1} had a linear relation with

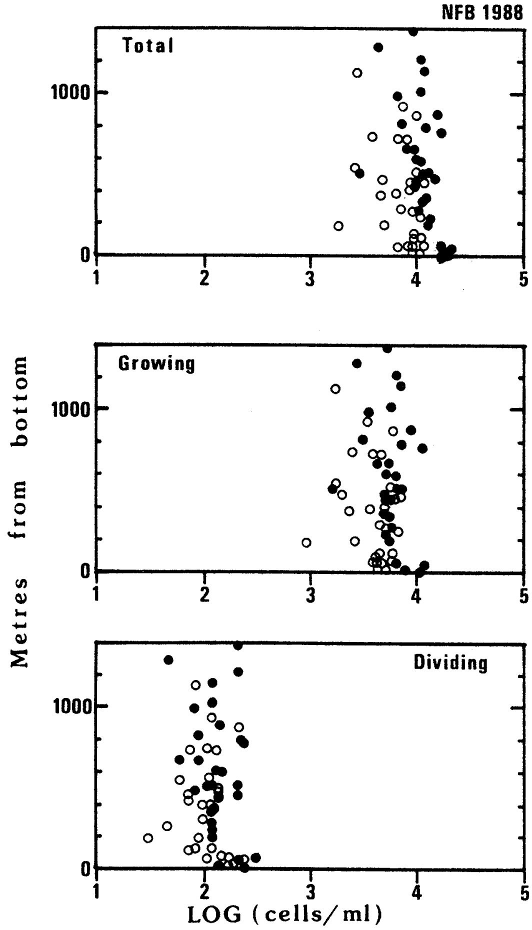

Fig. 1. Vertical distribution of total cells, growing cells and dividing cells of bacterioplankton in the bottom 1000 m layer of the North Fiji Basin. Closed and open circles indicate the bacterial abundance inside and outside the hydrothermal vent plumes, respectively.

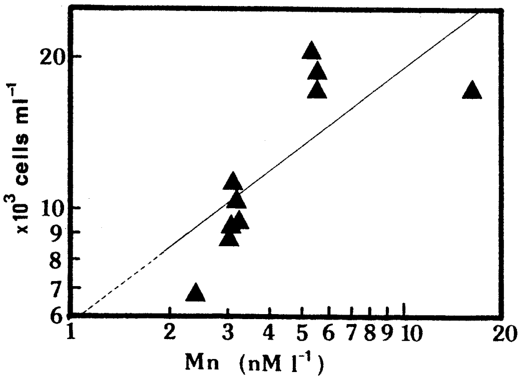

Fig. 2. Relationship between the manganese concentration and the total cells of bacterioplankton in the bottom-most water of the North Fiji Basin.

the manganese concentrations above 1–2 nM.

The counts of growing cells were almost within the range of $\times 10^3$ cells ml^{-1}, and the higher population densities were mostly observed inside the plumes (Fig. 1). The ratio of *total: growing* cell counts was 0.52 on an average. This means that about half of the total bacterioplankton were in the growing phase. No clear difference in the ratio was found among samples collected inside and outside the plumes.

The counts of dividing cells were within the range from $\times 10^1$ cells ml^{-1} to $\times 10^2$ cells ml^{-1}, and they were higher inside the plumes (Fig. 1). The *in situ* ratio of total: dividing cell count was 0.013 on an average, while the *in situ* ratio of growing: dividing cell counts was 0.024 on an average. No obvious difference in the FDC values was calculated between samples collected inside and outside the plumes.

There was an evident difference of bacterial abundance inside and outside vent plumes, as bacterioplankton occurred more abundantly inside the plumes. On the other hand, the ratio of total: growing cell counts and the *in situ* FDC estimations showed no difference for bacterioplankton inside and outside the plumes.

The fraction of thiosulfate-utilizers was found to be less than 1% of the total bacterioplankton. A previous study showed that a considerable fraction of the total counts was composed of thiosulfate-utilizers (NAGANUMA *et al.*, 1989). All the previous results were obtained from samples collected at plume centers where the manganese concentrations were higher. A lower abundance of thiosulfate-utilizers in this study indicates the samples were collected at locations closer to the edge or boundary of plumes.

3.2. Growth characteristics

Growth rates of the bacterioplankton, estimated from on-board cultivation immediately after sampling, ranged from nearly zero to 0.17 hr^{-1} (a generation time of 4.2 hrs). There was no clear difference between growth rates inside and outside vent plumes. The addition of thiosulfate had little influence on their growth, at least at the concentration used. Higher FDC values were, however, enumerated for the thiosulfate-enriched culture than in the non-enriched culture (Fig. 3), and the FDC-growth relationships were expressed as follows:

thiosulfate-enriched

$$[\text{FDC }\%]=0.89+4.56[\text{growth rate hr}^{-1}]$$
$$r^2=0.54(n=8, \text{ significant at } 20\% \text{ level})$$

non-enriched

$$[\text{FDC }\%]=0.61+4.45[\text{growth rate hr}^{-1}]$$
$$r^2=0.93(n=8, \text{ significant at } 0.1\% \text{ level})$$

total

$$[\text{FDC }\%]=0.70+5.26[\text{growth rate hr}^{-1}]$$
$$r^2=0.49(n=16, \text{ significant at } 5\% \text{ level})$$

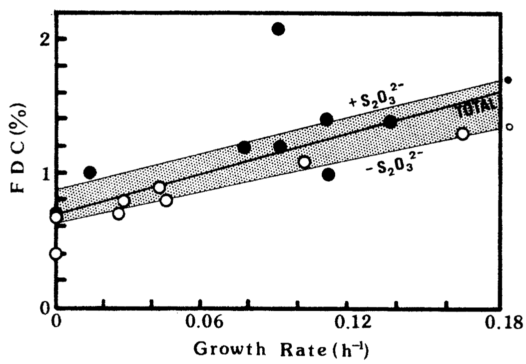

Fig. 3. Relationship between the growth rate and the frequency of dividing cells (FDC) measured by the chemostat culture. Closed and open circles indicate the thiosulfate enriched culture and non-enriched culture, respectively.

These equations and the *in situ* FDC values of bacterioplankton were used for estimating the *in situ* growth rates. With an average *in situ* FDC of 2.4%, the overall average *in situ* growth rate was calculated to be 0.32 hr^{-1} (generation time of 2.1 hrs), whereas the growth rate was 0.33 hr^{-1} (2.1 hrs) for the thiosulfate-enriched culture and 0.40 hr^{-1} (1.7 hrs) for the non-enriched culture. These estimations suggest that the thiosulfate-utilizers found near plune boundaries form a minority of the bacterioplankton community.

Acknowledgements

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北フィジー海盆の熱水プルーム内外における浮遊細菌の現存量と成長特性

長沼 毅・関 文威・堀田 宏

要旨：北フィジー海盆の熱水活動域における深層水から浮遊細菌を採集した。これらは熱水プルームの境界付近から採集され，浮遊細菌の現存量と成長速度をプルームの存在域と化学合成の観点から解析した。

細菌現存量はプルーム内ではプルーム外よりも高かった。しかし，細菌成長速度にはプルーム内外で明らかな差が見られなかった。また，チオ硫酸塩添加培地の使用によって算定される化学合成細菌の生息密度の低いことと，チオ硫酸塩の添加が現場浮遊細菌群集の成長速度に影響を及ぼさなかったことから，熱水プルームの境界付近に生息する浮遊細菌群集には，チオ硫酸塩利用の化学合成硫黄細菌の少ないことが明白となった。

La mer 29: 23-34, 1991
Société franco-japonaise d'océanographie, Tokyo

Design of the simple towed vehicle, "EIKO", for the acoustic Doppler current profiler*

Tsutomu HORI**, Masahiko NAKAMURA***, Wataru KOTERAYAMA*** and Arata KANEKO****

Abstract: A fundamental study is described on the dynamics of a submersible towed vehicle with a design which is light and stable to house an acoustic Doppler current profiler. A practical method of calculating the towing cable tension and profile, the attitude and submerged depth of the towed vehicle is proposed. Experimental studies were carried out to obtain the hydrodynamic coefficient of the vehicle to estimate its performance. On-site experiments of the resulting simple and high performance vehicle EIKO confirmed that the purpose of the design was well achieved.

1. Introduction

Ocean tides and currents are important because of their great effect on the global environment, fishery and transportation on the sea. Measured data of the distribution of flow velocity in ocean currents, however, is extremely limited compared with data on the waves, water temperature and salinity because of the lack of a simple and accurate measuring method. Though the conventional geometric electro kinetograph (GEK) is simple and popular, it is not capable of measuring the ocean currents because it is often disturbed by wind-affected local surface flow. A submerged buoy system with current meters is used to obtain a vertical profile of the current, but it is difficult to maintain many submerged buoy systems in the sea and an extremely large scale system is necessary when data is desired over a wide area (TAKEMATSU *et al.*, 1986).

Recently an acoustic Doppler current profiler (ADCP), which can measure the vertical distribution of current velocity in the sea, was developed with the progress of acoustic technology (JOYCE *et al.*, 1982, ISHII *et al.*, 1986, and KANEKO *et al.*, 1990, etc.) This revolutionary instrument instantaneously measures current velocity from the sea surface to a depth of 400 m in each of 128 layers. The measured data of each layer is transformed into the absolute velocity of the current at that depth by automatically calculating the speed of the ADCP relative to the earth if the ocean floor is within acoustic measuring range (400 m). Although this instrument can be directly installed on a research ship, motion of the ship caused by waves have great effect on accuracy of the measurement and installation on a ship hull is difficult. If, however, ocean currents are measured by an underwater towed vehicle on which an ADCP is installed, such a problem can be avoided because the motion of the underwater vehicle is much less than of the research ship (KOTERAYAMA *et al.*, 1988 & 1989), and installation of the towing cable in the ship's hull is very easy.

In this paper, the design of an underwater towed vehicle which carries an acoustic Doppler current profiler and maintains a stable attitude at a constant depth beneath the surface of the water is described, and the results of experiments at sea are reported.

2. Design of underwater towed vehicle

A schematic diagram of the designed system is shown in Fig. 1, in which the flow velocity relative to the towed vehicle is measured by ADCP. The obtained data are transmitted to the research ship through a conductor cable attached to the towing cable and processed in real time by a computer on the research ship. If the water depth is 400m or less, the measured relative velocity of ocean

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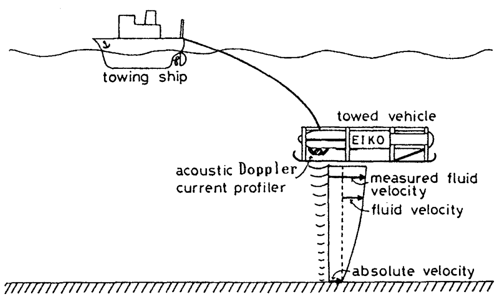

Fig. 1. Concept of the towed vehicle system with an acoustic Doppler current profiler.

currents to the towed vehicle is transformed into the absolute velocity relative to the earth by bottom tracking. If the water depth is over 400m, the measured relative velocity is transformed into absolute velocity using the ship speed which is obtained by the global positioning system (GPS) or the Loran-C navigation system. When the ADCP is located on board the research ship, the motion of the ship induced by surface waves and noise and bubbles generated by the ship's hulll have the serious adverse effects on the instrument's accuracy.

2.1. Design condition and structure

The towed vehicle must be lightweight and small in size for simple operation, but it should have adequate strength. It is also desirable that the vehicle have excess buoyancy so that it can be retrieved if the tow rope is accidentally cut. For accuracy of the profiler, the ship should generate minimum noise and bubbles ; therefore the length of the towing cable should be sufficient to maintain the towed vehicle at a depth of 10m below the sea surface.

In consideration of these design requirements, we decided on a 50m length of cable and a total vehicle length of 2m with a shape as shown in Fig. 2 ; we called it EIKO. The weight of the acoustic current profiler is

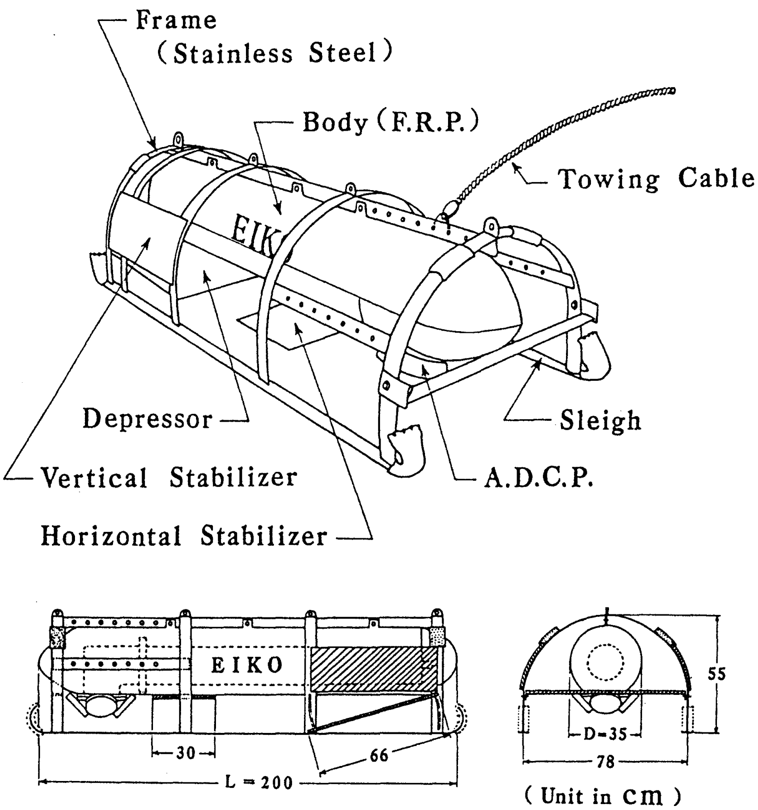

Fig. 2. Design of the towed vehicles (nicknamed EIKO).

about 70kgf, and total weight of the towed system is about 160 kgf ; EIKO's buoyancy is maintained by filling her body with a buoyant material. Though excess buoyancy is an asset in deployment and retrieval, if it is too great the motion of the underwater vehicle is negatively influenced, because its surge and heave is coupled. We therefore designed the vehicle to maintain a neutral buoyancy.

The lower part of the fore body which houses the transducer of the ADCP is open so as not to interfere with the acoustic beam. A depressor made of fiberglass reinforced plastics (FRP) is installed in the aft part of the body for use in lengthening the moment lever to the towed point, and this can be fixed at an arbitrary angle to adjust the lift force to a desired depth. A horizontal stabilizer made of FRP is equipped to prevent pitching and minimize the trim angle. Stainles steel vertical stabilizers minimize the roll and yaw and improve course stability. The main body is also made of FRP and has a shape designed to protect the current profiler and reduce fluid drag. The frame is made of stainless steel acts to further protect the porfiler from the shock of collision with the hull of the towing ship during retrieval and deployment. Two sleigh-type runners have the longitudinal strength and act as buffers when the vehicle is lifted onto the deck of the research ship.

2.2. Experiments on hydrodynamic characteristics in towing tank

Experiments were carried out in a large towing tank created for sea disaster research (L×B×D×d=80×8×3.5×3 m) at the Tsuyazaki Sea Safety Research Laboratory, which is part of the Research Institute for Applied Mechanics of Kyushu University. Hydrodynamic force was measured with a six component dynamometer as shown in Fig. 3. To avoid the free surface effects, the towed vehicle was submerged to the greatest depth possible. The hydrodynamic force acting on the vehicle was are obtained by subtracting the force acting on the strut from the total measured force. During these experiments, the depressor's attack angle β, of which the normal sense is counterclockwise, was fixed

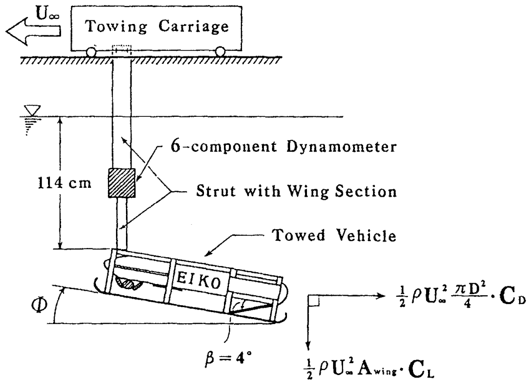

Fig. 3. Experimental setup in the towing tank.

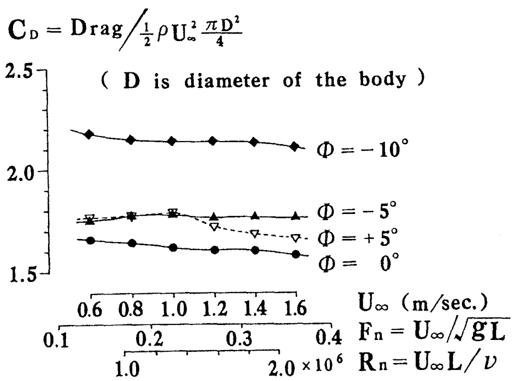

Fig. 4. Drag coefficients C_D of a towed vehicle versus ship speed for various trim angles.

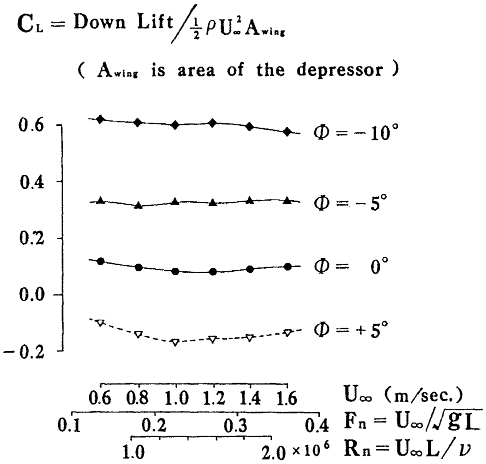

Fig. 5. Down lift coefficients C_L of a towed vehicle versus ship speed for various trim angles.

at 4°. This angle was decided by the conditions that length of the towing cable was 50m and submerged depth of the vehicle was 10m. The calculation method will be described in the next chapter. To examine the dependence of hydrodynamic coefficients upon the vehicle's trim angle Φ, of which the normal sense is clockwise, experiments were done for four cases $\Phi=-5°, 0°, 5°$ and $-10°$. The case of $\Phi=-5°$ corresponded to the actual towed attitude of the vehicle in the ocean. Towing speeds were 0.6~1.6m/s. We define that the direction of drag force is same as that of uniform flow, and that of lift force is perpendicular to the drag force.

Figure 4 shows that the drag coefficient C_D of the vehicle is normalized by the front projectional area $\frac{\pi}{4}D^2$, where D is diameter of the body shown Fig. 2. Figure 5 shows lift coefficients normalized by the wing area of the depressor ; the direction of the lift is positive downwards. These figures indicate that the drag and lift coefficients do not depend on the towing speed U_∞. The drag coefficient C_D is roughly proportional to Φ^2, and the lift coefficient C_L linearly increases with the increase of Φ. However, C_L is not zero at $\Phi=0°$ as shown in Fig. 5, because the vehicle is asymmetrical around the horizontal plane as shown in the front view of Fig. 2. We obtain $C_L=0$ at $\Phi=2°$ by the interpolation in Fig. 5. The reason C_D increases with the increase of trim angle Φ as shown in Fig. 4 is that the induced drags acting on the depressor and horizontal stabilizer increase as shown in Eq. (28) of the next chapter. The value of C_D reaches about 1.6 even at $\Phi=0°$, which means that the drag forces acting on appendages such as the frame of the vehicle, the transducer of the profiler and others account for most of the total drag of the vehicle; the induced drag of the wings is not large at $\Phi=0°$ as denoted in Eq.(28), and the drag coefficient of the main body is estimated as only 0.6. This fact is important because the tension of the towing cable is due primarily to the drag coefficient of the towed vehicle when the weight and length of the cable are small.

Figure 6 shows the heel moment coefficient

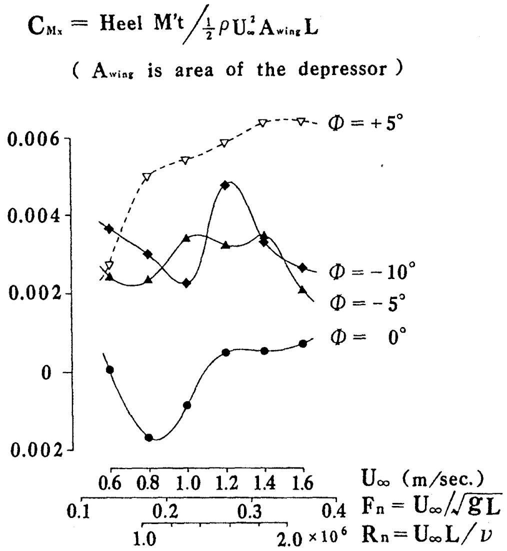

Fig. 6. Heel moment coefficents C_{Mx} of a towed vehicle versus ship speed for various trim angles.

C_{Mx}, which is normalized on the basis of the depressor's wing area and the vehicle's total length. The value of C_{Mx} is usually not zero because of unstable hydrodynamic force. Even small values of C_{Mx} cause the vehicle to capsize in high speed towing when $\overline{BG}$ of the towed vehicle is small, where $\overline{BG}$ is the distance between center of buoyancy and that of gravity. The dependence of C_{Mx} upon the towed speed is unstable as shown in Fig. 6 ; therefore it is actually not possible to adjust the body shape and the angle of wings in order to minimize C_{Mx}. It is thus essential that that the vehicle be stabilized by increasing the restoring force.

3. Theoretical calculation method

3.1. Profile and tension of the towing cable

The towing cable used in this study is short and neutrally buoyant in the water, therefore the dynamics is not important. On the contrary, when the cable is long and heavy, its dynamic analysis is important in estimating the performance of the towed system (Koterayama *et al.*, 1988 & 1989). The calculation method of the tension and the profile of a mooring cable, which is neutrally buoyant in the water, was shown by Pode (1951) in his

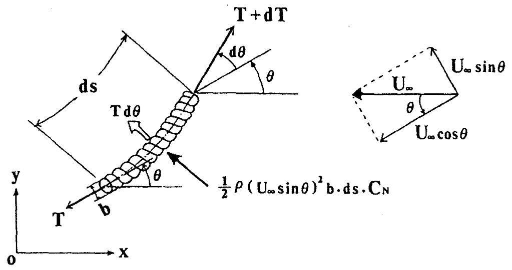

Fig. 7. Forces acting on the differntial element of a zero weight cable in the water.

study, but the same method is not practical for the towing cable. The purpose of this section is to develop the method of calculation for obtaining the depth of submersion.

As shown in Fig. 7, we take the *o-xy* co-ordinate system in which *ds* is the differential element of the cable and U_∞ is the uniform flow velocity. The frictional resistance acting along the cable is neglected because it does not contribute to the profile of the cable. We assume that the weight of the cable in the water is zero, then

$$dT=0 \tag{1}$$

Consequently, the tension T along the cable becomes constant

$$T=T_0 \quad (=Const.) \tag{2}$$

Since the drag force acts on the cable in the normal direction and the cable deflects as balancing with its force, the following differential equation is obtained.

$$ds+\lambda\cdot\frac{d\theta}{\sin^2\theta}=0 \tag{3}$$

in which θ is the slope angle of the cable, and λ is the parameter governing the deflection shape of the cable and is defined by

$$\lambda\equiv\frac{2T_0}{\rho U_\infty^2 b\cdot C_N} \tag{4}$$

where b is the diameter of the cable, C_N is the drag coefficient and ρ is the density of the water.

Since $s=0$ at $\theta=\theta_0$, the length s of the cable is obtained as the function of the cable slope θ in the following form by integration with Eq. (3)

$$s=\lambda\cdot(\cot\theta-\cot\theta_0) \tag{5}$$

Equation (5) can be rewritten as :

$$\cot\theta=\tilde{s}+\cot\theta_0 \tag{6}$$

where $\tilde{s}$ is the dimensionless cable length as $\tilde{s}\equiv s/\lambda$. If we use the normalized cable length $\tilde{s}$ and the cable slope θ_0 at the towed vehicle's side, we can estimate the cable slope θ at the end of the side of the research ship.

Since it is not easy to obtain the profile of the cable from Eq.(6), we transfrom the co-odinate system from (s, θ) to (x, y). By differentiating the equation of $\cot\theta=dx/dy$, we find that

$$\frac{d\theta}{\sin^2\theta}=-\frac{d^2x}{dy^2}dy \tag{7}$$

and from the definition, we get

$$ds=\sqrt{1+\left(\frac{dx}{dy}\right)^2}\,dy \tag{8}$$

Eliminating s and θ from Eq. (3) by substituting Eqs. (7) and (8), the profile of the cable can be written in the following form,

$$\tilde{x}=\cosh\{\tilde{y}+\sinh^{-1}(\cot\theta_0)\}-\cosh\{\sinh^{-1}(\cot\theta_0)\} \tag{9}$$

where $\tilde{x}\equiv x/\lambda$, $\tilde{y}\equiv y/\lambda$. From Eq. (9), we find that the profile of the towing cable of neutral buoyancy is a reverse catenary curve, and we can obtain the profile by replacing the horizontal co-ordinate x with the vertical one y.

The submerged depth $\tilde{y}$ of the towed vehicle can be obtained as follows:

$$\tilde{y}=\sinh^{-1}(\cot\theta)-\sinh^{-1}(\cot\theta_0) \tag{10}$$

and substituting Eq. (6) into Eq. (10), we obtain

$$\tilde{y}=\sinh^{-1}(\tilde{s}+\cot\theta_0)-\sinh^{-1}(\cot\theta_0) \tag{11}$$

Eliminating $\tilde{y}$ from Eq. (9) by using Eq. (11), the horizontal distance $\tilde{x}$ between the research ship and towed vehicle can be written in the following form

$$\tilde{x}=\cosh\{\sinh^{-1}(\tilde{s}+\cot\theta_0)\}-\cosh\{\sinh^{-1}(\cot\theta_0)\} \tag{12}$$

Consequently, if the cable length $\tilde{s}$ and the cable slope θ_0 at the end of towed vehicle's side are known, we can estimate $\tilde{y}$, $\tilde{x}$ and θ at the cable end of research ship's side. Equation (11), which explicity gives the submerged

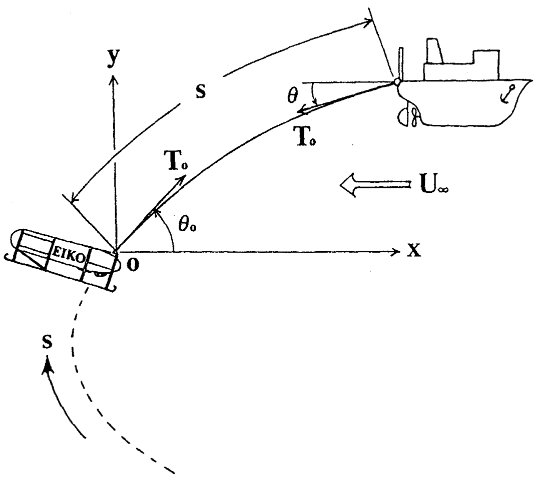

Fig. 8. Deflection shape of the zero weight cable in the water.

depth of the underwater towed vehicle, is especially helpful.

3.2 Attitude and wing angle of the towed vehicle

From the study of the former section we can evaluate the submerged depth of the vehicle when the cable slope at the cable end of the towed vehicle's side is known. In this section we explain the method of estimating the static attitude of the towed vehicle and this gives the condition of the cable end at the towed vehicles's side.

The noations of forces and their directions

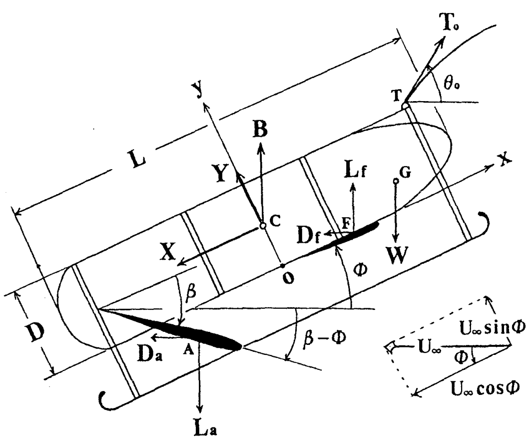

Fig. 9. Coordinate system and forces acting on the towed vehicle.

are defined as shown in Fig. 9. We take a Cartesian co-ordinate system o-xy, where the x-axis is positive in the longitudinal direction and the y-axis is in the transverse direction. As shown in the figure, the vehicle is towed at point T of the bow where the tension is T_0 and the angle is θ_0 at this point. Then the weight W in the water of the acoustic current profiler, the net buoyancy B of the vehicle's body and the drag force X, Y in the x, y direction respectively act on the main body of the towed vehicle. Also, the lift L_a, L_f and the induced drag D_a, D_f act on the depressor and horizontal stabilizer. The towed vehicle thus maintains a condition of static equilibrium as a result of these various forces. Since we consider only a two dimensional problem in the vertical plane, the contribution of the vertical stabilizer is not considered in the static analysis.

The static equilibrium equation of the trim moments about towing point T can be expressed as follows:

$$X\cdot(y_T-y_c)+Y\cdot(x_T-x_c)+B\cdot\xi_c+L_f\cdot\xi_f+D_f\cdot\eta_f+D_a\cdot\eta_a=W\cdot\xi_G+L_a\cdot\xi_a \qquad (13)$$

where ξ_j, η_j are the horizontal and vertical distances from the towing point (x_T, y_T) to each point, respectively, and are defined by

$$\left.\begin{aligned}\xi_j&\equiv(x_T-x_c)\cos\Phi-(y_T-y_c)\sin\Phi\\ \eta_j&\equiv(y_T-y_c)\cos\Phi+(x_T-x_c)\sin\Phi\end{aligned}\right\} \qquad (14)$$

In Eq. (13), X, Y, L_f, D_f are the function of the speed U_∞, the trim angle Φ of towed vehicle where L_a and Da depend on U_∞, the attack angle $\beta-\Phi$ of the depressor. Then, by Prandtle's lifting line theory L_a, D_a are expressed as the linear or quadratic function of the attack angle $\beta-\Phi$ in the following form, respectively

$$\left.\begin{aligned}L_a&\equiv\tilde{L}_a\cdot(\beta-\Phi)\\ D_a&\equiv\tilde{D}_a\cdot(\beta-\Phi)^2\end{aligned}\right\} \qquad (15)$$

We then compare each degree of the term $\beta-\Phi$ and rewrite it in the form of a quadratic equation

$$K_2\cdot(\beta-\Phi)^2-K_1\cdot(\beta-\Phi)+K_0=0 \qquad (16)$$

in which K_0, K_1 and K_2 are given, respectively, by

$$\left.\begin{aligned} K_2&=\tilde{D}_a\cdot\eta_a\\ K_1&=\tilde{L}_a\cdot\xi_a\\ K_0&=X\cdot(y_T-y_c)+Y\cdot(x_T-x_c)+B\cdot\xi_c\\ &\quad -W\cdot\xi_G+L_f\cdot\xi_f+D_f\cdot\eta_f \end{aligned}\right\}\quad(17)$$

For Eq. (16) two solutions exist as follows:

$$\beta-\Phi=\frac{K_1\pm\sqrt{K_1^2-4K_0\cdot K_2}}{2K_2}\qquad(18)$$

The coefficient K_2 of Eq. (17) corresponds to the induced drag of the depressor and is much smaller than the other coefficients K_0, K_1 (as shown by Eq. (28) in the next section). Investigating the asymptotic behavior of the solution obtained in Eq. (18) as $K_2\to 0$, we find that

$$\beta-\Phi\underset{K_2\to 0}{\sim}\begin{cases}\dfrac{K_1}{K_2}\longrightarrow\infty\\ \dfrac{K_0}{K_1}+\dfrac{K_0^2}{K_1^3}K_2+O(K_2^2)\end{cases}\qquad(19)$$

The lower solution of the double sign in Eq. (18) is obtained as the perturbation with K_0/K_1, which is the solution to the linear equation putting $K_2=0$ in Eq. (16). The upper solution has a large value because it diverges to the order of $1/K_2$ and so is not adopted. Then the angle β of the depressor is obtained as follows:

$$\beta=\Phi+\frac{K_1-\sqrt{K_1^2-4K_0\cdot K_2}}{2K_2}\qquad(20)$$

Thus if the speed U_∞ and the trim angle Φ of the towed vehicle are known, the wing angle β of the depressor is determined as written in Eq. (20). The tension T_0 and the slope θ_0 at the end of the cable are obtained from the equilibrium condition of the forces in the horizontal and vertical directions, respectively.

The equilibrium equation for the forces in each direction are:

$$\left.\begin{aligned} T_0\cos\theta_0&=X\cos\Phi+Y\sin\Phi\\ &\quad+D_f+D_a\equiv F_H\\ T_0\sin\theta_0&=X\sin\Phi-Y\cos\Phi\\ &\quad+W-B-L_f+L_a\equiv F_v \end{aligned}\right\}\quad(21)$$

From Eq. (21), we can easily determine T_0 and θ_0 in the following form

$$\left.\begin{aligned} T_0&=\sqrt{F_H^2+F_V^2}\\ \theta_0&=\tan^{-1}(F_V/F_H) \end{aligned}\right\}\quad(22)$$

where F_H, F_v are the horizontal and vertical components of T_o as defined by Eq. (21).

As mentioned above, if the tension T_0 and the slope θ_0 of towing cable are obtained by the analysis of static equilibrium at the side of the vehicle, the submerged depth of the towed vehicle can be obtained. Since we actually need to set the wing angle of the depressor to maintain the required submerged depth of the vehicle to correspond to the towing speed, the calculation must be carried out with an iterative procedure. A chart helpful in estimating the wing angle of the depressor is presented in section 3. 4.

3. 3 Hydrodynamic coefficients of the towed vehicle

In the static analysis of the towed vehicle described in section 3.2, the hydrodynamic coefficients acting on the main body and the two wings need to be determined. Experiments show that the coefficients of drag C_D (Fig. 4) and lift C_L (Fig. 5) for the vehicle are roughly constant versus the towing speed U_∞. In this section, we derive the method for determining the hydrodynamic coefficients acting on the main body and the two wings as functions of the trim angle Φ.

The drag forces X, Y in the x and y-directions acting on the main body of the vehicle (except two wings) are expressed in the following form,

$$\left.\begin{aligned} X&=\frac{1}{2}\rho\cdot(U_\infty\cos\Phi)^2\cdot\frac{\pi D^2}{4}\cdot C_X\\ Y&=\frac{1}{2}\rho\cdot U_\infty^2\sin\Phi\,|\sin\Phi|\cdot LD\cdot C_Y \end{aligned}\right\}\quad(23)$$

in which C_x, C_y are the drag coefficients based on the frontal projective areas.

Next, we examine the lifts and the induced drags acting on the horizontal stabilizer (fore) and the depressor (aft).

The lifts of L_f and L_a are respectively noted in the form

$$\left.\begin{aligned} L_f&=\frac{1}{2}\rho U_\infty^2\cdot b_f c_f\cdot\frac{2\pi k_f}{1+2/\Lambda_f}\cdot\Phi\\ L_a&=\frac{1}{2}\rho U_\infty^2\cdot b_a c_a\cdot\frac{2\pi k_a}{1+2/\Lambda_a}\cdot(\beta-\Phi) \end{aligned}\right\}\quad(24)$$

where k_f, k_a are the correction factors from Prandtle's lifting line theory, b_f, b_a are the breadth of the wings, and C_f, C_a are the chord length of the wings, respectively. The aspect ratios of each rectangular wing are defined as $\Lambda_f(=b_f/c_f)$ and $\Lambda_a(=b_a/c_a)$.

The induced drags of D_f, D_a can be written by

$$\left.\begin{aligned} D_f &= \frac{1}{2}\rho U_\infty^2 \cdot c_f^2 \cdot \frac{4\pi}{e_f(2/\Lambda_f)^2} \cdot \Phi^2 \\ D_a &= \frac{1}{2}\rho U_\infty^2 \cdot C_a^2 \cdot \frac{4\pi}{e_a(1+2/\Lambda_a)^2} \cdot (\beta-\Phi)^2 \end{aligned}\right\} \quad (25)$$

in which e_f, e_a are correction factors.

Using the expressions for hydrodynamic forces shown in Eqs. (23), (24) and (25), we obtain the equation of C_D and C_L for the main body with wings.

3.4 Results of computation and discussions

We calculate the submerged depth and trim angle Φ of the towed vehicle shown in Fig. 2 as the function of the angle β of the depressor and the required towing speed U_∞. The results shown in Fig. 10 reveal that the depth of the towed vehicle decreases with the increase of β because the increase of β results in an increse of Φ. This fact indicates that the wing fitted to the vehicle's aft portion performs the role of a controller of the trim rather than a "depressor". Figure 10 also shows that the depth of the vehicle decreases with the increase of U_∞ because of the increase of Φ and the vertical component F_v of the towing tension T_0. This knowledge is helpful when the wing angle and towing speed must be decided to realize a required submerged depth. We determined that wing angle β of the depressor is 4° for the desired submerged depth of 11m at the towing speed $U_\infty=4$ knots, and in this case the trim angle Φ is 2°.

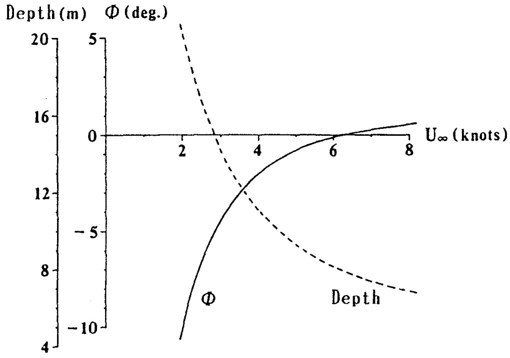

Fig. 11. Trim angles and submerged depths of the towed vehicle versus ship speed in the case of $\beta=4°$.

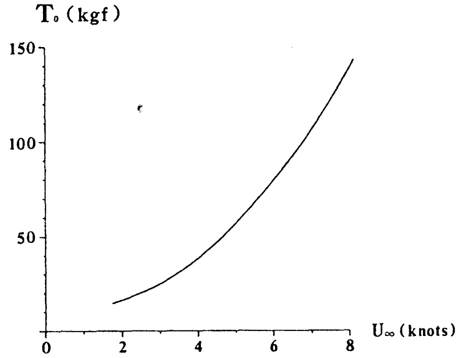

Fig. 12. Tension of the towing cable versus ship speed in the case of $\beta=4°$.

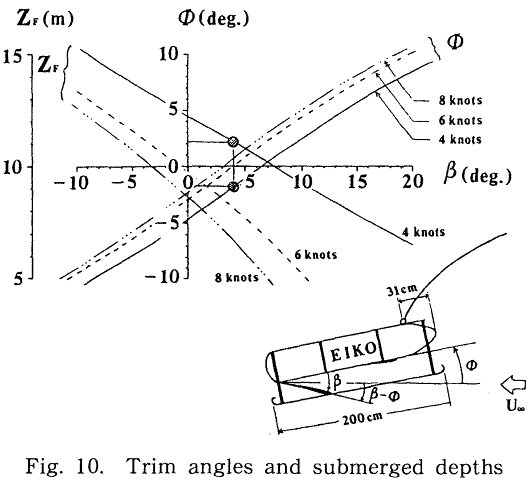

Fig. 10. Trim angles and submerged depths of a towed vehicle versus the attack angles of depressor for various ship speed.

Figure 11 shows the trim angle and the submerged depth of the vehicle versus towing speed U_∞ when β is 4°. The increase of the angle of the depressor and that of the towing speed have the same effect on the submerged depth of the towed vehicle. Both cause the trim angle Φ to increase and it results in a decrease in the depth of submersion. Figure 12 shows the tension T_0 of the towing cable and we find that this cable tension grows in proportion to the square of towing speed.

Since the towed vehicle has an excess buoyancy of 5kgf for the convenience of operation on the sea, it cannot maintain the static stable towing condition appearing in Fig. 11 when the towing speed approaches to zero.

In numerical simulations of motions of the towed vehicle, a quasi-steady solution is introduced in which the variations of attitude and submerged depth of the vehicle and the tension of the towing cable are determined on the basis of the static calculation developed in sections 3. 1 and 3. 2.

4. On-site experiments

Experiments were conducted in the Genkai Open Sea around Oki-no-shima off Fukuoka prefecture in August 1987 to confirm the performance of the towed vehicle "EIKO" on which the acoustic Doppler current profiler was installed. State of sea on the day of the experiments was calm and the height of ocean waves was about 1 m. EIKO was towed by the research ship using a 50 m long and 16 mm diameter towing cable made of polypropylene and with a nearly zero weight in water ; a conductor cable was fitted along the towing cable. Items to be measured were the vertical distribution of the current velocity in the ocean, by the ADCP ; the rolling and pitching angles of EIKO, by a clinometer installed in the ADCP ; the motions of the research ship with six degrees of freedom, by a gyroscopic measuring instrument ; and the tension of the towing cable. The experiments were performed under various conditions of towing speed, point of cable attachment and wing angle of the depressor. The confirmed allowable towing velocity of EIKO in these experiments was 2~8 knots ; at higher speed the vehicle capsized because of its unstable heel moment. One example of the experimental results is given ; the vehicle was towed at 4knots with the wing angle of depressor fixed at 4°.

In Fig. 13 the time records of surge, sway and heave of the research ship measured by the gyroscopic measuring instrument suggest that the wave height was about 1 m and the period more than 8.5 sec. Thus the sea weather was calm and the conditions were not the most suitable for the performance test of the towed vehicle, because measurement of the ocean flow by the towed vehicle and the ADCP system would be more informative under severe sea conditions. Figure 14 shows the time records of pitch, roll and yaw of the research ship.

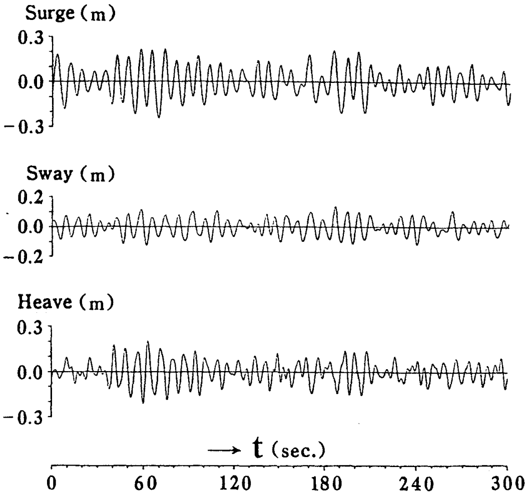

Fig. 13. Time record of the surge, sway and heave motions of the towing ship.

In Fig. 15, we show the time records for the motion of the towed vehicle. The quality of the data obtained is not the best because pitch and roll were measured by a clinometer of the gravitational type and the sampling period of data was about 4 sec because of the limitations in the processing ability of the portable computer on the deck of the research ship.

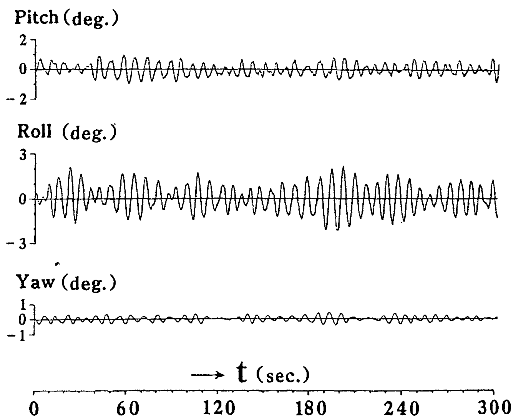

Fig. 14. Time record of the pitch, roll and yaw motions of the towing ship.

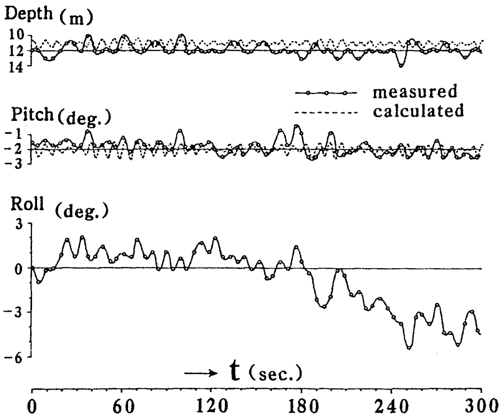

Fig. 15. Time record of the submerged depth and pitch, roll of the towed vehicle.

The characteristics of the oscillation of the towed vehicle, unfortunately, cannot be adequately evaluated with the data at hand. The calculation results of pitching angle shown by the broken line in Fig. 15 were obtained using the quasi-static technique on the basis of the static calculation shown in chapter 3. We have developed a full dynamic calculation method for a vehicle towed by a long and heavy cable, but lengthy computer times is required, making it impractical for calculations on a short, light cable. The calculated pitching angle of the vehicle is obtained by substituting the sum of the ship's mean speed of 4 knots and the fluctuating velocity instead of the steady towing speed U_{∞}. As shown in Fig. 15, the mean value of pitching angle obtained from the quasi-static calculation is about 2° which coincides with experimental findings. The results of the quasi-static calculations of the variation of pitching angle show good agreement with experiments. We suppose that the large fluctuations in the pitch appearing in the measured values are due to measurement errors because such a phenomenon is not possible in the towed vehicle system.

Experiments show that the rolling angle fluctuates slowly and may be caused by the unstable heeling moment shown in Fig. 6. This problem cannot been avoided so long as the rolling motion is not controlled. The short periodic amplitudes of the pitch and roll are kept within a 1 degree range, so that we can conclude that EIKO is comparatively stable.

The measured value of the submerged depth shown in Fig. 15 is obtained by subtracting the distance between the towed vehicle and the sea bottom measured by ADCP from the sea depth measured by the research ship's depth finder. The value of the submerged depth indicated by the broken line is obtained by quasi-static calculation. From a comparison of calculation and experiment of the submerged depth, we find that the heave fluctuation of the vehicle can be simulated by quasi-static calculation in which the submerged depth varies corresponding to fluctuations of the towing speed caused by surges of the research ship. Although large fluctuations occasionally appear in the measured time record of the submerged depth, theoretical calculation suggests that such a phenomenon cannot occur, and it is supposed that those shown on the record were caused by a measuring error due to the difference in extension of the acoustic beam of ADCP and the depth finder of the rearch ship. The results of the quasi-static calculation on the heave show fairly good agreement with the measured results.

Figure 16 shows the time record of the tension of the towing cable measured at the end of research ship's side. The calculated tension shown by the broken line is obtained by adding the frictional resistance acting along the cable to the time record of the cable tension obtained by quasi-static calculation. The tension variations obtained by the calculation coincide with those of experiments, and we find that the variations in tension are

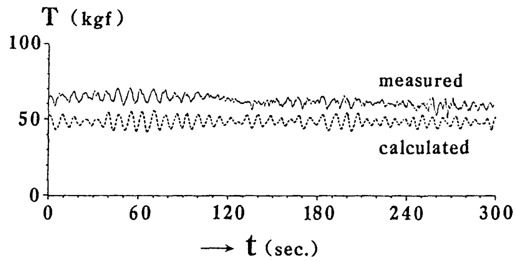

Fig. 16. Time record of the tension of the towing cable.

dependent upon the surging velocity of the research ship. The difference of the mean value of the measured and calculated findings might be due to the effects of an appendage such as the conductor cable which we did not take into account.

Next we show the experimental results of measurements of the ocean flow field by the ADCP installed on EIKO. The depth of the sea area was about 100 m ; current velocities were sampled at every 8 m of the water depth. Figure 17 is an example of the vertical profiles of the velocity and direction of ocean currents measured at latitude 34° 04' north and longitude 129° 32' east. For comparison, measurement data obtained by the submerged buoy system with current meters (ACM) are shown by circles in the figure. The data of the two systems coincide, confirming that the measuring system of ADCP proposed in this paper does provide accurate data of the ocean flow field. In Fig. 18, the time record of the current velocity at every 16 m of water depth is presented. These current vector data were sampled by traversing the Tsushima-East Channel from Tsushima-Izuhara to a spot 10 km to the north of Iki island.

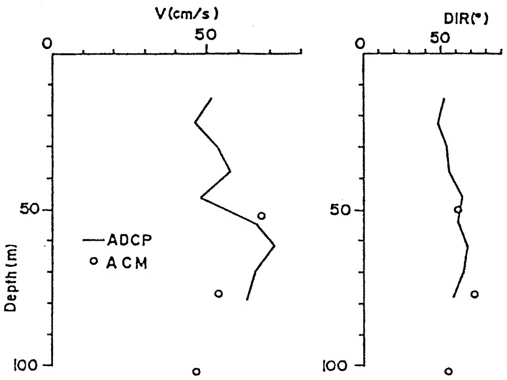

Fig. 17. Vertical profiles of velocity and direction of sea currents obtained by ADCP and ACM at 34°04' N, 129°32'E.

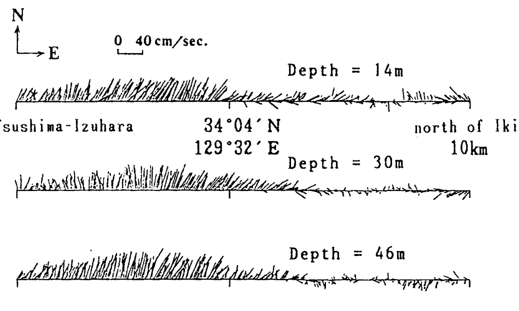

Fig. 18. Vectors of the current sea velocity at various depths.

The system of measurement using a towed vehicle mounted with an ADCP thus can collect ocean data over a wide area with high accuracy. The pitch and roll of the short period of EIKO were kept within a 1 degree range. The motions of EIKO were almost same as those of the research ship, however, because these experiments were done under conditions of following waves and the encounter period was comparatively long. The damping force for motions acting on the towing cable in the region of low frequency, therefore, could not expected. However, theoretical analysis has shown that the motion of the underwater towed vehicle is much less than that of the surface ship in a severe sea state, especially where waves come with high frequency (Koterayama *et al.*, 1988 & 1989).

5. Concluding Remarks

For the purpose of developing an underwater towed vehicle to carry an acoustic Doppler current profiler, we carried out the fundamental study of a tank test, theoretical calculation and the result was to design a small, lightweight vehicle. On-site experiments confirmed the performance of the vehicle, and we found that the system developed has the ability to carry out practical and informative ocean measurements. We also measured the tension of the towing cable and confirmed that it was within a permitted limit.

The superior characteristics of the towed vehicle suggested by theoretical analyses could not be thoroughly evaluated, however, because the wave height was extremely low and the encounter period comparatively long in the area of the sea where the experiments were performed. This thus remains to be done in future, but sufficient information was obtained to make the prospects very optimistic.

Acknowledgements

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超音波ドップラー式流速計塔載型の曳航式海中ロボットについて

堀　勉・中村　昌彦・小寺山　亘・金子　新

要旨：従来，海中の流速分布の計測例は，その重要性にも拘わらず簡便で精度の良い計測法が無かったため，波浪・水温・塩分等の観測データに比べて極めて少なかった。最近，音響技術の進歩により，海中流速の鉛直分布を瞬時にして計測し得る超音波ドップラー式音響流速計（acoustic Doppler current profiler: ADCP）が開発された。通常はこの流速計を直接に海洋観測船に搭載し目的の海域を航行して流速を計測するのであるが，波による船体運動やノイズ等の外乱が計測精度に悪影響を及ぼすことと，流速計の船体への固定が大掛かりになるために，専用船でない場合には運用上の問題等が生じ，実用的でなかったと言える。

本報告では，上述の難点を克服をすべく，音響流速計を搭載し制御を行わずして水面下の一定深度を安定な姿勢を保ちながら航走する小型で軽量な水中曳航体（愛称：EIKO）を開発し，昭和62年8月に玄海灘の沖ノ島周辺海域で実施した海上実験に於いてその性能を確認した結果について述べる。また，実際の曳航姿勢や潜航深度が，水槽試験データを用い，曳航索の水中重量を零として近似した準定常的な簡易計算法によって良好に推定できることを示す。

La mer 29: 35-38, 1991
Société franco-japonaise d'océanographie, Tokyo

Faits divers

Morphological and chronological tables of embryonic development in fish*

J. DEPECHE** and R. BILLARD***

This is a brief presentation of some references in embryonic development of fish including some species of agnatha. Numerous papers describe some morphological aspects of embryogenesis and the list below give several of them to show the variety of species studied and the long history of this discipline. Some works from the last century are very detailled, accurate and sometimes the drawings are colored by hand. Most of the recent papers give informations on chronology and details on the incubation conditions (temperature and sometimes dissolved oxygene and other compounds).

Several works were conducted in a prospective of ecological and evolutionary embryology and some were recently edited by BALON (1985). A significant contribution came from Japanese scientists in the framework of trials to breed fish in sea ranching programmes.

Table 1. Some references of morphological and sometimes chronological tables of embryonic development

Abramis brama (hybrids)	RYABOV, 1973
Acipencer transmontanus	BEER, 1980
Adinia xenica	CUNNINGHAM, 1982
Amia calva	DEAN, 1895; BALLARD, 1986
Anguilla japonica	YAMAMOTO 1981-1982, YAMAMOTO *et al.*, 1975
Aphyosemion calliurum	PETERS, 1963
Aptocyclus ventricosus	KYÛSTIN, 1975
Barbus barbus	PENAZ, 1973
Brachydanio rerio	HISAOKA and BATTLE, 1958; LAALE, 1984
Carassius auratus	KAJISHIMA, 1960
Chondrostoma nasus nasus	DEDUAL, 1990
Dicentrarchus labrax	BARNABÉ, 1976
Dorosoma petenense	SHELTON and STEPHENS, 1980
Dorosoma cepedianum	〃
Eopsetta qriqorjewi	FUJITA, 1965
Ernogrammus hexagrammus	FUJITA and USHITA, 1959
Esox lucius	LINDROTH, 1946; GIHR, 1957
Fugu poecilonotus	FUJITA, 1956a
Fugu rubripes	FUJITA and UENO, 1956a
Fugu stitonotus	FUJITA, 1956b
Fundulus heteroclitus	OPPENHEIMER, 1937; ARMSTRONG and CHILD, 1965
Gobius niger jozo	BALLARD, 1969
Heterandria formosa	FRASER and RENTON, 1940
Hypophthalmichthys molitrix (hybrids)	RYABOV, 1973
Ictalurus nebulosus	ARMSTRONG and CHILD, 1962
Inimicus japonicus	FUJITA and NAKAHARA, 1955
Labeotropheus	BALON, 1977
Lampetra lamotteni and others	SMITH *et al.*, 1968

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Lepomis macrochirus and hybrids	Heckerman, 1969
Micromesistius poutassou	Coombs and Hiby, 1979
Nibea argentata	Fujita, 1956c
Nothobranchuis guntheri	Peters, 1963
Nothobranchuis korthausae	Wourms, 1972
Oncorhynchus keta	Mahon and Hoar, 1956
Oncorhynchus mykiss (*S. gairdneri*)	Pasteels, 1936; Ballard, 1973, Witschi, 1956-1962; Vernier, 1969, Knight, 1963
Oncorhynchus nerka	Velsen, 1980
Ophiocephalus striatus	Yapchiongco and Demonteverde, 1965
Oryzia latipes	Gamô and Terajima, 1963
	Hisaoko and Battle, 1958
Percina caprodes semifasciata	Paine and Balon, 1984
Platypoecilus and Xiphophorus	Tavolga, 1949
Platypoecilus indicus	Fujita and Ueno, 1956
Platypoecilus maculatus	Tavolga and Rugh, 1947
Poecilia reticulata	Bui, 1963 in Chambolle, 1963
Polyodon spatula	Ballard and Needham, 1964
Pseudoblennius percoides	Fujita, 1957
Salmo trutta fario	Henneguy, 1888; Korpsch, 1898
Salmo salar	Trifona *et al.,* 1959; Klinkhardt, *et al.,* 1987; Battle, 1944
Scyliorhinus canicula	Balfour, 1978; Mellinger *et al.,* 1986;
Sebastes oblongus	Fujita, 1958
Sillago sihama	Uneno and Fujita, 1954
Sphyraena pinguis	Shojima *et al.,* 1957
Tanakuis kitaharai	Fujita, 1965
Thymallus thymallus	Bielek, 1974; Zaytsev, 1986
Tinca tinca	Penaz *et al.,* 1981
Trichogaster trichopterus	Hisaoka and Firlit, 1962

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学 会 記 事

1. 1991年1月18日（金）東京水産大学において平成2年度第5回幹事会が開かれた。主要な議事は下記のとおり。

1) 12月11日（火）日仏会館で日仏関連学会が開催された。関連学会会員の会館（会員）への入会（関連学会会員は入会金不要），日仏図書交換，会館図書館の積極的な利用等の要望があった。

2) 11月に日仏会館で行われた日仏シンポジウムのプロシーディングス刊行費として，同会館から70万円の入金があった。なお，このプロシーディングスは，La mer 28巻4号（1990年12月発行）として，4月頃印刷の見こみである。

3) 日本学術会議第15期会員の推薦について
会員の候補者の届出の締切りは1月31日（木），推薦人（予備者を含む）の届出の締りは2月20日（水）である。前回の幹事会で，前期にならって，推薦人には有賀会長，推薦人予備者には高木副会長を届け出ることとした。しかし，日本海洋学会，日本プランクトン学会等からの推薦をも考慮して，下記のとおりとすることになり，評議員の了承を求めることとした。

会員の候補者　有賀祐勝会長
推薦人　須藤英雄幹事
推薦人予備者　高木和徳副会長

4) 第6回日仏学術シンポジウム（第3回日仏海洋シンポジウム）について

5) 関幹事提案の，創立30周年記念出版（40人くらいの分担執筆で海をトピックとした岩波ジュニア新書を刊行する）の件については，同幹事が岩波書店側と交渉をすすめている。

2. 1991年3月19日（火）東京水産大学において平成2年度第6回幹事会が開かれた。主要な議事は下記のとおり。

1) 日本学術会議第15期会員の推薦について
3月15日付けで，有賀祐勝会員候補者の資格の認定の通知と推薦人会議の日程（水産学は6月7日（金）午後）の連絡があった。

2) 日仏会館からの連絡について

3) 第3回日仏海洋シンポジウムの一環として2月7～9日ヌメアで行われたスターメール・プロジェクトの Hydrothermal Vents に関するシンポジウムは，成功裡に終了した。

4) 創立30周年記念出版（海をトピックとした岩波ジュニア新書の刊行）については，関幹事が岩波書店側と交渉をすすめ，8月出版の予定で準備がすすめられている。今後の編集についての書店側との連絡，交渉等は関，小池両幹事に一任することとした。なお，印税については，第1刷については著者と学会とで折半，以後は全額学会が受け取るようにする。

5) 日仏海洋シンポジウム（セミナー）について
1991年11月オーシャンフラックスに関してフランスから5名の来日が予定されているので，日仏会館で研究集会を計画している。

6) 学協会著作権協議会から再度依頼のあった複写権の委託については，これにより，La mer から引用されなくなるおそれがでてくる等のマイナス面も予想されるので，当面現状どおりとすることを確認した。

7) 1991年度学術研究発表大会及び総会の期日は5月31日（金）を第1候補として準備をすすめる。

3. 日仏会館からの推薦依頼による1991年度日仏学者交換事業候補者については，1月19日付けで佐伯和昭氏を推薦することとした。

日仏海洋学会役員・評議員
(1990～1991年度)

顧　問　ユベール・ブロシェ　ジャン・デルサルト　ジャック・ロベール　アレクシス・ドランデール　ベルナール・フランク　ミシェル・ルサージュ　ロベール・ゲルムール　ジャック・マゴー　レオン・ヴァンデルメルシュ　オーギュスタン・ベルク

名誉会長　ユベール・セカルディ

会　長　有賀祐勝

副会長　高木和徳，岡市友利

幹　事　（庶務）須藤英雄，有元貴文；（会計）松生洽，高橋　正；（渉外）佐伯和昭，隆島史夫（研究）関　文威，小池勲夫；（編集）山口征矢，渡辺精一

監　　事　久保田　穰，辻田時美

編集委員長　村野正昭

評 議 員　青山恒雄，阿部友三郎，有元貴文，有賀祐勝
石野　誠，宇野　寛，大塚一志，岡市友利，
岡部史郎，梶浦欣二郎，金成誠一，鎌谷明善
川合英夫，国司秀明，久保田穰，黒木敏郎，
小池勲夫，小長俊二，佐伯和昭，坂本市太郎
坂本　亘，須藤英雄，杉村行勇，杉森康宏，
関　文威，平　啓介，高木和徳，隆島史夫，
高野健三，高橋　正，高橋正征，竹松　伸，
谷口　旭，辻田時美，寺本俊彦，鳥羽良明，
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前田明夫，松生　洽，松山優治，丸茂隆三，
三浦昭雄，村野正昭，森田良美，柳　哲雄，
山口征矢，和田　明，渡辺精一

〔参考〕　平成３年度学会賞受賞候補者推薦委員会委員
青木三郎，阿部友三郎，石野　誠，井上　實
落合正宏，鎌谷明善，高野健三，竹松　伸，
谷口　旭，中村重久，根本敬久，松生　洽，
村野正昭，柳　哲雄，山口征矢

日本学術会議だより　№19

「創薬基礎科学研究の推進について(勧告)」を採択

平成２年11月　日本学術会議広報委員会

日本学術会議は，去る10月17日から19日まで，第110回総会を開催しました。今回の日本学術会議だよりでは，その総会で採択された勧告等を中心に，同総会の議事内容等についてお知らせします。

日本学術会議第110回総会報告

日本学術会議第110回総会（第14期・第６回）は，平成２年10月17～19日の３日間開催された。

1　総会第１日目の冒頭に，先に逝去された，時永淑会員（第３部）及び大谷茂盛会員（第５部）を追悼して黙禱を捧げた。続いて，会長からの経過報告，各部・委員会報告の後，内規改正，勧告，対外報告の３案件の提案説明が行われた。これらの案件については，同日の午後の各部会での審議を経た上で，第２日目の午前中に審議・採択された。

2　今回総会で採択された事項は次のとおりである。

(1)日本学術会議の運営の細則に関する内規の一部改正

本件は，①来年春の第14期最後の総会が５月（通常は４月）開催になったことに伴い，「副会長世話担当研究連絡委員会の運営に関する総会決定」の適用期間を，１か月間延長するとともに，②第14期限りの措置として，地球圏ー生物圏国際協同研究計画(IGBP)のフォローアップ組織として，地理学研究連絡委員会に「IGBP専門委員会」を設置するために，関係各部等の研究連絡委員会委員定数について必要な処理を行ったものである。

(2)創薬基礎科学研究の推進について(勧告)

本件は，薬科学系の３研究連絡委員会と薬理学研究連絡委員会が従来からの検討結果を勧告案として取りまとめ，第７部提案として，今回総会に付議したものである（この勧告の詳細は，別掲参照)。この勧告は，同日午後直ちに内閣総理大臣に提出され，関係省庁に送付された。

(3)第６常置委員会報告ー外国人研究者・大学院留学生受入れに関する問題点と改善の方策についてー

本件は，第６常置委員会が，今期の重要課題の一つとして審議を重ねてきた結果を「対外報告」として取りまとめたものを，外部に発表することについて承認したものである（この報告の詳細は，別掲参照)。

3　以上の諸報告及び提案審議のほかに，特に，近藤会長から，前回総会で討議された南アフリカ共和国科学者の我が国入国をめぐる諸問題については，その後，外務省と折衝した結果，ビザ発給手続きの合理化措置が講じられ，国際学術連合会議(ICSU)の理解が得られたとの報告があった。また，提案事項採決後行われた自由討議では，大学等高等教育関係予算拡充問題，遺伝子操作に関する法規制問題等について意見交換が行われた。

4　第２日目午後には，「特別委員会審議状況報告に基づく意見交換」が開催された（この意見交換の詳細は，別掲参照)。また，第３日目の午前中には各特別委員会が，午後には各常置委員会がそれぞれ開催された。

創薬基礎科学研究の推進について(勧告)

(勧告本文)

優れた医薬の創製すなわち創薬の研究は，空前の老齢化社会を目前にして，健やかな長寿を目指す健康社会実現のため，さらには国際的立場から地球上の全人類の福祉に貢献するため，我が国にとって大きな意味を持つものである。特に，多くの成人病，老年病，またエイズやいわゆる難病等についての的確な予防薬・治療薬の創製が待望されている。しかしながら，これらの疾患に対する優れた医薬の創製は世界的にみて,医薬創製のよりどころとなるべき基礎理論,研究技術の発展が十分でないため遅々として進んでいない。

とりわけ我が国は先進国の一角を占めているとはいえ，大学，企業，公的研究機関共に，ひとつの疾患の予防・治療に変革をもたらし得るほどの画期的医薬創製の実績に乏しく，国の内外から研究態勢の遅れが指摘されている。とはいえ，最近のバイオサイエンス分野の急速な展開と，我が国科学者のこの方面での活躍の実績をみるならば，学際的な創薬基礎科学研究の推進を図り，これによって人類の福祉向上に貢献することは，現下の我が国にとって緊要の課題である。

このため，早急に創薬基礎科学研究の推進組織を設け，これを核とした強力かつ広範な研究態勢の確立を図るべきである。これに当たっては，医薬の創製における倫理の尊重を基本理念とし，生体機構及び病態の解析研究とそれに基づいた独創的・画期的医薬の創製を指向する分子設計並びに薬効・安全性評価の基礎理論の樹立，さらに薬効・安全性の測定技術・ヒトの病態のシミュレーション技術等，各種の新技術の開発研究を特に重視すべきである。

この研究推進組織の設置には，関係省庁が関与すると共に，地方自治体，大学及び民間の参画を可能とし，また，関連科学各分野の学際的なネットワークを構築するなど多次元的な協力と交流による研究の推進を図るため，格段の効果的措置を講じ得る形態とすべきである。

日本学術会議は，創薬基礎科学研究の推進を図るため，上記の趣旨に基づいて必要な施策を速やかに講ずるよう勧告する。

第6常置委員会報告－外国人研究者・大学院留学生受入れに関する問題点と改善の方策について－(要旨)

（平成2年10月18日　第110回総会承認）

外国人研究者・大学院留学生の受入れを促進するうえで，言語，研究環境，外国人研究者の任用，大学院留学生の学位，外国人研究者・大学院留学生の選考が問題になる。

日本語能力は研究の対象とする学問分野や研究課題との関係が留意されねばならない。分野によっては，日本語能力は日常生活に必要なもので足り，研究のためには英語の能力が必須である。研究者の受入れに当たり，その研究に耐え得る日本語又は英語の能力を備えているかを十分に審査しておくことが，研究を実りあるものとするために必要である。

貧弱な研究設備のまま，また十分な研究費を持たないままで外国人研究者を受け入れる事は受け入れた外国人研究者を失望させるだけでなく，日本人研究者の研究を阻害する。また劣悪な居住環境や，事務局等の対応組織の不備も，外国人研究者の研究活動を妨げる。国は，研究環境を整備することに対して十分な予算措置を講ずべきである。

我が国の大学における外国人研究者の任用は，その道が開かれているとはいえ，まだ十分でない。外国人研究者の任用に関して広く情報を提供する機関の設置，あるいは大学等において外国人研究者を一定数受け入れる体制の確立が望まれる。

大学院留学生の博士学位の取得は，帰国後の処遇と関係して問題となっている。受入れ大学院において，博士学位の取得促進につき一層の改善努力が払われることが期待される。

外国人研究者の選考については，受入れ側が研究者の素質をよく理解し，公正な基準によって行うことが大切である。大学院留学生については，素質の多様化と学生数の急増に伴い多くの問題が生じており，その選考方法に対し抜本的改善が要望される。

解剖学研究連絡委員会報告－日本における解剖学の教育と研究（現状の考察と将来への展望)－(要旨)

（平成2年9月21日　第758回運営審議会承認）

自然科学の急速な発展に伴い，医学部・医科大学における教育・研究・診療のすべての分野に，大きな変化が生じた。すなわち研究手法の開発，研究機器の発達により，既存の学問領域の進歩に加えて，新たな学問分野が分化し，教育内容は多様化すると共に著しく増大した。さらに人口の増加と高齢化，経済の成長など種々の社会的要因の変化も複合されて，医学における教育と研究の重点と目標にも変化が生じた。それらは，これまで医学の基礎を形成して来た伝統的な講座に，とりわけ強い影響を与え，その在り方について検討し，改善をはかる必要性を生じさせた。

本報告は，このような状況を踏まえ，我が国における解剖学の教育と研究について，現状を考察し，今後の在り方に関する指針をまとめたものである。報告では，解剖学の定義と使命，医学教育と研究における解剖学，解剖学教室の構成，解剖学者の養成，医学部他教室及び社会との関係などの，現状と問題点について検討し，医学の変貌に対処すべき改善の方途を明らかにすると共に，将来に向けての展望が示唆された。

総会中の「特別委員会審議状況報告に基づく意見交換」

今回総会の第2日目の午後には，1時から4時間にわたって「特別委員会審議状況報告に基づく意見交換」が行われた。従来この時間帯には，その時々の学術上の重要課題を取り上げて，会員による「自由討議」が行われてきた。今回は，これに代わり，第14期も2年余を経過し，余すところ9か月足らずとなったこの機会に，今期の当初に決定された第14期活動計画において，「緊急に調査審議を行って第14期中に適切な形で報告・提言を取りまとめるべき課題」ごとに設置された各特別委員会から，今までの審議状況を報告してもらい，それに基いて会員間の意見交換を行って，各特別委員会の今後の審議の参考に供することにしたものである。

1　まず最初に，医療技術と社会に関する特別委員会の水越治委員長（第7部）から，同委員会における「脳死をめぐる問題」に関する審議の経過を取りまとめた「中間まとめ」について報告がなされた後，「日本人の国民性に根ざした死の概念との関わり」,「臓器移植を必要とする患者と臓器提供者の需給関係の問題」,「死の認定基準のあり方」,「前期の学術会議における脳死問題に関する審議状況との関係」等について意見交換が行われた。

2　次に，農業・農村問題特別委員会の水間豊委員長（第6部）から，同委員会が今後取りまとめることを予定している「農業・農村のもつ今日的意義と課題(仮題)」の概要について報告がなされた後，「他の先進諸国の農業との比較の必要性」,「国内外の政治との関わり」,「世界の食糧問題に対する日本農業の果すべき役割」,「他産業を絡めた農業・農村の振興策」等について意見交換が行われた。

3　最後に，人間活動と地球環境に関する特別委員会の吉野正敏委員長（第4部）から，同委員会が現在取りまとめを行っている「人間活動と地球環境に関する日本学術会議の見解(案)」について報告がなされた後，「地球環境教育の重要性」,「国際学術協力事業等国際的対応のあり方」,「医学・保健問題との関わり」,「地球環境保全と経済成長との関係」,「南北問題との関わり」等について意見交換が行われた。

第15期日本学術会議会員選出のための登録学術団体の概況

本会議では，現在第15期（平成3年7月22日～平成6年7月21日）会員（定員210人）選出のための手続きが進められているが，先般6月末日を締切期限として，学術研究団体からの登録申請が受け付けられた。その後日本学術会議会員推薦管理会で審査が行われ，結果は次のとおりであった。

学術研究団体の登録申請の審査結果
　申請団体数……………… 952団体
　登録団体数……………… 915団体

※日本学術会議会員推薦管理会が登録した915団体名は，日本学術会議月報平成2年12月号に掲載されるので，御参照願いたい。

御意見・お問い合わせ等がありましたら，下記までお寄せください。
〒106 東京都港区六本木7-22-34
日本学術会議広報委員会　電話03(403)6291

日本学術会議だより　№20

公開講演会成功裡に開催さる

平成3年2月　日本学術会議広報委員会

日本学術会議は，例年どおり，平成2年度においても，主催の公開講演会を3回開催しました。今回の日本学術会議だよりでは，その講演会に加えて，本会議の国際的活動や最近公表された「委員会報告」などについてお知らせします。

平成2年度日本学術会議主催公開講演会

本会議は，本会議の会員が，学術の成果について広く市民と語り合う機会として，時宜にかなったテーマを選定して，毎年，公開講演会を開催している。本年度は，次の3回の講演会を開催したが，いずれも成功裡に終了した。

I　公開講演会「高度技術と市民生活」

標記講演会は，去る平成2年10月13日（土）13時30分～17時に，兵庫県加東郡社町の社町福祉センターホールで，約250人の聴講者を得て開催された。各演題と講師は，①「高齢化社会と高度技術」原沢道美（第7部会員，東京逓信病院院長），②「消費生活と高度技術」正田彬（第2部会員，上智大学教授），③「地域振興と人間主導型高度技術」竹内啓（第3部会員，東京大学教授）であった。

II　公開講演会「資源エネルギーと地球環境に関する展望」

標記講演会は，去る平成2年10月30日（火）13時～17時に，本会議講堂で，約330人の聴講者を得て開催された。各演題と講師は，①「人間と環境」大島康行（第4部会員，早稲田大学教授），②「エネルギーと環境」石井吉徳（第5部会員，東京大学教授），③「エネルギーと経済問題」則武保夫（第3部会員，立正大学教授），④「エネルギーとCO_2対策」上之園親佐（第5部会員，摂南大学教授）であった。

III　公開講演会「人間は21世紀を生きられるか」

標記講演会は，去る平成3年2月19日（火）13時30分～17時に，本会議講堂で約200人の聴講者を得て開催された。各演題と講師は，①「科学・技術・政策」杉本大一郎（第4部会員，東京大学教授），②「科学と人間－生存のための条件づくり」下山瑛二（第2部会員，大東文化大学教授），③「人間の適応能力とリスク」土屋健三郎（第7部会員，産業医科大学長）であった。

いずれの講演会も，時期にあった，関心の呼ぶ企画であったため，多くの聴講者が来場する盛会となり，また，各講師の講演後の質疑応答では，聴講者から活発な質問や意見の開陳がなされ，まさに市民との対話の感があり，極めて有意義であった。

なお，これらの講演会については，後日，「日学双書」として，（財）日本学術協力財団から出版される予定である。

平成2年度二国間学術交流事業

本会議では，二国間学術交流事業として，毎年2つの代表団を外国に派遣し，各訪問国の科学者等と学術上の諸問題について意見交換を行って，相互理解の促進を図る事業を行っている。

この事業は，昭和58年度から実施されており，これまで，アメリカ，マレイシア，西ドイツ，インドネシア，スウェーデン，タイ，フランス，大韓民国，連合王国，シンガポール，チェッコスロヴァキア，ポーランド，カナダ，イタリア，スイス及びインドの16か国に代表団を派遣してきた。

平成2年度には，①9月11日から22日まで，中華人民共和国へ，渡辺格副会長以下4名の会員等から成る代表団を，②9月17日から27日まで，オーストラリア及びニュー・ジーランドへ，大石泰彦副会長以下5名の会員等から成る代表団をそれぞれ派遣した。

中華人民共和国派遣代表団は，中国科学院，中国社会科学院，中国医学科学院，北京大学，西安交通大学，復旦大学など約20機関を訪問し，中華人民共和国の学術や今後の交流の推進策などについて会談，意見交換を行った。中華人民共和国側からは，すでに，日本の多くの大学，研究機関と交流を行っているが，さらに交流を拡大したいとの期待が表明され，両国間の今後のより積極的な交流・協力をめぐって活発な意見の交換が行われた。

オーストラリア及びニュー・ジーランド派遣代表団は，オーストラリアでは，オーストラリア科学アカデミー，オーストラリア国立大学，シドニー大学，連邦科学・産業研究機構など，ニュー・ジーランドでは，ニュー・ジーランド王立協会，マッセイ大学，ヴィクトリア大学，科学技術研究機構など，両国合わせて20を越える諸機関を訪問し，それぞれの国の学術，今後の交流の可能性などについて，会談，意見交換を行った。特に，両国では近年，国家，国民に実際に役立つ技術の発展を目指した科学技術の大きな改革が進められており，これらの問題等について，熱心に意見の交換が行われた。

今回の成果は，代表団派遣時だけのものではなく，今後のわが国の学術の国際交流・協力の進展に大きく役立つものと期待される。

平成３年(1991年)度共同主催国際会議

本会議は，国際的な活活の一環として，毎年，日本で開催される学術関係国際会議を関係学術研究団体と共同主催してきている。平成３年（1991年）度には，次の６件の国際会議を開催する。

■第21回国際農業経済学会議
開催期間　平成３年８月22日～29日
開催場所　京王プラザホテル（東京都新宿区）
参加者数　国外550人，国内950人，計1,500人
共催団体　日本農業経済学会外４学会

■国際医用物理・生体工学会議（第16回国際医用生体工学会議・第９回国際医学物理会議）
開催期間　平成３年７月７日～12日
開催場所　国立京都国際会館（京都市）
参加者数　国外1,000人，国内1,500人，計2,500人
共催団体　（社）日本エム・イー学会，日本医学物理学会

■国際純正・応用化学連合1991国際分析科学会議
開催期間　平成３年８月25日～31日
開催場所　日本コンベンションセンター（千葉市）
参加者数　国外500人，国内1,000人，計1,500人
共催団体　（社）日本分析化学会

■第22回国際シミュレーション＆ゲーミング学会総会
開催期間　平成３年７月15日～19日
開催場所　立命館大学，国立京都国際会館（京都市）
参加者数　国外170人，国内300人，計470人
共催団体　日本シミュレーション＆ゲーミング学会

■一般相対論に関する第６回マーセルグロスマン会議
開催期間　平成３年６月23日～29日
開催場所　国立京都国際会館（京都市）
参加者数　国外380人，国内170人、計550人
共催団体　（社）日本物理学会

■第22回国際動物行動学会議
開催期間　平成３年８月22日～29日
開催場所　大谷大学（京都市）
参加者数　国外400人，国内400人，計800人
共催団体　日本動物行動学会

経営学研究連絡委員会報告－経営学教育改善のために－（要旨）

（平成２年11月26日　第763回運営審議会承認）

企業環境の激変，就中技術革新，高度情報化，国際化等々の急進展に伴って，経営学教育は，大きく見直され，かつ新たな体系化と一層の内容の充実の必要性に迫られている。すなわち，学術的分野の広がり，国際化や情報化の急進展は，経営学の外延的拡大を要請し，また経営管理の高度化，複雑化および戦略的視点の重要性増加は，斯学の多面的な内容の充実強化を要求している。本報告は，かかる状況下において経営学教育の現状分析を行い，かつ(1)教育体系（とくにカリキュラム）の再編成と(2)教育方式の新たな在り方を探り，もって経営学に対する社会的ニーズへの即応と経営学教育の総合的な体系化への試みを展開したものである。とくに教育する側，される側両面での人材育成を強く念頭に置いて経営学教育改善の方途を示すとともに，大学院教育へのつながりを意識しながら将来への展望を示唆しようとしたものである。

統計学研究連絡委員会報告－統計学研究教育体制の整備のための具体的方策について（要旨）

（平成２年12月21日　第764回運営審議会承認）

現今，高度情報化の進展による情報資源の多激な蓄積にともない，統計的情報処理を適切に行える人材に対する社会的需要が著しく高まっている。現在米国では60を超える大学に統計学科が存在するのに対し，我が国では統計学関連の大学院専攻はただ一つあるのみである。最近の学術研究における，調査，実験，観測等の活動の急速な増大を考慮するとき，データ有効利用の学としての統計学の研究教育体制の不備は，我が国の学術研究の将来に対し，国際的に見て著しく不利な状況を生み出しつつある。

本報告では，統計学を一つの専門分野として狭く把える従来の考え方を避け，本来学際的な性格を持つ統計学研究の実態に即して，諸科学との関連をより重視する統計科学の概念を確立し，広範な関連分野の研究者の協力により統計科学研究所あるいは専攻等を設立することの推進を提案する。この提案を具体化することにより，国際的に見ても先進的な統計学研究教育体制を実現することが可能になるものと期待される。

実験動物研究連絡委員会報告－動物実験を支援する人材育成について－（要旨）

（平成２年12月21日　第764回運営審議会承認）

医学，生物学領域において，動物を用いた実験研究が先導的な形で寄与し，社会に貢献してきたことの意義は大きい。遺伝子・分子・細胞の各レベルにおける研究成果を総合して個体の生物機能・生理現像を理解し，病的現象に適確な対応を計るために，個体レベルの研究，すわわち，動物実験による研究の必要性はますます増加し，多種類かつ高品質の動物が精細な計画・技術のもとで実験に供されるようになった。以上の観点から動物実験を取り囲む現状を詳しく検討した結果，動物実験の高度化・多様化に対応できる，専門的知識と技術を習得した技術者の数が著しく不足していることを強く認識するに至った。

本報告は，このような現状に対する改善の方向を明らかにするとともに，バイオサイエンス研究支援体制を一層整備するための方策として，特に動物実験技術者の教育機関の設立を中心に，技術の審査・認定制度の確立，技術者の採用制度の検討，身分・処遇保障等についての将来展望を示唆するものである。

日学双書の刊行案内

日本学術会議主催公開講演会の記録をもとに編集された次の日学双書が刊行されました。

・日学双書No.10「くらしと学問の近未来」
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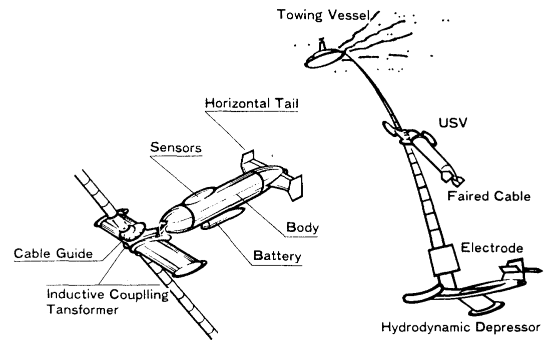
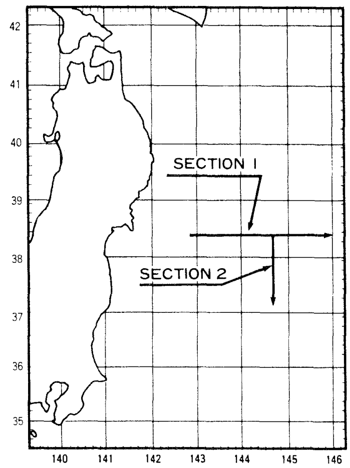
スライド式高速曳航体 JAMSTEC TSK方式

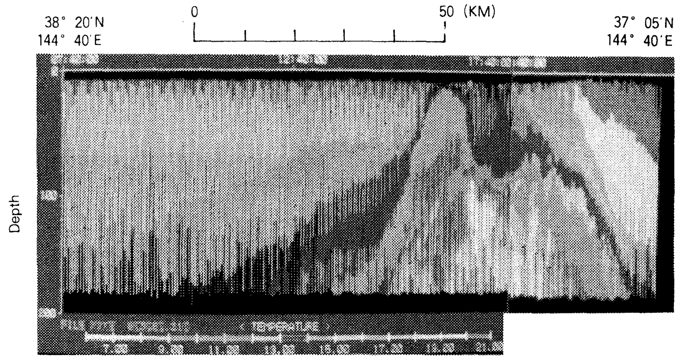
Underwater Sliding Vehicle System (USV)

○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

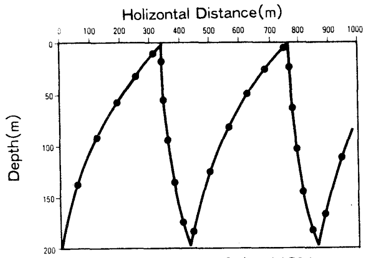




T.Sスライド式高速曳航体によって得られた三陸沖の水温鉛直分布のカラー画像。
(海洋科学技術センター殿から資料を御提供頂きました。)

SPECIFICATIONS

Towing Speed	:0～8knots	
Operation Dapth	:Max.400m	
Tow Cable	:8㎜ hydrodynamically fared stainless steel wire rope with polyurethane coating	
Sensor	Range	Accuracy
Conductivity	20～70ms	±0.05ms
Temperatune	−2～35℃	±0.05℃
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

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