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Binary fission patterns of heterotrophic nano-flagellates, *Actinomonas mirabilis* Kent and *Cafeteria roenbergensis* Fenchel and Patterson, observed with a CCD camera

Tetsuji ISHIGAKI*,† and Makoto TERAZAKI*

Abstract: Patterns of binary fission of the heterotrophic nano-flagellates *Actinomonas mirabilis* and *Cafeteria roenbergensis*, which were isolated by a stepwise dilution method from the water taken in inner part of Tokyo Bay, Japan, were recorded with a microscopic CCD camera. By analysis of the video records, the entire course of the fission could be divided into 7 phases for *Actinomonas* and 6 phases for *Cafeteria*. *Actinomonas* performed a longitudinal binary fission in 10–20minutes, whereas *Cafeteria* performed an apparently transverse binary fission in 5–10 minutes.

1. Introduction

Heterotrophic nano-flagellates (HNF) have been recognized as bacterial feeders and play an important role in marine habitats (e.g. AZAM *et al*., 1983; GOLDMAN *et al*., 1985; CARON *et al*., 1985; ECCLESTON-PARRY and LEADBEATER, 1995). Therefore, studies have been carried out in order to estimate their quantitative impact on energy flow in microbial food webs, for example, measurement of their growth (FENCHEL, 1982) and grazing rate (SHERR *et al*., 1987; NYGAARD *et al*., 1988; NYGAARD and HESSEN, 1990). These studies, however, treated HNF as a group without paying attention to species compostion. Such studies assume that the modes, frequency and time duration of grazing and fission of the HNF assemblages are homogeneous, but it is not clear that they are. We observed the grazing pattern of *Actinomonas mirabilis* Kent and *Cafeteria roenbergensis* Fenchel and Patterson (ISHIGAKI and TERAZAKI, 1998). The doubling time for both species at 20℃ was about 2 hours (unpublished data). We consider that correct information about these physiological rates is necessary to determine adequate sampling design to investigate the ecology of the assemblages.

In this paper, we repoort the modes and time duration of binary fission in two HNF, *Actinomonas* and *Cafeteria* determined using a microscopic VTR system.

2. Material and method

HNF were isolated in March 1994 from water collected from the landing stage at the Tokyo University of Fisheries, located at the inner part of Tokyo Bay, using a stepwise dilution method. Two species of HNF, *Actinomonas mirabilis* Kent and *Cafeteria roenbergensis* Fenchel and Patterson (Fig. 1), were established in rice grain culture, where they fed on bacteria derived from the original seawater. Stock cultures were subcultured with fresh rice grains once per month and maintained at 20℃ at a salinity of 36 psu in the dark.

These flagellates were injected into a spermatozoon counting chamber (Sefi-madical Instruments, Haifa, Israel: MAKLER COUNTING CHAMBER) which has a depth of 10 μm between cover-slip and slide-glass. This chamber was placed under an inverted phase contrast microscope (Nikon Diaphot 300, 12V 100W Halogen Lamp, Tokyo, Japan) equipped wiht a

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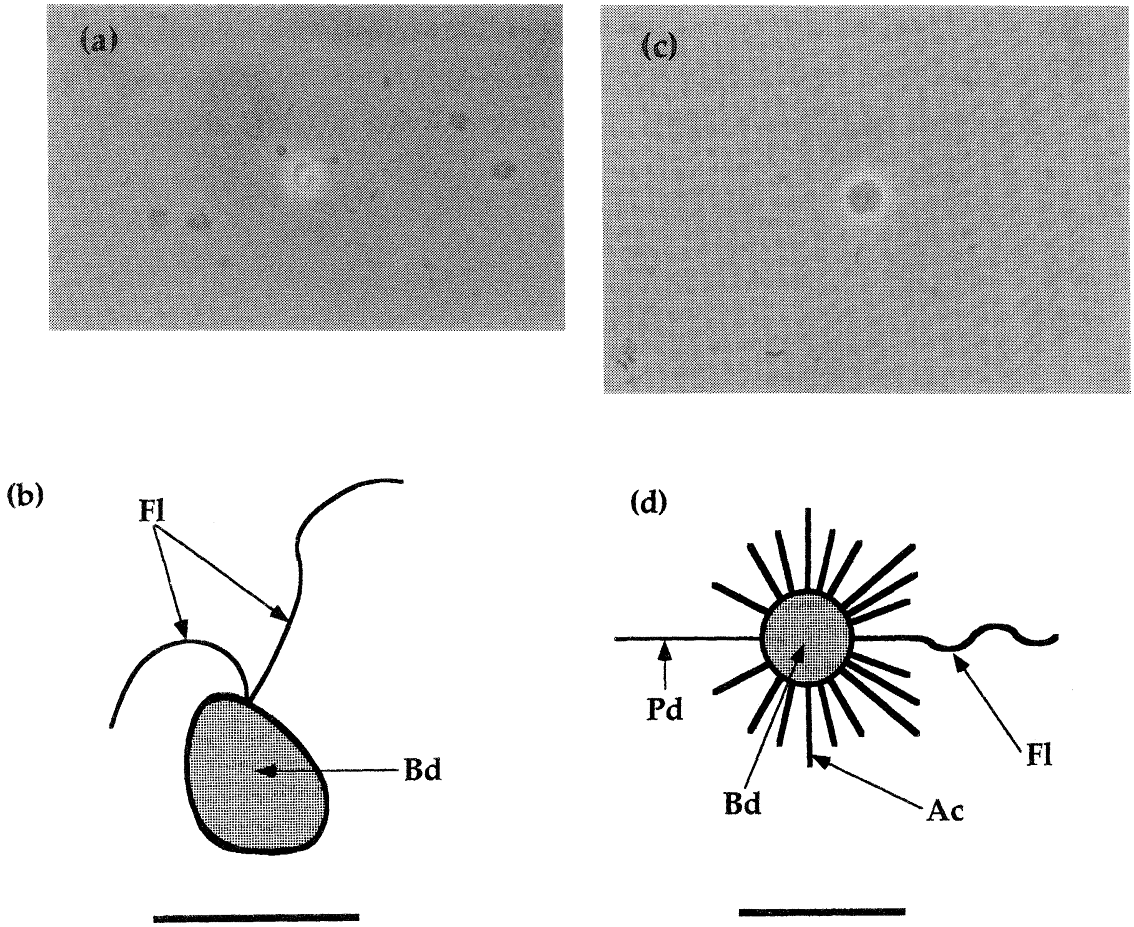

Fig. 1. *Cafeteria roenbergensis* Fenchel and Patterson (a), (b) and *Actinomonas mirabilis* Kent (c), (d). Phase contrast micrograph of living cell (a), (c) and schematic diagram (b), (d). Bars indicate 5 μm for (a), (b), and 10 μm for (c), (d). Ac: Actinopodia. Bd: Body. Fl: Flagella. Pd: Pedicel.

CCD camera (Nikon, Tokyo, Japan). The microscope was installed in an incubator box (TLTG-200 Low temperature incubator gloves box, Technica Co. Ltd., Tokyo, Japan). Binary fission of the cells at the early exponential growth phase of *Actinomonas* and *Cafeteria* which had been incubated at 20 ℃ and 36 psu was recorded by VTR (Victor, HR-V3, Tokyo, Japan). The records were made at 17 $\pm$0.3 ℃ in the incubator box, and no specimen was observed for longer than 30 minutes since the surface temperature of the chamber could increase by 3 ℃ in 30 minutes. A new sample was placed in the chamber every 30 minutes, and samples from the same culture were observed throughout a period of 24 hours. During each observation, if a flagellate moved, the stage of the microscope was moved to bring it back to the centre of the field.

3. Results

The continuous process of binary fission of *Actinomonas* cells was divided into 7 phases as follows. Phase 1: two short flagella were observed in all dividing cells and appeared one on each side of the basal portion of the mother flagellum (Fig. 2 ①). Phase 2: daughter flagella extend in length and the mother cell body expanded (Fig. 2 ②). Phase 3: the mother flagellum stopped moving, shrank to the body and was absorbed into or was divided from the body, and daughter flagella extend to a length equal to 1.5 times the cell body length (Fig. 2 ③). Phase 4: the mother cell body became narrow in the middle (Fig. 2 ④). Phase 5: the part between the daughter cell bodies was gradually stretched forming a bridge (Fig. 2 ⑤). Phase 6: this bridge extended and became thread-like (Fig. 2 ⑥). Phase 7: the mother cell separated into two daughter cells (Fig. 2⑦). This binary fission pattern was longitudinal and was observed in 25 examples of *Actinomonas*. The time duration required from phase 3 to 7 of the fission in *Actinomonas* was about 20 minutes maximally, and about 10 minutes minimally. All cells which subsequently divided first developed the two new short flagella on both sides of the basal portion of the mother flagellum. However, some cells on which the two new flagella appeared on both sides of the mother flagellum did not proceed to divide into two cells, and their two new flagella shrank and disappeared without division of the cell.

In contrast, the binary fission pattern of *Cafeteria* was divided into 6 phases. Phase 1: the movement of the long flagellum stopped (Fig. 3①). Phase 2: the cell body elongated (Fig. 3②). Phase 3: the part between anterior (daughter cell) and posterior (mother cell) hemisphere cell became constricted, and a pair of new flagella appeared at the opposite end of the cell, on the future daughter cell (Fig. 3③). The new flagella were diagonally symmetric around the centre of cell body with respect to the mother flagella. Phase 4: the distance between the mother cell and daughter cell was gradually increased and bridged as occurred in *Actinomonas* (Fig. 3④). Phase 5: this bridge extended to become thread-like (Fig. 3⑤). Phase 6: the cell finally separated (Fig. 3⑥). This binary fission pattern is seemed to transverse and was observed in 13 samples. The time duration required from phase 2 to 6 of the fission in *Cafeteria* was maximally about 10 minutes and minimally about 5 minutes. During binary fission, *Actinomonas* and *Cafeteria* always stopped swimming and held their body stationary on the glass surface by using actinopodia or the short flagellum.

4. Discussion

Protists are unicelluar and have asexual and sexual modes of reproduction (e.g. FARMER, 1980). This study concerned asexual reproduction and involved the observation of binary fission. Cell binary fission is divided into three types depending on the plane in which fission occurs; these are longitudinal, transverse and oblique (or pseudo-transverse) binary fission. Flagellates divide almost exclusively by longitudinal binary fission (FARMER, 1980: LAYBOURN-PARRY, 1984). The binary fission pattern of *Pteridomonas*, which is very similar to *Actinomonas* , shows the same fission pattern as found for *Actinomonas* (PATTERSON and FENCHEL, 1985). The shortening of the original mother tinsel flagellum is consistent with the view that each new basal body forms first an anterior tinsel flagellum and in the daughter cell a former anterior basal body becomes a posterior basal body (SLEIGH, 1988). Before cell division each basal body replicates and two new long tinsel flagella would be expected to appear on the two new anterior basal bodies. In our observations, *Actinomonas* divided by longtitudinal binary fission. *Cafeteria* showed transverse-like binary fission. We did not observe that daughter cell receives one old flagellum and newly formed flagellum during cell division in this case. For this we consider that it is necessary more clearly to observe fission pattern of *Cafeteria*.

It was observed that a sign for binary fission of *Actinomonas* was the appearance of two new short flagella on both sides of the basal portion of the mother flagellum. However, this was not observed as a clear sign for binary fission of *Cafeteria* (Figs. 2, 3). For *Actinomonas* , in all dividing cell the new short flagella appeared, however, all the cell in which the new two flagella appeared did not divide. Cell division of protists is attribute to their cell cycle. The appearance of the new short flagella was recognized a state of preparation for binary fission.

In the future, it is necessary to observe the life cycle for *Actinomonas* and *Cafeteria* and also to analyse the relationship between fission

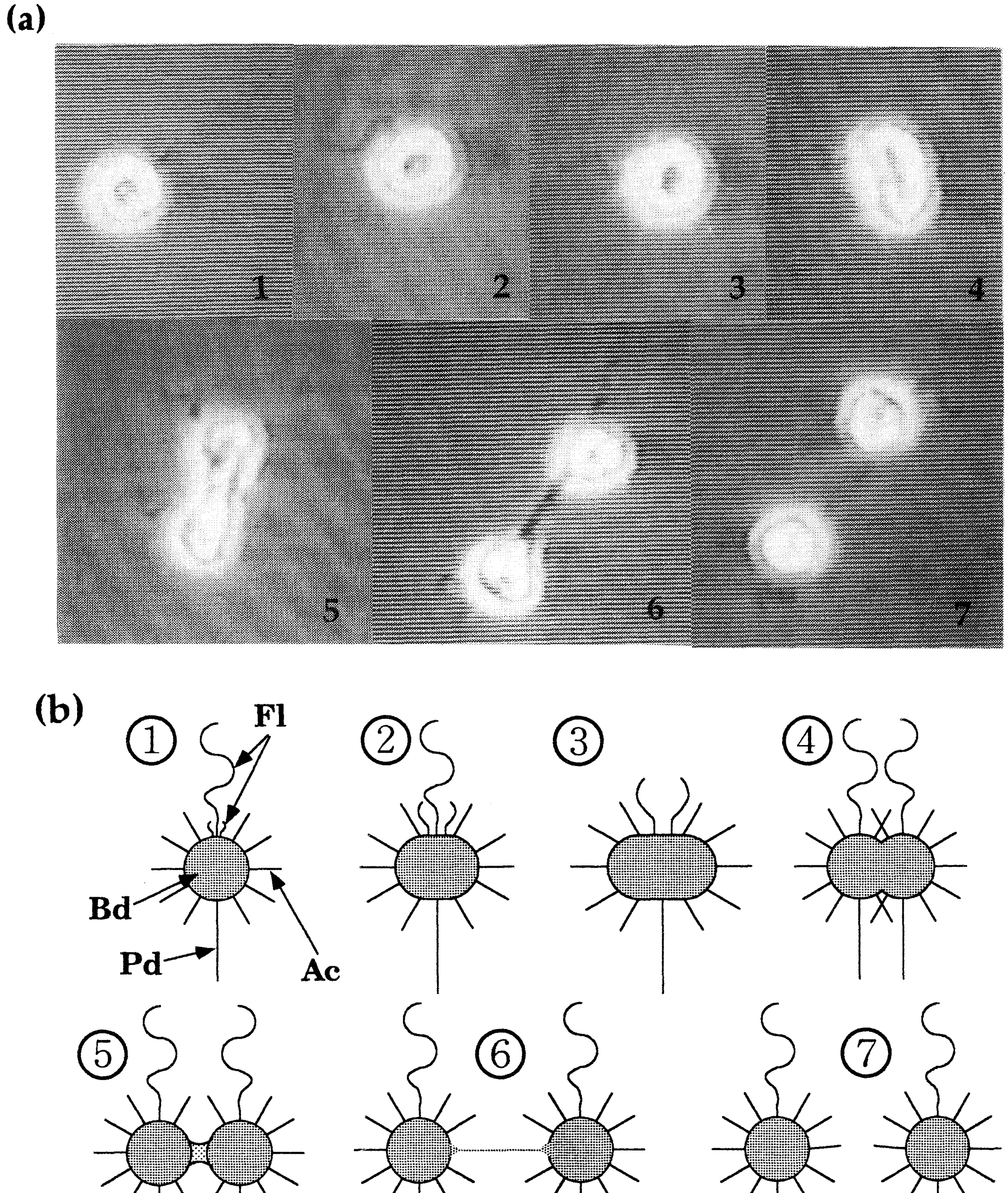

Fig. 2. Fission pattern of *Actinomonas* . (a): photograph from video tape. (b): schematic diagram. Numbers correspond to the phases described in the text. Abbreviations follow Fig. 1.

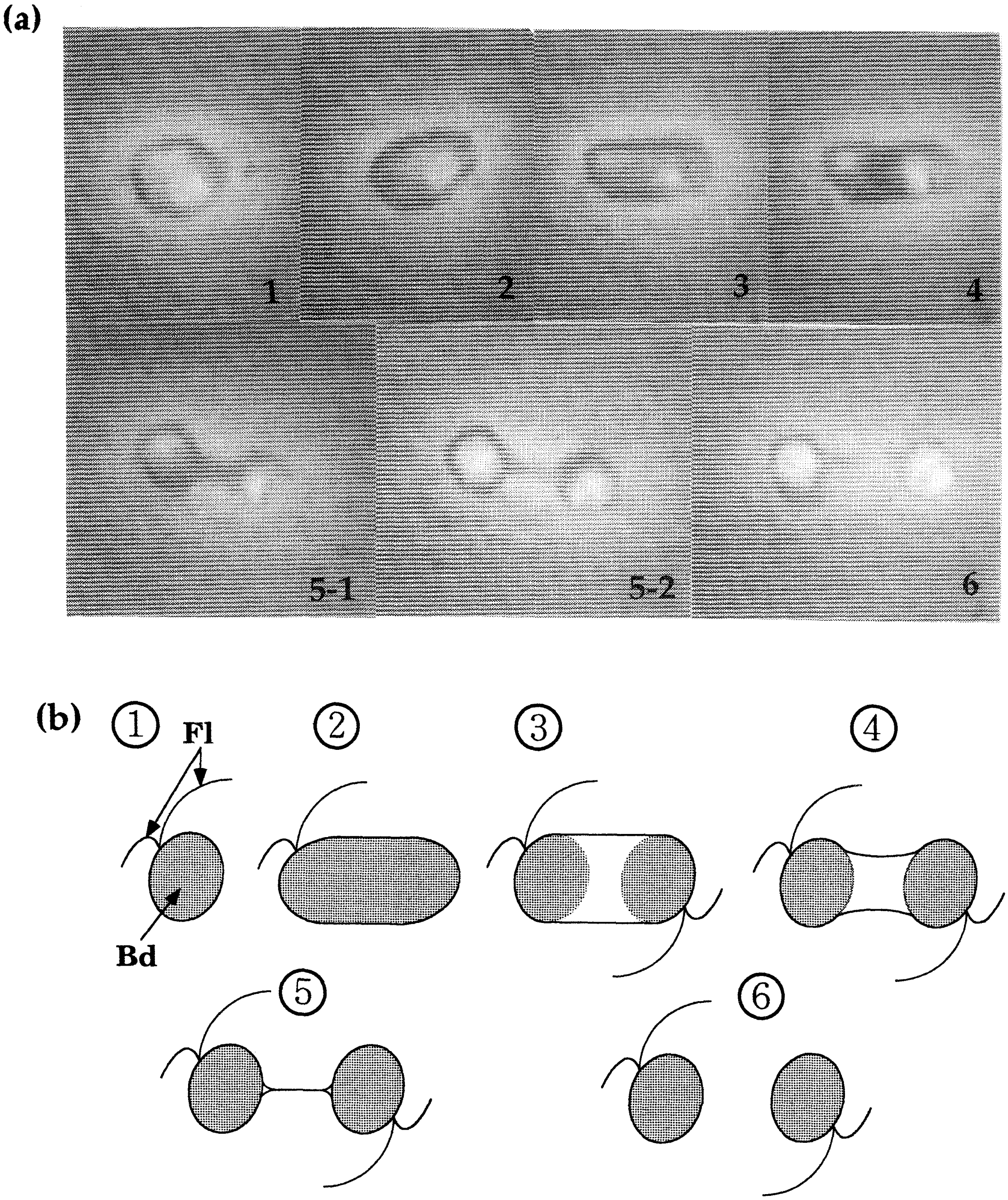

Fig. 3. Fission pattern of *Cafeteria*. (a): photograph from video tape. (b): schematic diagram. Numbers correspond to the phases described in the text. Abbreviations follow Fig. 1.

and natured environmental conditions.

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Numerical experiments of inertial oscillations in the Kuroshio, west of Okinawa

Kye-Young KIM* and Jong Yul CHUNG*

Abstract: NAKAJIMA *et al.* (1994) reported that inertial oscillations were generated in the Kuroshio, west of Okinawa by the typhoon in August and September, 1990 and that they were found at the underlying region of the Kuroshio as well as the surface Ekman layer. To simulate observed inertial currents and to investigate the main factors controlling the temporal and spatial structures of inertial oscillations, numerical modelings with ideal and real wind forcing were carried out, separately. According to the numerical results of ideal forcing, inertial oscillations are mainly controlled by the temporal variation of wind and mean flow. As the mean flow becomes stronger, inertial oscillations tend to be weakened. Temporal variation of the wind is very important as well because it is closely related with addition or removal of momentum generated by surface stress. In addition, the way of representing the turbulent process is important in simulation of inertial oscillations.

Numerical results with real wind forcing showed discrepancy with the observed inertial currents (NAKAJIMA *et al.*, 1994). Compared with the observed results, it has small amplitudes of inertial currents and large phase differences. This inconsistency seems to be derived from the various factors such as stratification, mean flow, wind data and characteristics of numerical model. It also suggests that simulation of the vertical structure of inertial oscillations is impractical.

1. Introduction

Inertial oscillations have been widely observed in the ocean and they are known to be produced by sudden changes of the surface wind stress associated with the local wind field, passage of a hurricane, sea breeze and interaction of the barotropic tide with bottom topography (CHEN *et al*, 1996). The wind-generated inertial oscillations are observed to be intensified near the surface and reduced as the mixed layer deeper (GILL, 1982). They transfer kinetic energy downward and make the mixed layer deepen (MELLOR and DURBIN, 1975 ; KLEIN, 1980 ; MARTIN, 1985 ; SHAY *et al.*, 1992 ; TROWBRIGE, 1992). Sometimes, the inertial energy can oscillate the deep water through the thermocline (KROLL, 1975 ; NOWLIN *et al.*, 1986; NAKAJIMA *et al.*, 1994).

To examine the factors determining temporal and spatial structures of inertial oscillations, numerical modelings have been performed by several investigators. Using one-dimensional model, POLLARD (1970) generated inertial waves by winds. He suggested that the amount of energy put into inertial oscillation is nearly independent of the stratification and of the horizontal scale of the wind but is strongly influenced by the temporal variation of the wind. Also, he pointed out that the changes in the wind field are very important in both generating and destroying inertial oscillations. KLEIN (1980) simulated the deepening of the mixed layer generated by inertial oscillations and reported that the thermal and dynamic structure of the marine upper layers are affected by the periodicity of the wind sequences as well as the wind forcing. Similarly, CHEN *et al.* (1996) related the generation of inertial oscillations with the temporal variation of the surface wind stress. They reported that a simple mixed layer model, when the downward transfer of the near-inertial energy to the deep stratified layer is small, shows agreement with the near-inertial currents in the mixed layer.

On the contrary, according to the results of

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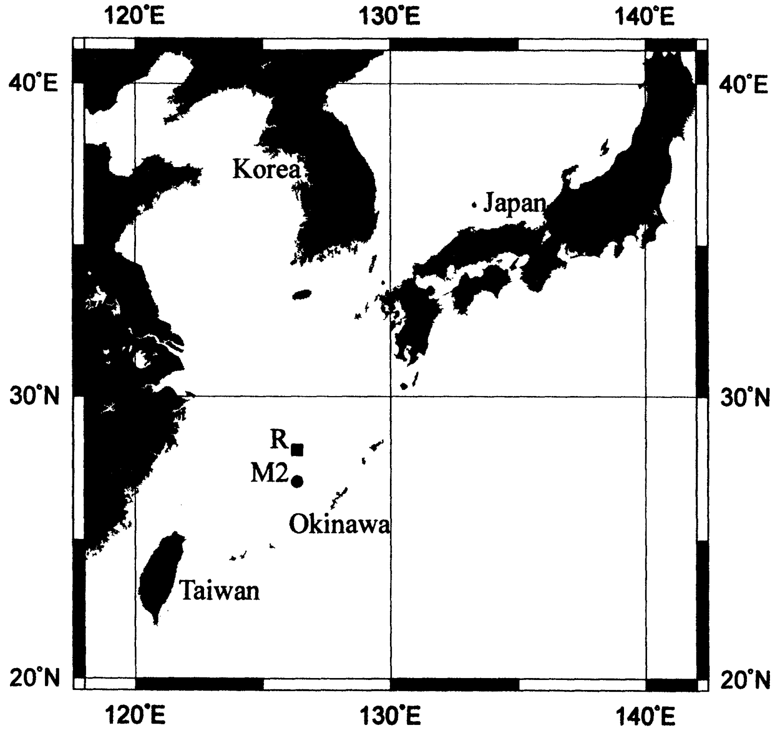

Fig. 1. Locations of the ADCP mooring (M2) and JMA buoy (R) (NAKAJIMA *et al.*, 1994). The location of M2 is 27°04′ N, 126°21′ E and that of R is 28°10′ N, 126°20′ E. The depth of station M2 is about 1500 m and the depth of the moored ADCP is 398 m in August and September, 1990. The sampling interval of M2 is 30 minutes and it was recorded at 16 m intervals. The wind at R was measured at 8 m height above the sea surface every 3 hours.

two-dimensional numerical model in a recent paper (CHEN and XIE, 1997), the cross-self gradient of surface elevation and the vertical gradient of Reynolds stress control the inertial oscillations. While the temporal and spatial structures of inertial oscillations in the open ocean depend on the local wind field, thickness of the mixed layer and vertical stratification, they are constrained by the coastline and are modified due to the bottom topography in the coastal region (CHEN *et al.*, 1996).

Recent studies about inertial oscillation in the Kuroshio mainly introduced their generations by typhoons (TAIRA *et al.*, 1993; NAKAJIMA *et al.*, 1994; TAKANO *et al.*, 1994; MAEDA *et al.*, 1996). Especially, NAKAJIMA *et al.* (1994) analyzed one-year term moored ADCP data obtained in the Kuroshio west of Okinawa and explained inertial oscillations in relation with the wind data of Japan Meteorology Agency (JMA) buoy robot (Fig. 1). They reported that strong inertial oscillations were observed not only in the surface Ekman layer but also in the underlying region of the Kuroshio during the typhoon period and that they were also accompanied by significant reduction of the Kuroshio energy at the surface layer.

The purpose of this study is to examine the important factors mentioned above for the generation of inertial oscillations using a numerical model and to simulate the inertial oscillations with the observed values of NAKAJIMA *et al.* (1994)

2. Numerical Model

The model used in this study is the Princeton Ocean Model (POM) developed by BLUMBERG and MELLOR (1987). It uses a sigma coordinate

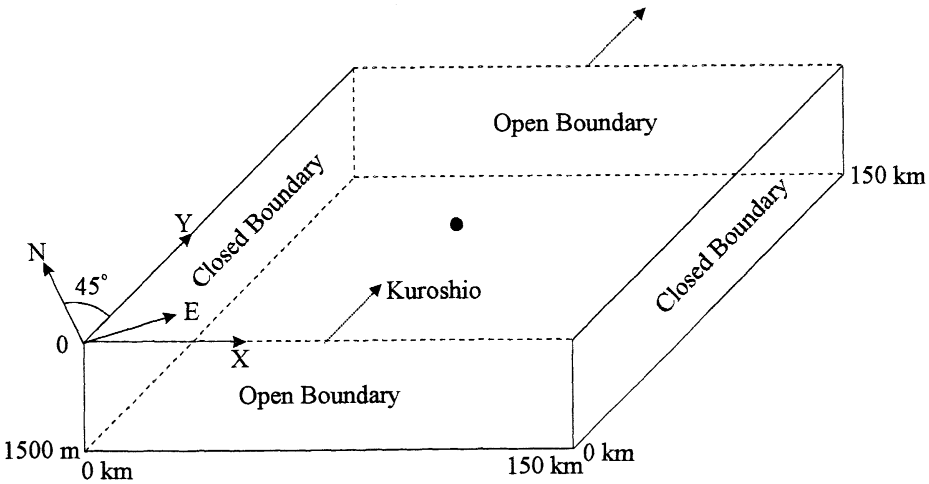

Fig. 2. Schematic of the structure of the numerical model; The solid circle indicates the location of computed velocities shown in Fig. 5 and 6.

in the vertical direction and a Cartesian coordinate in the horizontal directions. It has a "mode splitting" technique to calculate the external mode and internal mode separately.

The model consists of the continuity, momentum, hydrostatic, temperature and density equations :

$$u_x+v_y+w_z=0 \quad (1)$$

$$u_t+uu_x+vu_y+wu_z-fv = -p_0^{-1}p_x+(K_M u_z)_z+F^u, \quad (2)$$

$$v_t+uv_x+vv_y+wv_z+fu = -p_0^{-1}p_y+(K_M v_z)_z+F^v, \quad (3)$$

$$pg=-p_z, \quad (4)$$

$$T_t+uT_x+vT_y+wT_z=(K_H T_z)_z+F^T, \quad (5)$$

$$S_t+uS_x+vS_y+wS_z=(K_H S_z)_z+F^S, \quad (6)$$

$$p=p(T,S) \quad (7)$$

Where (u, v, w) are the velocity components in the (x, y, z) directions, respectively; P is the pressure; T is the temperature; S is the salinity; p is *in situ* density; p_0(=constant) is the reference density; f is the Coriolis parameter; g is the gravitational acceleration; K_M is the vertical eddy viscosity; K_H is the vertical eddy diffusivity; $F^{(u,v)}$ is the horizontal eddy friction terms; and $F^{(T,S)}$ is the horizontal eddy diffusion terms. The equations of (1)-(6) are transformed into the sigma coordinate system defined by $\sigma=(z-\eta)/(H+\eta)$, where η and H are the surface elevation and the water depth, respectively.

The horizontal viscosity coefficient A_M and A_H are set to 500 m^2/s and the vertical eddy viscosity and diffusion coefficients are calculated from the level 2.5 turbulent kinetic energy closure (MELLOR and YAMADA, 1982). For simplicity, frictional coefficients are assumed to be constant in time; $C_z=0.0025$.

The model domain is a rectangular basin of constant depth 1500 m, of which x and y-axis are 45° rotated clockwise from the north (Fig. 2). The northern and southern boundaries are opened to consider the Kuroshio. The grid spacing is 5 km at the x and y-direction, respectively and it has a distance of 150 km and a width of 150 km. To compare with the ADCP observations described by NAKAJIMA *et al.* (1994), $\Delta\sigma=0.011$ of vertical spacing is used above 395 m and $\Delta\sigma=0.033$ was used between 395 m and 1500 m (49 points in the vertical). According to the typical CFL condition given by BLUMBERG and MELLOR (1987), the external time step used in this study is 12 seconds and the internal time step is 180 seconds.

The numerical experiments were run with ideal and real wind forcing, separately. In case of ideal wind forcing (Table 1), the basic distribution of temperature was given by a simple equation (Fig. 3a),

$$T=5.0+25.0\times e^{H/350} \quad (8)$$

Table 1. Summary of the numerical experiments in case of ideal wing forcing ; T, temperature ; K_M, vertical eddy viscosity ; K_H, vertical eddy diffusivity ; W_S, wind speed in Eq. 9 ; W_d, direction of wind blowing ; V_{mean}, mean flow in the v-direction ; ΔT, internal time step : M-Y, level 2.5 turbulent kinetic energy closure (MELLOR and YAMADA, 1982),

Experiment	T (℃)	K_M and K_H	W_S (m/sec)	W_d	V_{mean} (m/sec)	ΔT (sec)	Description
1	Eq. 8	M-Y	20	South	0.0	180	Basic case
2	20	M-Y	20	South	0.0	180	Homogeneous
3	Eq. 8	M-Y	20	South	0.0	180	Weak stratified (T=5.0+12.5x$e^{H/350}$)
4	Eq. 8	0.001	20	South	0.0	180	K_M=K_H=0.001m^2/s
5	Eq. 8	0.01	20	South	0.0	180	K_M=K_H=0.01m^2/s
6	Eq. 8	M-Y	30	South	0.0	180	Strong Wind
7	Eq. 8	M-Y	20	West	0.0	180	Constant wind
8	Eq. 8	M-Y	20	West	0.0	180	Different direction of wind blowing
9	Eq. 8	M-Y	20	South	0.1	180	Mean flow of 0.1 m/s
10	Eq. 8	M-Y	20	South	0.2	180	Mean flow of 0.2 m/s
11	Eq. 8	M-Y	20	West	0.2	180	Experiment 8+Mean flow of 0.2 m/sec
12	Eq. 8	M-Y	20	South	0.0	540	Large internal time step

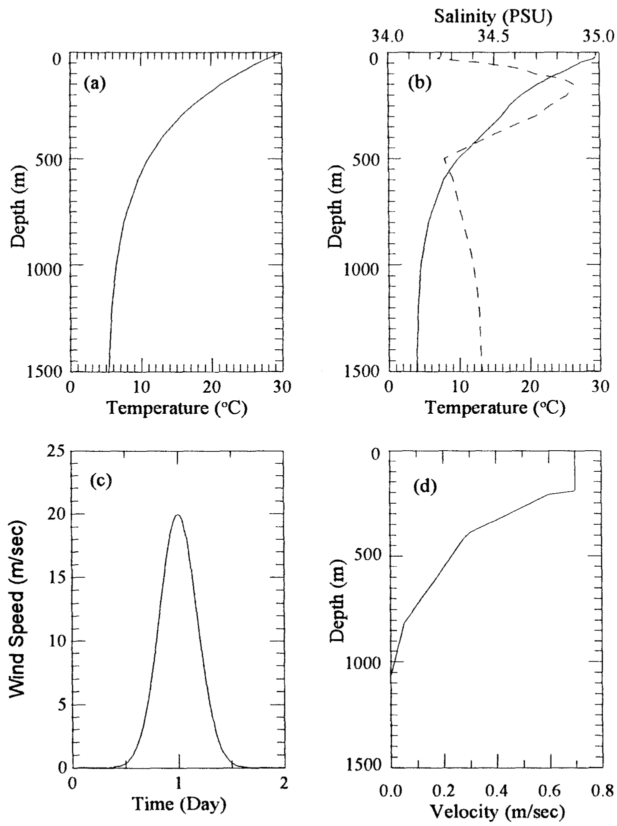

Fig. 3. Initial distribution of (a) temperature in case of ideal wind forcing, (b) temperature (thick line) and salinity (dashed line) in case of real wind forcing, (c) ideal wind speed (d) mean flow in the direction of Kuroshio in case of real wind forcing.

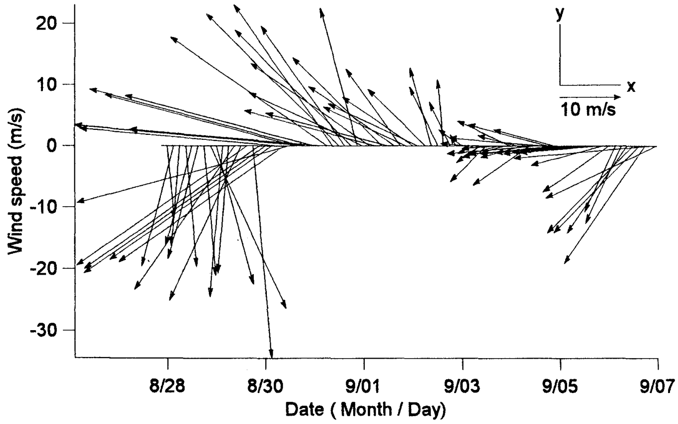

Fig. 4. Wind vectors of a JMA buoy robot (No.22001) at R station in Fig. 1 during August 28 to September 7, 1990 when the typhoon T9015 passed the site.

where H is the water depth and salinity was set to 35 psu. On the contrary, in case of real wind forcing, the initial distribution of temperature and salinity was given by a vertical profile of observed data from NODC oceanographic database. The sampling location is 27° 00′ 00″ N, 126° 22′ 59″ E and the sampling date is July 28, 1990 (Fig. 3b).

In case of ideal wind forcing, the form of Gaussian function is used (CHEN and XIE, 1997), i.e.,

$$W = W_S e^{-\frac{(t-a)^2}{b^2}} \tag{9}$$

where W_S is the amplitude of the wind velocity, a is a time of the maximum wind and b is the e-folding time scale. In our experiments, a was taken as 24 hours and b was 6 hours (Fig. 3c). The data of real wind was taken from a buoy robot (No. 22001) of the JMA during the same period of the ADCP mooring (Fig. 4).

For most of the experiments, free radiation condition was used, while the external and internal velocities were specified at the open boundaries in some cases (Table. 1). In case of real wind forcing, the flow field of Kuroshio was taken from the velocity distribution during autumn in 1991 (YUAN *et al.*, 1994) and it was imposed at the open boundaries (Fig. 3d).

According to NAKAJIMA *et al.* (1994), the inertial period at the station M2 is 26.3 h and hence, to compare with the ADCP observations, the band-passed filter admitting periods between 25 and 30 hours was used in calculating inertial currents. After the wind blowing stopped (Fig. 3c), the model was run for 5 days in cases of ideal wind forcing. for real wind forcing, the model was run for 10 days except the spin-up time.

3. Model Results and Discussion

Numerical experiments of ideal wind forcing were carried out to study the dependence of the response on stratification, vertical eddy viscosity and diffusivity, wind speed, wind direction, mean current and numerical time step (Table 1).

The effect of stratification was examined by stratified and homogeneous cases. Experiment 1 (Fig. 5a) shows the basic case of model response to the wind stress, caused by the wind pattern of Fig. 3c. The amplitudes of the inertial currents at the upper layer above 50 m were greater than 0.3 m/s and it gradually decreased when water depth increased. On the contrary, in homogeneous case, near-inertial currents are very weak and they decayed rapidly after the wind stopped (Fig. 5b). In addition, the oscillations in the upper layer were almost in phase with the lower layer, while they were 180° out of phase in stratified case (Fig. 5a). The effect of reduced stratification is shown in Fig. 5c and it seems that the downward transfer of energy from the upper layer

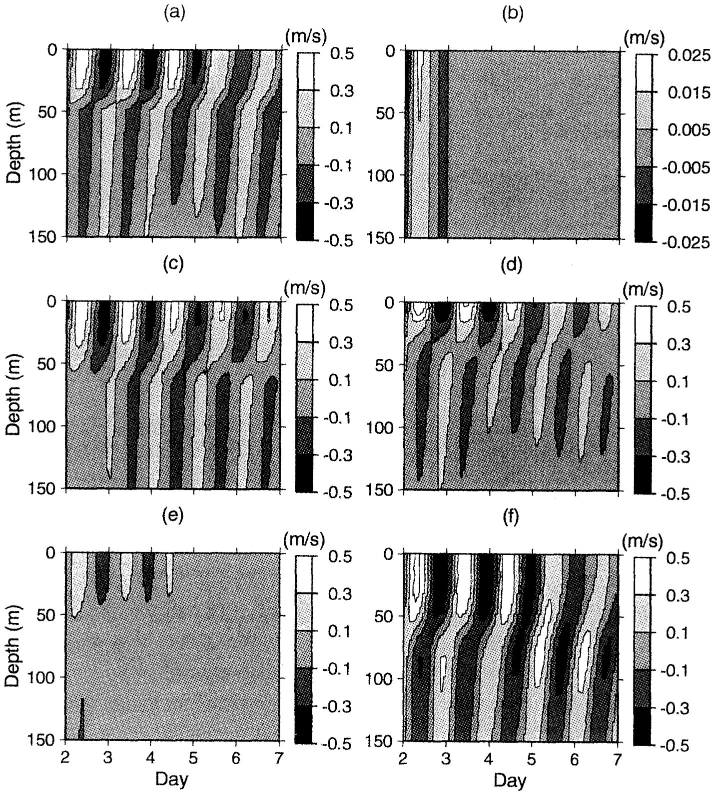

Fig. 5. Time series of the band-passed inertial currents at the surface layer of Fig. 2 from (a) experiment 1 with a basic stratified case, (b) experiment 2 with a homogeneous case, (c) experiment 3 with a weak stratified case, (d) experiment 4 with $K_M=K_H=0.001$ m^2/s, (e) experiment 5 with $K_M=K_H=0.01 m^2/s$, and (f) experiment 6 with strong wind. The contour represents the v-velocity.

was more active than that of experiment 1. It coincides with the result of POLLARD (1970) that the stratification controlled the rate at which energy at near-inertial frequencies dispersed downwards out of the forced layer.

Experiment 4 and 5 shows the effects of different parameters for vertical eddy viscosity and diffusivity. According to the result of experiment 4 with constant vertical eddy viscosity and diffusivity, $K_M=K_H=0.001$ m^2/s, sharp gradients of inertial currents appear at the upper layer and rapidly decay as time goes on (Fig. 5d). Velocities of experiment 4 are stronger than those of experiment 1 during only few hours after wind had stopped. On the other hand, in experiment 5 with $K_M=K_H=0.01$ m^2/s, inertial oscillations are very weak (Fig. 5e). ALLEN *et al.* (1995), in the numerical simulation of the upwelling circulation at Oregon continental shelf with different parameterizations for vertical eddy viscosity and diffusivity, pointed out that the across-shelf circulation with constant coefficients differs considerably from that in the basic case with the MELLOR-YAMADA level 2.5 closure. Similarly, our results of experiment 4 and 5 show the importance of the particular representation of turbulent processes used in the model and it implies that the simulation of inertial currents with real wind field can be very difficult.

Effects of different wind speed and duration are shown in Fig. 5f and 5g. In experiment 6 of the strong wind case, the inertial velocities are stronger than those of experiment 1 and the

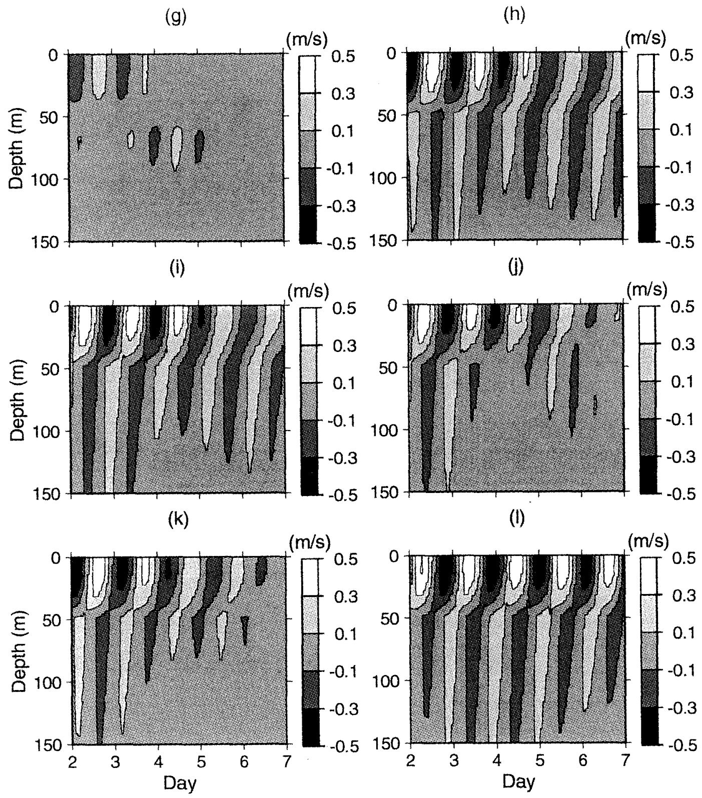

Fig. 5. (Continued)(g) experiment 7 with constant wind, (h) experiment 8 with westward wind (i) experiment 9 with mean flow, $V_{mean}=0.1m/s$, (j) experiment 10 with mean flow, $V_{mean}=0.2m/s$, (k) experiment 11 with mean flow, $V_{mean}=0.2m/s$ and westward wind and (l) experiment 12 with large internal time step.

downward transfer of energy seems to be more effective (Fig. 5f). However, in experiment 7 of constant wind blowing instead of impulsive wind forcing, the inertial velocities are very weak (Fig. 5g), which clearly shows that inertial oscillation is strongly influenced by the time dependence of wind blowing (POLLARD, 1970). The duration of wind blowing is the important factor in determining whether the momentum will be added or removed from the oscillations.

When wind is blowing westward, the vertical distribution of v-velocity is similar to that of experiment 1 (Fog. 5h). However, if numerical experiments of inertial oscillations were run in shallower regions with varying depths, it would be dependent on the direction of the wind (CHEN and XIE, 1997).

When a mean current of 0.1 m/s exists, inertial oscillations become weaker than those of experiment 1 (Fig. 5i). In experiment 10, a mean current 0.2 m/s is used and inertial currents become much weaker (Fig. 5j). Similarly, when the wind is blowing westward and the mean current of 0.2 m/s exists (Fig. 5k), amplitudes of inertial currents are smaller than those of experiment 8 (Fig. 5h). According to CHEN and XIE (1997), when the wind phase was opposite of diurnal tidal currents, the interaction of wind- and tide-induced currents tends to reduce the amplitude of near-inertial oscillations. In our experiments, even though there is no diurnal tidal current, the mean current plays a role in reducing the amplitude of inertial current.

In experiment 12, of which numerical time

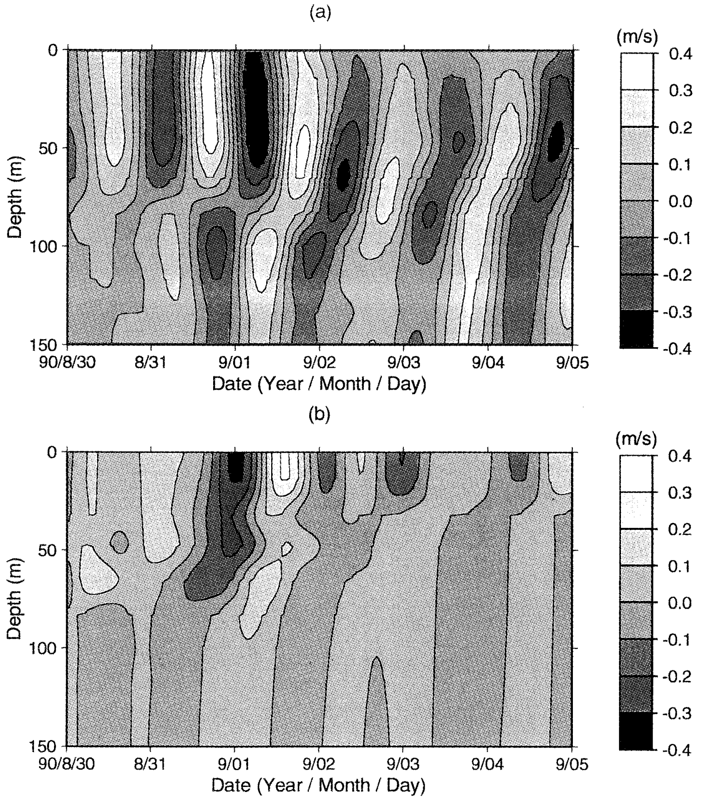

Fig. 6. Time series of the band-passed inertial currents at the depth from 0 to 150 m of Fig. 2 from (a) observed ADCP velocities (b) calculated velocities with real wind forcing between August 28 and September 7, 1990. The contour represents the v-velocity.

step is three times of experiment 1, the vertical distribution of inertial currents become stronger (Fig. 5l). This result shows that the simulation of inertial oscillation is not so simple. In our experiments, three-dimensional velocities were calculated at every internal time step and the same profile of wind stress (Fig. 3c) as experiment 1 was used. However, different amplitudes of inertial oscilations were generated simply because the time interval of calculating three-dimensional velocities was defferent from that of experiment 1. The result seems to be strange at first sight, but it was proved by GILL (1982) using a simple equation that the amplitude of inertial oscillation is strongly dependent on the time of the wind variation.

Figure 6a represents the near-inertial currents observed from a moored ADCP during a typhoon attacked the station M2 (Fig. 1) in August and September, 1990 and the downward propagation of inertial oscillations is well expressed. As expected from our previous numerical experiments of ideal wind forcing, numerical results with real wind forcing are in poor agreement with the observed (Fig. 6b). The amplitudes of inertial currents are relatively small and they have large phase differences with the observed ones. In addition, downward propagation of inertial oscillations seems to be hindered after September 2, 1990. The reasons for this poor result can be considered as follows.

First, as pointed out by ALLEN *et al.* (1995), the representation of turbulent processes used in the numerical model is important. When a wind stress begins to act on the surface of a stratified fluid, momentum is mixed rapidly downwards by turbulence to create a well-mixed layer. Additionally, when the mixed layer is very weakly stratified, momentum is spread fairly evenly through it (POLLARD, 1970). As shown in our results of experiment 2 and 3 (Fig. 5b and 5c), the effect of stratification on the downward transfer of momentum cannot be ignored. In addition, the initial distribution of temperature and salinity (Fig. 3b) may not be appropriate to the simulation because the sampling location and period is not exactly the same as those of the ADCP mooring site. However, it is clear that the selection of parameters like vertical eddy viscosity and diffusivity is more important in turbulent process (Fig. 5d and 5e). In Princeton Ocean Model (POM) used in this study, vertical eddy viscosity and diffusivity are calculated using the level 2.5 turbulent kinetic energy closure (MELLOR and YAMADA, 1982) and ALLEN *et al.* (1995) reported that the results of simulation with constant coefficients differed considerably from that with this turbulence model. Moreover, MARTIN (1985) pointed out that the calculated mixed layer depths are too shallow in this turbulence model. Therefore, it can be concluded that simulation of inertial oscillation with real wind forcing is dependent on the characteristics of numerical model itself.

Secondly, because of the temporal variation of wind, the simulation of inertial currents has limits on representing not only its vertical structure but also its surface layer. As presented in the results of the experiments 6 and 7, it is natural that increase of wind speed (Fig. 5f) and the duration of wind (Fig. 5g) are the important factors in determining inertial oscillations. However, the result of experiment 12 with different numerical time step confirms that the amplitude of inertial oscillation is strongly dependent on the time of the wind change. It also implies that comparisons of simulated inertial oscillations with the observed are impractical. In addition, the location of wind buoy, which is about 100 km apart from that of the ADCP mooring, can be one of the reasons for poor results. It appears that the 3-hour interval in measuring wind is too long to apply it to numerical modeling.

4. Conclusion

Inertial oscillations in the open ocean are mainly controlled by the temporal variation of the wind, mean flow and stratification. In the generation of inertial oscillations, stratification plays a role in controlling the rate at which energy is transferred downwards out of the forced layer, but the temporal variation of the wind and the mean flow are more effective in controlling its rate. As the mean flow strengthens, inertial oscillations tend to weaken and they are almost independent of wind directions. The temporal change of the wind is closely related with addition or removal of momentum generated by surface stress and it is more important than any other factors in determining the generation of inertial oscillations. In addition, the way of representing the turbulent process is very important in simulation of the inertial oscillations. Numerical experiments with constant vertical eddy coefficient show the considerable differences from the case with the MELLOR-YAMADA level 2.5 closure. It is because the transfer of the momentum from the upper layer is calculated with the vertical eddy coefficient in numerical modeling.

Numerical results with real wind forcing show discrepancy with the observed results. The calculated amplitudes of inertial currents were relatively small and showed large phase differences with the observed. This appears to result from the combined effects of all parameters such as stratification, mean flow, wind data and characteristics of numerical model. Furthermore, it clearly shows that it is impractical and difficult to simulate the vertical structure of inertial oscillations with real wind forcing and to compare it with the observed.

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Seasonal occurrence and abundance of larval and juvenile fishes in a Philippine surf zone

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Abstract: Larval and juvenile fishes, collected by a milkfish fry sweeper from the surf zone off Panay Island, Philippines, from May 1986 to September 1987, numbered 18,282 individuals, representing 38 families of 13 orders, with 13 specimens unidentified. The most abundant taxon was *Ambassis* spp. (8,216 individuals, accounting for 44.94% of the total), followed by *Sillago sihama* (3,490 ind., 19.09%). Three occurrence patterns were apparent: year-round (e.g., *Ambassis* spp., *Gerres* sp. 1 and 2), dry-season only (*Sillago aeolus*, *Gerres* sp. 3) and rainy-season only (*Chanos chanos, Lates calcarifer*). Although no clear trend in seasonal abundance (represented by number of individuals per day) was obvious, more species were represtned during dry-season months, generally from November to April, than during the rainy season. The cluster analyses based on the similarity index of Jaccard's coefficient of community (species' composition only) and Pianka's α-index (species' composition and abundance) between each month indicated that fish assemblages in the dry season were relatively stable, those in the rainy season being more changeable. A more or less drastic change in fish assemblages was apparent during seasonal transitions, based on the similarity indices between consecutive months.

1. Introduction

Surf zone and sandy beach habitats have recently been attracting the attention of marine biologists because of their role as nursery grounds for fishes. Accordingly, biological information on larval and juvenile fishes in the surf zone was compiled from a symposium hosted by the Japanese Society of Fisheries Science in September 1997(SENTA and KINOSHITA, 1998). In this, KINOSHITA(1998)stressed the significance of surf zones as nursery grounds for fishes. Although many studies have been conducted on surf zone fish assemblages, most have concentrated on coasts of temperate regions, such as North America, South Africa, North Sea and Japan(SENTA, 1998), with only few on assemblages in the surf zones of tropical or subtropical regions (BAGARINAO and TAKI, 1986: Panay Island, Philippines; YANG and SENTA, 1993: Makung Island, Penghu Islands, Taiwan). Clearly, there exists a need for more information on fish assemblages in the surf zones of the latter regions. The composition of fish larvae and juveniles occurring in the surf zone of Panay Island, Philippines, are examined herein, seasonal changes in abundance and species' composition being analyzed in detail.

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2. Materials and Methods

Specimens examined in this study were collected from the surf zone along the beach at Tigbauan, Iloilo, southern part of Panay Island, Philippines, from 18 May 1986 to 28 September 1987. During this period, fishes were collected with a milkfish fry sweeper (see MORIOKA *et al.*, 1993) for 91days, the frequency of collections ranging from 1 day (August 1986) to 12 days (December 1986) per month. On each sampling day, fishes were collected by operating the fry sweeper five times for about 50 m parallel with the beach line at a depth of 1-1.5 m. Fishes collected were fixed with 5% fromalin and preserved in 70% ethylalcohol at the Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC), Tigbauan, Iloilo, Philippines. Sorting, identification and measurement (SL to the nearest 0.1 mm) of the samples were undertaken in the Laboratory of Ichthyology, Tokyo University of Fisheries, Japan, in 1992 and 1993. Identifications were based mainly on OKIYAMA (1988), being made to the familial, generic or specific levels. In many cases, multiple species included in families or genera (being the lowest identified level) were not subject to finer distinction, being labelled spp. In the study, seasonal changes in abundance of individuals and species' compositon were analyzed by month, based on the mean number of individuals collected per day and number of species collected each month, respectively. The coefficient of community (JACCARD, 1902: cited in KIMOTO and TAKEDA, 1989) and Pianka's α-index (PIANKA, 1973: cited in KIMOTO and TAKEDA, 1989) were used as indices indicating similarities in species' composition and species' composition with individual abundance, respectively, UPGMA being used for a clster analysis. All of the specimens used in this study are deposited in the Museum, Tokyo University of Fisheries, under the catalog numbers MTUF-P (L) 333-802.

3. Results

Fishes collected during the survey from May 1986 to September 1987 numbered 18,282 individuals, representing 38 families of 13 orders, with 13 unidentified specimens representing three further species (Table 1). All of the specimens collected were at the larval or juvenile stage, ranging from 1.8 mm (*Lates calcarifer*) to 78.0mm (Syngnathidae sp.) SL. The most abundant taxon (taxa) in terms of individual number was *Ambassis* spp. (8,216 individuals, accounting for 44.94% of the total collected), followed by *Sillago sihama* (3,490, comprising 19.09%), three species of *Gerres* (1,731 individuals (9.47%) of sp. 3, 1,250 (6.84%) of sp.2 and 1,035 (5.66%) of sp.1), *Sillago aeolus* (705, comprising 3.86%) and *Chanos chanos* (600, comprising 3.28%). The 10 top-ranking taxa occupied 95.66% of the overall total collected, whereas nine taxa were represented by only one specimen and 15 taxa by 2-5 specimens (Table 1).

Figure 1 shows seasonal occurrences of the 8 top-ranking taxa (the rainy season extending generally from May to October and the dry season from November to April). Three different occurrence patterns were apparent. *Ambassis* spp., *Gerres*sp. 1 and 2, and Mugilidae sp. 2 occurred throughout survey period, with no noticeable seasonal fluctuations. On the other hand, *Sillago sihama*, *S. aeolus* and *Gerres* sp. 3 were collected much more abundantly during the dry season. In particular, *S. aeolus* showed remarkable seasonality, its occurrence being restricted to the dry season form December to April (see also KATO *et al.*, 1997). In contrast, *Chanos chanos* were more abundant in rainy season months. Similar patterns were seen in some less-abundant taxa not included in Figure 1. *Megalops cyprinoides*, *Terapon jarbua* and Gobiidae spp. showed year-round occurrence, Atherinidae spp. and Teraponidae sp. were more abundant during the dry season, and Leiognathidae spp. and *Lates calcarifer* occurred mainly in the rainy season.

As shown in Figure 2, the month with the greatest number of individuals collected per day was October 1986 (483.9 ind./day), followed by July 1986 (465.0), September 1986 (323.7) and December 1986 (303.0), whereas those with the least number of individuals collected per day were May 1986 (29.0), June 1986 (33.8), July 1987 (56.0) and September 1987 (57.3). Although the mean number of individuals collected per day in the 1986 (May-October) and 1987 (May-September) rainy seasons was 236.6 and 88.9, respectively, the mean number in the 1986/1987 dry season (November 1986-April 1987) was 190.0, there being no obvious seasonal differences in the number of individuals collected per day (Fig.2).

The month in which the greatest number of species was recorded was December 1986 (30 species), followed by June 1987 (22), April 1987 (21) and January 1987 (20) (Fig.2). On the other hand, the lowest number of species (8) was recorded in May, June and August 1986. The mean number of species in the 1986 (May-October) and 1987 (May-September) rainy seasons was 10.0 and 14.2, respectively, compared

Table 1. Fishes collected from the surf zone off Panay Island, Philippines, from May 1986 to September 1987

	Number of indiv.	Size range(SL, mm)	Composition of total collection(%)	Rank(based on no. of indiv.)
Elopiformes				
Elopidae				
Elops hawaiensis	2	30.1, 31.9	—	14
Megalopidae				
Megalops cyprinoides	91	19.8–28.8	0.50	
Anguilliformes sp.	1	64.0	—	
Clupeiformes				
Clupeidae spp.	105	9.6–20.1	0.57	13
Engraulidae spp.	126	13.0–30.6	0.69	10
Gonorynchiformes				
Chanidae				
Chanos chanos	600	9.1. 13.1	3.28	7
Stomiiformes				
Gonostomatidae sp.	1	21.6	—	
Myctophiformes spp.	4	6.8–31.3	—	
Lophiiformes				
Antennariidae spp.	3	4.3–9.4	—	
Atheriniformes				
Atherinidae sp.	34	9.5–31.3	0.19	18
Beloniformes				
Hemiramphidae spp.	4	15.5–19.9	—	
Exocoetidae sp.	7	11.1–17.0	—	
Syngnathiformes				
Syngnathidae spp.	2	52.5, 78.0	—	
Scorpaeniformes				
Playcephalidae spp.	4	9.5–10.1	—	
Perciformes				
Centropomidae				
Lates calcarifer	12	2.8–8.1	0.07	
Ambassidae				
Ambassis spp.	8216	3.0–28.9	44.94	1
Teraponidae				
Terapon jarbua	125	8.8–15.9	0.68	11
Teraponidae sp.	117	8.3–15.6	0.64	12
Apogonidae spp.	49	5.3–8.1	0.27	17
Sillaginidae				
Sillago aeolus	705	8.9–26.0	3.86	6
Sillago sihama	3490	6.3–22.9	19.09	2
Carangidae spp.	27	5.8–26.4	0.15	19
Leiognathidae spp.	77	6.4–22.0	0.42	16
Lutjanidae				
Lutjanus sp.	1	18.5	—	
Gerreidae				
Gerres sp. 1	1035	10.0–20.3	5.66	5
Gerres sp. 2	1250	7.3–18.0	6.84	4
Gerres sp. 3	1731	5.5–11.5	9.47	3
Haemulidae sp.	1	25.3	—	
Sparidae sp.	5	9.4–10.8	—	
Sciaenidae spp.	2	3.9, 8.6	—	
Pempheridae sp.	1	5.8	—	
Ephippididae spp.	3	8.9–25.0	—	
Scatophagidae				
Scatophagus sp.	1	9.0	—	
Pomacentridae sp.	1	12.6	—	
Mugilidae sp. 1	89	8.5–32.9	0.49	15
Mugilidae sp. 2	206	6.9–30.5	1.13	8
Labridae sp.	1	6.8	—	
Trichonotidae sp.	3	16.9–17.5	—	
Gobiidae spp.	130	5.0–28.9	0.71	9
Siganidae				
Siganus sp.	1	17.3	—	
Sphyraenidae				
Sphyraena sp.	2	21.6, 27.8	—	
Cetrolophidae spp.	2	7.6, 10.0	—	
Tetraodontiformes				
Tetradontidae spp.	2	5.6, 15.4	—	
Unidentified sp. 1	2	4.1, 4.8	—	
Unidentified sp. 2	9	8.8–11.3	—	
Unidentified sp. 3	2	4.0, 4.4	—	

with 21 in the 1986/1987 dry season (November 1986–April 1987), there being an apparent tendency for more species to occur in the dry season than in the rainy season (Fig.2).

The cluster analysis based on the similarity index of Jaccard's coefficient of community between each month indicated that a cluster was formed by the six dry–season months from November 1986 to April 1987, plus May 1987 and July 1986 (Fig.3). Although other two clusters were formed by rainy–season months (May, June and August 1986; and September and October 1986 plus June–September 1987), the latter cluster together formed a natural grouping with the dry–season cluster. The similarity index of Jaccard's coefficient of community between consecutive months was also high in the dry–season months from November–December 1986 to April–May 1987, the index ranging from 0.548 to 0.739 (Fig.4). On the other hand, the index was hovered between 0.385–0.529 and 0.407–0.522 during the 1986 and 1987 rainy sea-

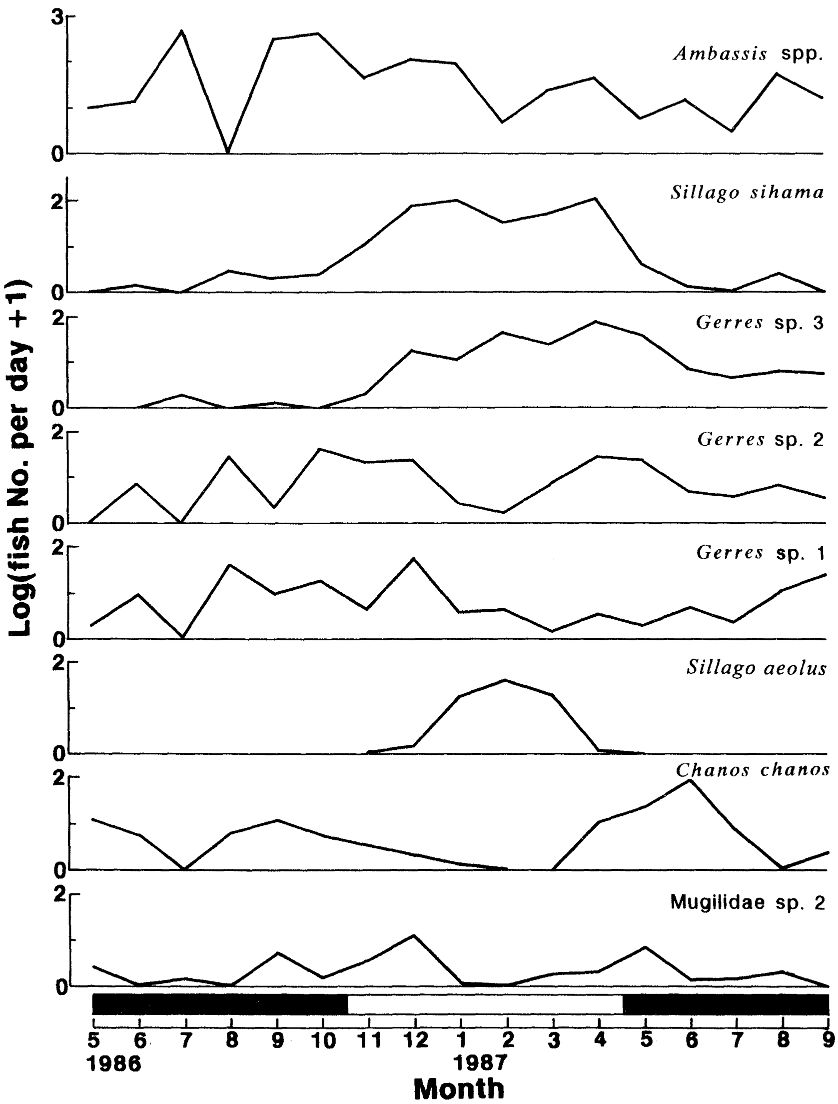

Fig. 1. Monthly changes in abundance of major fish species collected from the surf zone off Panay Island, Philippines, from May 1986 to September 1987.

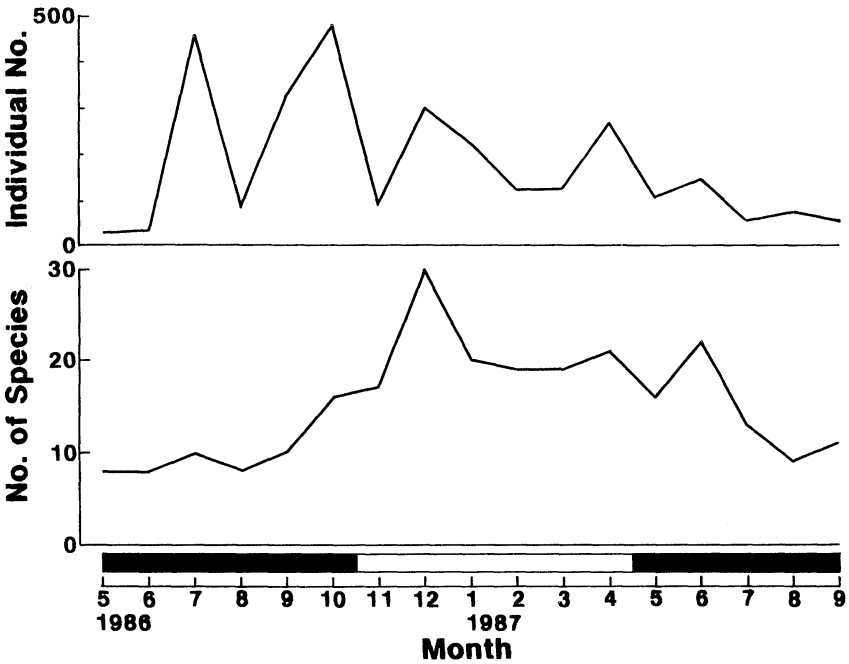

Fig. 2. Monthly changes in number of individuals and species of fishes collected from the surf zone off Panay Island, Philippines, from May 1986 to September 1987.(Number of individuals expressed as mean number collected per day for each month; number of species equals that recorded each month.)

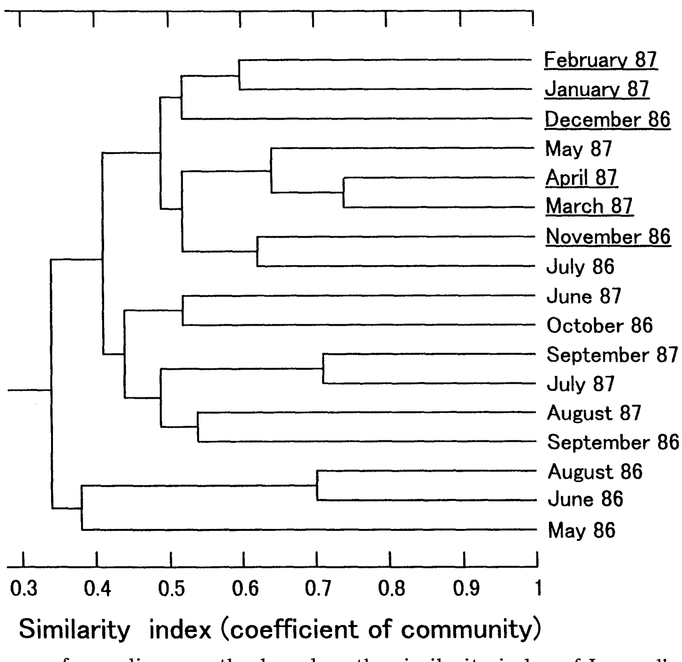

Fig. 3. Dendrogram of sampling months, based on the similarity index of Jaccard's coefficient of community, for fishes collected from the surf zone off Panay Island, Philippines, from May 1986 to September 1987(Dry-season months underlined.)

sons, respectively. The greatest monthly drop in the index (from 0.682 to 0.407) was seen between April–May and May–June 1987.

The similarity index of Pianka's α-index, on the hand, showed the dry-season months from December 1986 to April 1987 as forming a culster (Fig.5). Although a second cluster was formed by the rainy-season months of June, July, September–November 1986 and August 1987, this was closely grouped with the dry season clusters. Other rainy-season months formed two cluster (May 1986 and 1987 and June 1986; August 1986 and September 1987), with July 1987 being grouped only with the overall cluster. The similarity indices of consecutive dry-season months from September–October 1986 to March–April 1987 remained at high values, except for that of January–Feburuary 1987 (0.517), ranging from 0.821 to 0.994 (Fig.4). By comparison, indices for rainy-season months fluctuated; higher values were observed in May–June–July 1986, and April May–June and August–September 1987, and lower values in July–August–September 1986 and June–July–August 1987. The greatest jump in the index occurred between August–September and September–October 1986, increasing from 0.029 to 0.994, whereas subsequent values decreased gradually overall, from March–April (0.935) to July–August (0.093) 1987.

4. Discussion

Fishes representing 38 families, in addition to three unidentified species, were collected in the present study from the south coast of Panay Island, Philippines, whereas BAGARINAO and TAKI (1986) reported 47 families from the northern west coast of the same island. Fish assemblages

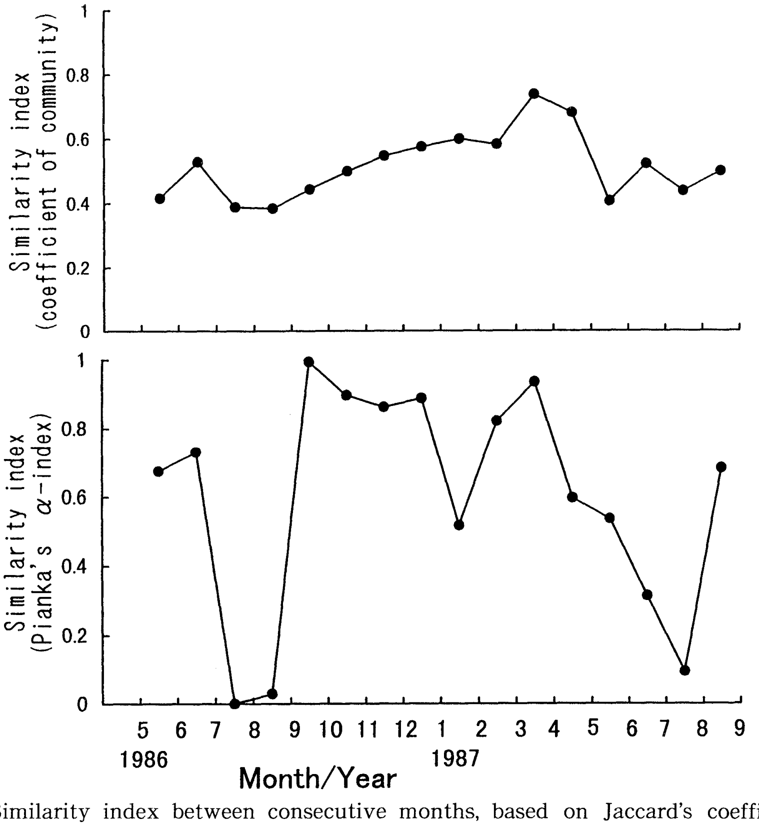

Fig. 4. Similarity index between consecutive months, based on Jaccard's coefficient of community (above) and Pianka's α-index (below), for fishes collected from the surf zone off Panay Island, Philippines, from May 1986 to September 1987 (Note dry season extended from November to April).

reported from surf zones so far as follows: forty nine families from Tosa Bay, Shikoku, Japan (KINOSHITA and HAMADA, 1983: cited in KINOSHITA, 1984), 52 families from Kyushu, Japan (SENTA and KINOSHITA, 1985), 32 families Makung Islalnd, Penghu Islands, Taiwan (YANG and SENTA, 1993), 29 families plus unidentified specimens from Gulf of Mexico (RUPLE, 1984) and 16 families plus unidentified specimens from South Africa (WHITFIELD, 1989).

Temperate water studies have indicated that the number of individuals and species occurring in the surf zone is greater in spring and summer than in autumn and winter (SENTA and KINOSHITA, 1985; WHITFIELD, 1989). YANG and SENTA (1993) also reported that the surf zone fish assemblages in a subtropical region (Taiwan) were most diverse and abundant in spring and summer (April to July) and poorest in late winter (February and March).

In terms of aundance of individuals per day, no obvious seasonality was detected in this study. BAGARINAO and TAKI (1986) also found that the average catch per sample did not change markedly with season.

As to the number of species, collections during the dry season (November to April) produced a greater number than those during the rainy season, contrary to the results of BAGARINAO and TAKI (1986), in which the greater number of species were seen in June to September. The sampling site of BAGARINAO and TAKI (1986) was located on the northern part of the west coast of Panay Island, subject to southwesterly monsoon winds, such plus the heavy surf being considered to cause a passive accumulation of fish larvae and juveniles. However, the sampling site of the present study was located on the south coast of Panay Island, where southwesterly monsoonal infulences are slight. During the monsoon season from June to September, the fish faunas reported by BAGARINAO and TAKI (1986) and this study deiffered considerably: the number of taxa reoprted only in the former study being 21, whereas the vice versa being 4; and four taxa collected in the monsoon season in the former

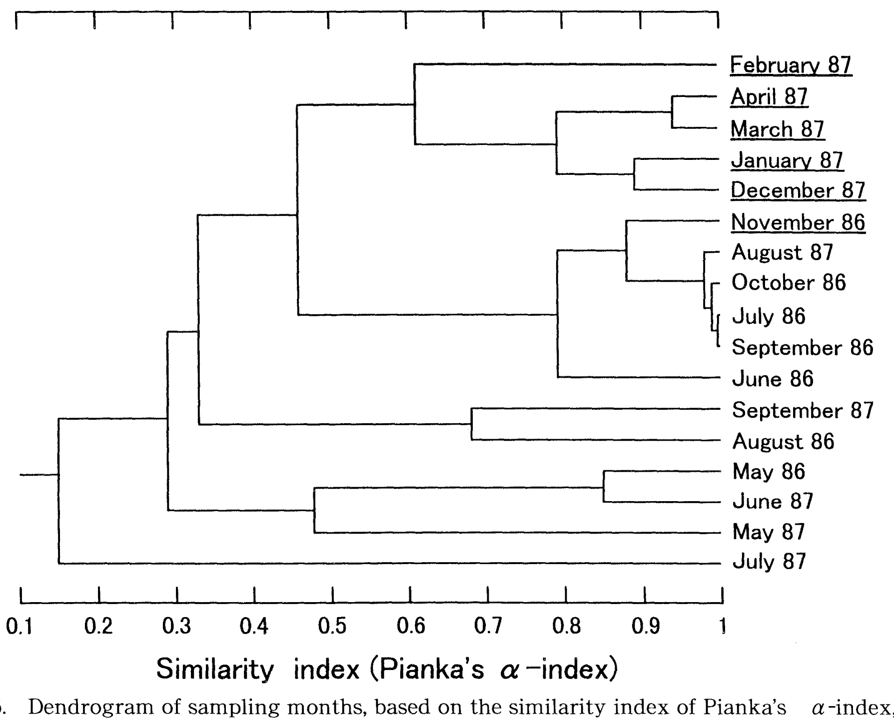

Fig. 5. Dendrogram of sampling months, based on the similarity index of Pianka's α-index, for fishes collected frome the surf zone off Panay Island, Philippines, from May 1986 to September 1987(Dry-season months underlined.)

study being recorded only during dry season in the latter study. To clarify factors affecting fish assemblages in surf zone, environmental influences such as monsoon, wind and heavy surf, in addition to bioloical aspects of fishes, need to be examined further.

The dry-season months from November 1986 to May 1987 (species' composition) or from December 1986 to April 1987 (abundance and species' compositon) formed clusters in this study, indicating some stability of the fish assemblages during these periods. The occurrence of assemblage stability is further supported by the high similarity index values between consecutive months from November-December 1986 to April-May 1986 (species' composition) and September-October 1987 to March-April 1987 (abundance and species' composition). On the other hand, the rainy-season months formed disordered clusters, irrespective of year, some being grouped with the dry-season cluster. Furthermore, in the rainy season, the similarity indices of consecutive months were either low (species' composition) or fluctuated in a disoredered manner (abundance and species' compostion), suggesting that the fish assemblages at that time were changeable, unlike those characterizing the dry season.

At the transition between seasons, differences between the indices of consecutive months were variable. From the dry season to the rainy season, the greatest difference was seen between April-May and May-June 1987 (sepecies' composition), the index for abundance and species' compostion decreasing gradually from March-April to July-August 1987. From the rainy season to the dry season, the greatest difference occurred between August-September and September-October 1986 (abundance and species' composition). These results indicated that the fish assemblages changed more or less drastically at the transition between seasons.

Surf zone habitats are considered important for fish larvae and juveniles. Although BROWN and MCLACHLAN (1990) stated that biological studies of sandy beaches were lagging well behind those of rocky shores, information on species' composition and abundance of fish larvae and juveniles occurring in the surf zone has been accumulated by many authors (see SENTA, 1998). KINOSHITA (1984, 1998) indicated the possibility of surf zone habitats as feeding grounds for fish larvae and juveniles, although the site of the present study was considered unsuitable for the milkfish, *Chanos chanos*, following a comprehensive study of that species by MORIOKA *et al.*, (1993, 1996). On the other hand, KATO (1994) studied juvenile feeding habits of two sillaginid species from the same site and concluded that both required a period of surf zone existence for successful development. These studies suggest the need for species-by-species' evaluation of surf zone requirements during their development. Furthermore, in order to understand the relative importance of surf zone, it is important to compare the fish assemblages of such with those of other inshore habitats, such as estuaries, sandy beaches and reefs, as demonstrated by BENNETT (1989), who compared the abundance of juveniles in a surf zone with those in other inshore marine habitats in South Africa.

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La mer 36: 111-117, 1999
Société franco-japonaise d'océanographie, Tokyo

学 会 記 事

1. 1998年11月20日（金） 東京水産大学において，1998年度第1回幹事会が開かれた．主な議事は下記のとおり．
報告事項
1）平成11年10月末日段階の学会の会計状況が報告された．
2）学会誌 La mer の編集状況が報告された．
協議事項
1）日仏諸学会総合シンポジウムについて審議し，八木宏樹会員に講演を依頼したことを了承した．
2）その他

2. 1998年11月20日（金） 東京水産大学において，1998年度学会賞受賞候補者推薦委員会（第1回）が開かれ，委員長に松山優治会員を選出し，推薦の方法および次回の日程を決めた．

3. 1998年12月16日（水） 東京水産大学において，1998年度学会賞受賞候補者推薦委員会（第2回）が開かれ，評議員より推薦のあった候補者について審議の結果，須藤英雄会員（立正大）を第1候補者とし，全委員に E-mail で賛否を問うこととした．松山委員長より都合により委員長を交代したい旨申し出があり，審議の結果今脇資郎会員を委員長として選出した．

4. 1998年12月18日（金）～20日（日） 日仏会館ホールにおいて，日仏諸学会総合シンポジウム「日本にとってフランスとは」が開催された．12月20日午後，本学会を代表して八木宏樹会員の講演「フランスと日本における水産増殖の比較」が行われた．

5. 1998年12月25日（土） 東京水産大学において，1998年度学会賞受賞候補者推薦委員会（第3回：E-mail）が開かれ，集計の結果須藤英雄会員を平成11年度日仏海洋学会賞受賞候補者と決定し，会長へ報告することとした．

6. 新入会員（正会員）

氏 名	所属・住所	紹介者
河野 博	東京水産大学資源育成学科 〒108-8477 港区港南4－5－7	山口征矢

7. 会員資格・所属・住所等変更
（正会員・受付順）

下田 徹	国際農林水産業研究センター水産部 〒305-8686 つくば市大わし 1-2
奥村 裕	東北区水産研究所海区水産業研究部 〒985-0001 塩釜市新浜町 3-27-5
前田昌調	国際農林水産業研究センター水産部 〒305-8686 つくば市大わし 1-2

8. 退会（受付順）
藤石昭生，岡見 登，杉森康宏

9. 逝去
津田良平，市村俊英，菊地真一

10. 受贈図書（受付順）
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Preliminary Report of the Hakuho Maru Cruise KH95-5
国立科学博物館専報 31
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Bulletin of Marine Science and Fisheries 18
海洋与湖沼 29(1, 3, 4)
Journal of the Korean Society of Oceanography 33(2, 3, 4)
Meereswissenschaftliche Berichte 30, 31
ОКЕАНОЛОГИЯ 36(3, 6), 37(6), 38(1, 2, 3)
青島海洋大学学報 28(3, 4)
韓国海洋学会 3(4)
海洋水産研究 19(1,2)

11. お知らせ

1) 日本学術会議では学術会議の活動を広く伝えるために平成11年4月からホームページを開設し「日本学術会議だより」「学術研究集会等開催予定」等を随時掲載することになりましたので，ご利用下さい．日本学術会議ホームページアドレスは下記の通りです．

http://www.scj.go.jp

2) ミキモト海洋生態研究助成基金の公募

御木本真珠発明100周年を記念して，平成4年7月1日に設立された「公益信託ミキモト海洋生態研究助成基金」の第7回助成対象者が募集されます．大学等の研究機関の研究者または研究グループ，中・高等学校等の教諭，生物クラブなどで，潮間帯から浅海にわたる海域を対象とした1）生物に関する調査・研究，2）生物の生息環境に関する調査・研究，3）生態の保全のあり方に関する調査・研究に対し，総額350万円が助成されます．応募締め切りは平成11年5月10日，助成金の支給は平成11年7月中旬を予定しています．募集要項，申請書等は下記あてハガキでご請求ください．

【申請書等の請求先】
〒113-0034　東京都文教区湯島 2-29-3
財団法人自然環境研究センター内
公益信託ミキモト海洋生態研究助成基金　事務局
電話　03-3812-0811（担当：掘田）

お知らせ

下記の国際会議の開催案内が来ています。詳細は直接 Secretariat Office 宛お問い合わせ下さい。

Third World Fisheries Congress

Sustainable Fisheries and Optimizing Food Composition

31 October - 3 November 2000
Beijing International Convention Center
Beijing P. R. China

Invitation to Participation
and
Call For Presentations

Organized by: China Society of Fisheries
Sponcered by: China Society of Fisheries
Asian Fisheries Society
American Society of Fisheries
World Aquaculture Society
Australian Society of Fish Biology
Sponcered by: Ministry of Agriculture of P. R. China
Ministry of Science and Technology of P. R. China

Secretariat Office
China Society of Fisheries
Bldg 22, Maizidian Street, Chaoyang District 100026
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Prospectus
For
The 3rd World Fisheries Congress

I OBJECTIVES

The first World Fisheries Congress, sponsored by American Fisheries Society, Asian Fisheries Societies, and other international Fisheries Societies, was held at Athens in March 1992 and the second was held at Brisbane in July 1996. During the second congress, the International Steering Committee resolved that the China Society of Fisheries will hold the 3rd World Fisheries Congress & Scientific Trade and Service Exhibition at Beijing in the year of 2000.

The Congress has two major objectives: the one is to improve worldwide scientific fishery collaboration and cooperation between the experts, governments, fishery organizations;the other is to recommend actions to develop sustainable fisheries and maintain healthy fishery resource so as to increase the food resource for mankind in the next century.

II TIMING, LOCATION, SCALE, AND LANGUAGE

TIMING: October 31-November 3 2000

Location: Beijing International Conference Center

Scale: around 800 participants

The official language for the congress is English, including international congress announcement, academic exchange and the publication of the proceedings. On the opening ceremony, consecutive or simultaneous translation will be available. The domestic meeting notification will be in Chinese.

III CONGRESS THEME

Sustainable Fisheries and Optimizing Food Composition

Due to the increasing growth of the global population and economy, the world is now faced with shortage of land resources, which force the mankind to expand their living area to the sea, which covers 71% of the earth surface. It has become an inevitable trend to make reasonable use of the fisheries resources while we are exploiting our living area. Because of the poor grain harvest in recent years, the food stocks of the world are dropping severely while the demand for food is increasing with the growth of the population, which makes the food supply a hot topic all over the world.

Although threatened by such unfavorable factors as water pollution, over fishing, the world fishery industry still has the potentialities and conditions for sustainable and steady development as long as it is scientifically managed and protected with new technology.

To promote the share of aquatic products as food in the human food composition can not only optimize the food structure, so as to improve the nutrition level, but also release the pressure of grain production.

This Theme is suitable for both developed and developing countries, as every country in the world has the will to contribute their bit to sustainable development and improving the living level for their people.

The keynote lecture will be given by vice Minister of Agriculture or Director General of Fisheries Bureau, or president of Chinese Academy of Fishery Sciences, the topic is supposed to be the prospects into the 21st century for sustainable fisheries and optimizing food composition in China. An official from FAO will be invited to give report on world fisheries related to the Congress theme.

IV TOPICS

1 The effect of the sustainable fisheries on optimizing food composition and improving human health care.
2 The scientific management,reasonable exploitation and protection for fisheries resources.
3 Selected fishing technologies
4 the affect of the fishery environment on the sustainable fisheries.
5 healthy aquaculture and ecosystem
6 Bio-technology and its application in fisheries
7 Aquatic products processing and comprehensive utilization
8 Fishery bio diversity and protection.
9 Fishery machines and instruments
10 Fishery economics
11 Fishery policies and sustainable fisheries
12 Application of information technology in fisheries

V The Organizing Committee of China

1 Responsibility: to organize and coordinate all the events related to the congress

Society of Fisheries will be served as Chief officer of the Secretariat.

VI The International Steering committee

1 Responsibilities: to offer constructive advice to the congress as regards academic work such as to determine the topics for discussion, to identify speakers and so on, to offer suggestion on the organization of the congress, to publicize the congress through magazines, websites and other kinds of medium,to help solicit donations for the congress, to discuss the issues regarding to the next congress.

2 Members: the committee will consist of about 30 members, of whom 7 members will be sent by China, others are chosed experts from the world related fisheries organizations or societies. Mr. Chen Yiyu, Vice President and academician of The Chinese Academy of Sciences is served as Chairman

VII The Symposium Committee

1 Responsibilities: To be responsible for paper reviewing, academic activities, publication work.

2 Members:

Chairman Mr. Zhou Yingqi President Shanghai Fisheries University

Members:

Mr.Tang Qisheng	Research Fellow	YellowSea Fisheries Institute
Mr. Li Si fa	Professor	Shanghai Fisheries University
Mr. Mai Kangsen	Professor	Qingdao Marine University
Mr. Dong Shuanglin	Professor	Qingdao Marine University
Mr. Chen Liqiao	Professor	Huadong Teacher's University
Mr. Wu Hanmin	Professor	Ninbo Fisheries University
Mr. Zhang Miaoyong	Research Fellow	Institute of Fishery Machine
Mr. Huang Xichang	Research Fellow	East China Sea Fisheries Research Institute
Mr. Xia Dequan	Research Fellow	Wuxi Fresh Water Fisheries Research Center
Mr. Wang Jianguo	Vice Research Fellow	Institute of Hydrobiology China Science Academia
Mr. Tong Heyi	Professor	Shanghai Fisheries University
Mr. Wang Qingyin	Research Fellow	Yellow sea Fisheries Research Institute Sciences
Mr. Yang Ninsheng	Vice Research Fellow	Chinese Academy of Fishery Sciences

VIII The Scientific Trade Exhibition

The International Fisheries Scientific Trade and Service Exhibition will be held in conjunction with the congress. Exhibition will involve in fishery science and technology and fishery trade, with the emphasis on new fishery technology and new products.

IX Publicity of the Congress

Successful publicity of the Congress will lead to the success of the Congress.To give good publicity of the Congress to the world fishery community, the following methods will be adopted:

1 To send the congress materials to selected fishery organizations and experts.
2 To put advertisement on the fishery magazine, newspaper or other publications.
3 To set up website on international network.
4 To promote the Congress through international or domestic fishery conference by distributing the Congress materials or news release.
5 To promote the Congress by the members of International Steering Committee in their country or fields.

X Funding

The funding for the congress will come mainly from financial support given by government. The rest will come from the donation of international fisheries organizations or societies, the registered fees, the income of the exhibition and sales of the Congress proceedings and other documents.

X Planned Program of Congress

1 Work done

In July 1996, with the approval of National Science and Technology and Ministry of Agriculture, China Society of Fisheries applied to the International Steering Committee of 2^{nd} World Fisheries Congress for hosting 3^{rd} Congress in Beijing and the proposed was approved.

In October 1997, The Congress was approved by the State Council.

In April 1998, The Standing Committee of China Society of Fisheries pass the Prospectus for the Third World Fisheries Congress

In September 1998, at the recommendation of international organizations or experts, with the approval of Fisheries Bureau of Ministry of Agriculture, the International Steering Committee was established

In October 1998, with the approval of Ministry of Agriculture, the

Organizing Committee was established.

In November 1998, The brochure of Invitation to Participation and Call for Presentation was published and 1000pcs was distributed at the Fifth Forum of Asian Fisheries Society

Another four thousand pieces of brochures was delivered to fishery professionals till the end of December 1998.

2 Work to be done

The first Plenary Meeting of Organizing Committee in China will be held in January 1999 in Beijing

The first Plenary Meeting of International Steering Committee will be held in January 1999 in Beijing.

From March 1999 on, advertisement for the Congress will be put on international and domestic magazines, newspaper, other publication, and internet.
The first domestic announcement will be delivered in September 1999.

The registration brochure will be published and delivered to paricipants.

The second plenary session of International Steering Committee and Organization Committee will be held in Beijing in January 2000.

To deliver invitation to Exhibition in March 2000

Congress material will be distributed on some international fishery expositions and conference such as The Boston Seafood Show,European Seafood Exposition, World Aquaculutre 99 in Sidney, Japan international Seafood &Technology Expo.

The second domestic announcement will be delivered in April 2000

To issue the third international announcement and second domestic announcement for the congress in April 2000

The abstracts of papers will be published in September 2000 and will be distributed to participants at the beginning of the Congress.
October 31 to November 3, The Congress will be held.

賛　助　会　員

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日仏海洋学会入会申込書

（正会員・学生会員）

	年度より入会	年　　月　　日申込
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入会申込書送付先：〒150-0013 東京都渋谷区恵比寿 3-9-25

（財）日仏会館内

日 仏 海 洋 学 会

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