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Studies on the Bottom Fishes of Continental Slope off Makurazaki, Southern Japan - I

— Faunal Composition and Variation of Abundance* —

Takakazu OZAWA**

Abstract

The series of this study researches the fishery biology of bottom fish stock of continental slope (300 to 400 m in depth) off Makurazaki, southern Japan. This paper reports the faunal composition and the variation of abundance. The samples were collected from the catch of commercial shrimp fishing boats monthly from 1975 to 1981. After having identified, their sizes and numbers were measured. The results obtained are as follows.

1. The bottom-dwelling fish fauna is composed of 111 species. The richest family in species number is Macrouridae.
2. The most abundant species is a chlorophthalmid *Chlorophthalmus albatrossis*, followed by a peristediid *Peristedion orientale*, a squalid *Etmopterus lucifer*, a percichthyid *Synagrops japonicus*, macrourids *Coelorhynchus kamoharai* and *Ventrifossa garmani*, etc. Most of them are small in size, less than 20 cm in length and less than 100 gr in weight.
3. The species composition is estimated to be almost constant throughout the study period.
4. The monthly catches of total fishes and *C. albatrossis* show the synchronized fluctuation of summer increase and winter decrease, that is, the abundance of bottom fishes is dominated by the seasonal change of *C. albatrossis*.

1. Introduction

For these 20 years, the bottom-dwelling fishes below continental shelves have come to commercial fishery resources in several countries with developed high-sea fishery. Representatives of those fishes are a pentacerotid *Pentaceros richardsoni* in the North Pacific, a macrourid *Macrourus rupestris* in the western North Atlantic, merluciids *Merluccius* spp. around South America, etc. (see NASU, 1980). They have 3×10^6 tons of potential increase in catch (MOISEEV, 1973) and are said to be the last biological sea resources for human. Together with test catches, the biological studies about them have been progressively accumulated (for example see GORDON, 1979). In Japan, those studies are rare and the following few papers restricted to the continental slope fishes could be seen: stomach content analysis (KUDŌ *et al.*, 1970); fish fauna in Japan Sea (NISHIMURA, 1965a, b, 1966, 1968, 1969; OGATA *et al.*, 1973); seasonal analysis of fish abundance off Miyako, northern Japan (KINOE, 1955).

At the depth of 300 to 400 m off Makurazaki, southern Japan, bottom fishes are caught by commercial shrimp Danish seine which has been exploited since 1970. All of them, irrespective of edible or non edible, are discarded after selection of shrimps. This area, a little deeper than 200 m and limited in space, is located nearby our Faculty and is convenient for us to collect bottom fishes.

The present author thought the systematic study will contribute to the knowledge of understanding the bottom fish stocks of continental slope. Along this theme, the fishes were collected from commercial catches of shrimp Danish seine in the above area and the following sub-

* Accepted June 4, 1983.
** Faculty of Fisheries, Kagoshima University, Kagoshima 890, Japan

jects were studied successively since 1975: fish fauna, variations of abundance, stomach content analysis, growth, maturation and recruitment. In this paper, the results of the first two studies are reported.

2. Materials and methods

The fishing ground is located at the south of Makurazaki, southern Japan, its depth ranging from 300 to 400 m (Fig. 1). The bottom is silty sand.

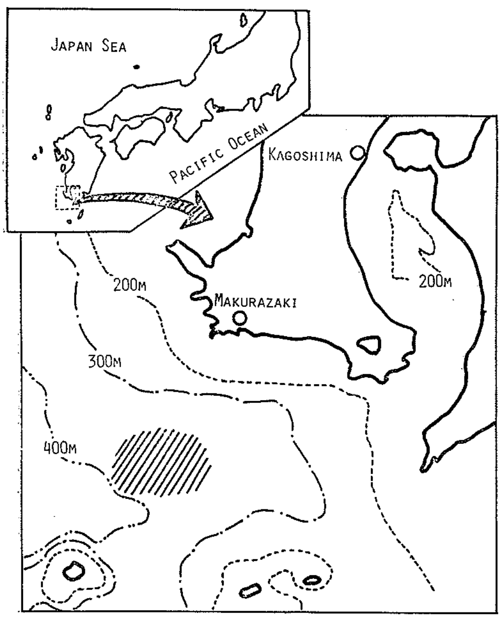

Fig. 1. Map of the study area (shaded part).

Commercial fishing boats are small, about 10 tons in size and with 40 to 70 HP engines. Operations are done five times a day during daytime and the duration of tow extends 2 hrs. The fishing method is a kind of Danish seine. The gear consists of one pair of warp and wing, and a bag net. The lengths of a warp and a wing are 1,500 and 50 m, respectively. The bag net made up with Polyvinylealcohol netting (20's/3/3) is constructed as follows: height and width of mouth, 4.5×2.1 m; length, 13 m; mesh size, 28 mm.

This study was continued for 7 years from 1975 to 1981. The collections of materials were made on board once a month and all of the fishes of the last catch of the day were sampled customarily. The collections from January to March were made occasionally due to prohibited season.

Fishes were preserved in 10% formalin, and their body length and wet weight were measured. The body length was defined as total length for elasmobranchs and anguilliformes, trunk length for macrourids and morids, and standard length for other fishes.

3. Results

Forty eight samples taken over 7 years provided 111 and 18 species of bottom and mesopelagic fishes, respectively (Table 1). The mesopelagic fishes are not included in the later consideration in this paper.

The species number newly collected progres-

Table 1. List of fishes with Japanese name.
(*: Mesopelagic fishes)

Hexanchiformes: Kagurazame-moku

Hexanchidae: Kagurazame-ka

Heptranchias perlo (Bonnaterre): Edoaburazame

Lamniformes: Nezumizame-moku

Scyliorhinidae: Torazame-ka

Galeus eastmani (Jordan et Synder): Yamorizame

Cephaloscyllium umbratile Jordan et Fowler: Nanukazame

Scyliorhinus torazame (Tanaka): Torazame

Squaliformes: Tsunozame-moku

Squalidae: Tsunozame-ka

Squalus mitsukurii Jordan et Fowler: Futotsunozame

Etmopterus lucifer Jordan et Snyder: Fuzikuzira

Centrophorus atromarginatus Garman: Aizame

Squatinidae: Kasuzame-ka

Squatina nebulosa Regan: Korozame

Pristiophoridae: Nokogirizame-ka

Pristiophorus japonicus Günther: Nokogirizame

Rajiformes: Ei-moku

Torpedinidae: Shibireei-ka

Torpedo tokionis (Tanaka): Yamatoshibireei

Rajidae: Gangiei-ka

Raja kenojei Müller et Henle: Gangiei
Raja macrocauda Ishiyama: Kitsunekasube

Chimaeriformes: Ginzame-moku
Chimaeridae: Ginzame-ka
Chimaera phantasma Jordan et Snyder: Ginzame
Hydrolagus mitsukurii Dean: Akaginzame

Elopiformes: Karaiwashi-moku
Albulidae: Sotoiwashi-ka
Pterothrissus gissu Hilgendorf: Gisu

Salmoniformes: Sake-moku
Argentinoidei: Nigisu-amoku
Argentinidae: Nigisu-ka
Argentina kagoshimae Jordan et Snyder: Kagoshimanigisu
Glossanodon semifasciata (Kishinouye): Nigisu

Stomiatoidei: Wanitokagegisu-amoku
Gonostomatidae: Yokoeso-ka
Polymetme elongata (Matsubara): Ryugūhadaka
Astronesthidae: Tokagehadaka-ka
**Astronesthes lucifer* Gilbert: Yamorihadaka
**Astronesthes cyaneus* (Brauer): Kurotokagegisu
Sternoptychidae: Muneeso-ka
**Polyipnus tridentifer* McCulloch: Hōneneso
**Polyipnus matsubarai* Schultz: Hoshihōneneso

Myctophiformes: Hadakaiwashi-moku
Myctophioidei: Hadakaiwashi-amoku
Chlorophthalmidae: Aomeeso-ka
Chlorophthalmus acutifrons Hiyama: Tomomehikari
Chlorophthalmus albatrossis Jordan et Starks: Aomeeso
Neoscopelidae: Sotooriiwashi-ka
Neoscopelus microchir Matsubara: Sangoiwashi
Myctophidae: Hadakaiwashi-ka
**Diaphus kuroshio* Kawaguchi et Nafpaktitis: Kuroshiohadaka
**Diaphus watasei* Jordan et Starks: Hadakaiwashi
**Diaphus sagamiensis* Gilbert: Sagamihadaka
**Diaphus garmani* Gilbert: Hirohadaka
**Diaphus malayanus* Weber: Hanarehadaka

Alepisauroidei: Mizuuo-amoku
Paralepididae: Hadakaeso-ka
**Lestrolepis japonica* (Tanaka): Hadakaeso

Cetomimiformes: Kuzirauo-moku
Ateleopidae: Shachiburi-ka
Ateleopus purpureus Tanaka: Murasakishachiburi

Anguilliformes: Unagi-moku
Anguilloidei: Unagi-amoku
Congridae: Anago-ka
Conger japonicus Bleeker: Kuroanago
Congriscus megastomus (Günther): Okianago
Alloconger anagoides (Bleeker): Hanaanago
Conger myriaster (Brevoort): Maanago
Gnathophis nystromi nystromi (Jordan et Snyder): Ginanago
Ophichthidae: Umihebi-ka
Ophichthus urolophus (Temminck et Schlegel): Susoumihebi

Nemichthyoidei: Shigiunagi-amoku
Nemichthyidae: Shigiunagi-ka
*Nemichthyidae sp.

Syngnathiformes: Yōziuo-moku
Macrorhamphosidae: Sagifue-ka
Macrorhamphosus scolopax (Linnaeus): Sagifue

Beryciformes: Kinmedai-moku
Berycoidei: Kinmedai-amoku
Trachichthyidae: Hiuchidai-ka
Hoplostethus mediterraneus Cuvier: Hiuchidai
Polymixiidae: Ginmedai-ka
Polymixia japonica Günther: Ginmedai
Berycidae: Kinmedai-ka
Beryx splendens Lowe: Kinmedai

Zeiformes: Matōdai-moku
Zeidae: Matodai-ka
Zeus japonicus Valenciennes: Matōdai
Zenopsis nebulosa (Temminck et Schlegel): Kagamidai
Parazen pacificus Kamohara: Benimatōdai
Zenion japonicum Kamohara: Sokomatōdai
Zen itea (Jordan et Fowler): Kagomatōdai
Grammicolepididae: Hishimatōdai-ka
Xenolepidichthys dalgleishi Gilchrist: Hishimatōdai

Perciformes: Suzuki-moku
Scombroidei: Saba-amoku
Gempylidae: Kurotachikamasu-ka
**Thyrsittoides marleyi* Fowler: Nagatachikamasu
**Neoepinnula orientalis* (Gilchrist et von Bonde): Tōyōkamasu
**Rexea solandri* (Cuvier): Kagokamasu
**Gempylus serpens* Cuvier: Kurotachikamasu
Trichiuridae: Tachiuo-ka
Trichiurus lepturus Linnaeus: Tachiuo
Benthodesmus tenuis (Günther): Tachimodoki

Stromateoidei: Ibodai-amoku
Centrolophidae: Ibodai-ka
**Psenopsis anomala* (Temminck et Schlegel): Ibodai

Nomeidae: Eboshidai-ka
Cubiceps squamiceps (Lloyd): Bōzukonnyaku

Percoidei: Suzuki-amoku
Apogonidae: Tenzikudai-ka
Epigonus denticulatus Dieuzeidi: Hageyasemutsu

Scombropidae: Mutsu-ka
Scombrops boops (Houttuyn): Mutsu

Pentacerotidae: Kawabisha-ka
Pentaceros japonicus Döderlein: Tsubodai

Percichthyidae: Suzuki-ka
Doederleinia berycoides (Hilgendorf): Akamutsu
Malakichthys elegans Matsubara et Yamaguti: Nagaoomehata
Malakichthys griseus Döderlein: Oomehata
Malakichthys wakiyae Jordan et Hubbs: Wakiyahata
Synagrops japonicus (Steindachner et Döderlein): Sumikuiuo
Synagrops philippinensis (Günther): Himesumikuiuo

Serranidae: Hata-ka
Plectranthias anthioides (Günther): Izuhanadai

Cepolidae: Akatachi-ka
Owstonia grammodon (Fowler): Sokoamadaimodoki

Champsodontidae: Wanigisu-ka
Champsodon guentheri Regan: Kurowanigisu
Champsodon snyderi Franz: Wanigisu

Uranoscopidae: Mishimaokoze-ka
Gnathagnus elongatus (Temminck et Schlegel): Aomishima

Blennioidei: Ginpo-amoku
Percophididae: Hokaketoragisu-ka
Bembrops filodorsalis Okada et Suzuki: Itohikiaitoragisu
Bembrops curvatura Okada et Suzuki: Namiaitoragisu

Ophidioidei: Ashiro-amoku
Ophidiidae: Ashiro-ka
Neobythites fasciatus Smith et Radcliffe: Shimaitachiuo
Homostolus japonicus Matsubara: Itohikiaitachiuo
Gliptophidium oceanicum Smith et Radcliffe: Shirochōman
Hoplobrotula armata (Temminck et Schlegel): Yoroiitachiuo

Tetraodontiformes: Fugu-moku
Balistoidei: Mongarakawahagi-amoku
Triacanthodidae: Benikawamuki-ka
Atrophacanthus japonicus (Kamohara): Ukeguchikawamuki
Macrorhamphosodes uradoi (Kamohara): Fuekawamuki

Tetraodontoidei: Fugu-amoku
Tetraodontidae: Fugu-ka
Liosaccus pachygaster (Müller et Troschel): Yoritofugu

Scorpaeniformes: Kasago-moku
Cottoidei: Kajika-amoku
Cottidae: Kajika-ka
Stlengis osensis Jordan et Starks: Kushikajika
Stlengis masakia (Jordan et Starkes): Urokokajika
Cottunculus brephocephalus Jordan et Starks: Bōzukajika

Agonidae: Tokubire-ka
Percis matsuii Matsubara: Tonboinugochi

Scorpaenidae: Fusakasago-ka
Helicolenus hilgendorfi (Steindachner et Döderlein): Yumekasago
Lioscorpius longiceps Günther: Yaseakakasago
Setarches longimanus (Alcock): Akakasago

Hoplichthyidae: Harigochi-ka
Hoplichthys filamentosus Matsubara et Ochiai: Itoharigochi
Hoplichthys regani Jordan et Richardson: Harigochi

Triglidae: Hōbō-ka
Lepidotrigla spiloptera Günther: Tsuranagasokokanagashira
Lepidotrigla guentheri Hilgendorf: Kanado
Lepidotrigla abyssalis Jordan et Starks: Sokokanagashira
Pterygotrigla hemisticta (Temminck et Schlegel): Sokohōbō

Peristediidae: Kihōbō-ka
Satyrichthys murrayi (Günther): Hanabirokihōbō
Satyrichthys amiscus (Jordan et Starks): Higekihōbō
Satyrichthys engyceros (Günther): Sokokihōbō
Peristedion liorhynchus Günther: Moyōkihōbō
Peristedion orientale Temminck et Schlegel: Kihōbō

Pleuronectiformes: Karei-moku
Pleuronectoidei: Karei-amoku
Citharidae: Kokebirame-ka
Kepidoblepharon opthalmolepis (Weber): Urokogarei

Bothidae: Darumagarei-ka
Chascanopsetta lugubris Alcock: Zaragarei

Pleuronectidae: Karei-ka

Dexistes rikuzenius Jordan et Starks: Migigarei
Tanakius kitaharai (Jordan et Starks): Yanagimushigarei

Soleoidei: Ushinoshita-amoku
Cynoglossidae: Ushinoshita-ka
Symphurus orientalis (Bleeker): Azumagarei

Gadiformes: Tara-moku
Gadoidei: Tara-amoku
Moridae: Chigodara-ka
Physiculus japonicus Hilgendorf: Chigodara
Physiculus maximowiczi (Herzenstein): Ezoisoainame
Bregmacerotidae: Saiuo-ka
**Bregmaceros atlanticus* Goode et Bean:

Macrourioidei: Sokodara-amoku
Macrouridae: Sokodaro-ka
Coelorhynchus jordani Smith et Pope: Kyūshūhige
Coel. kishinouyei Jordan et Snyder: Mugurahige
Coel. smithi Gilbert et Hubbs: Kishūhige
Coel. kamoharai Matsubara: Ichimonjihige
Coel. longissimus Matsubara: Tongarihige
Coel. hubbsi Matsubara: Moyōhige
Coel. anatirostris Jordan et Gilbert: Nezumihige
Coel. hige Matsubara: Katahige
Hymenocephalus longiceps Smith et Radcliffe: Wanidara
Hymen. striatissimus Jordan et Gilbert: Suzidara
Nezumia japonica (Matsubara): Kagamihige
Nezumia condylura Jordan et Gilbert: Nezumidara
Hymenogadus kuronumai (Kamohara): Yaridara
Ventrifossa garmani (Jordan et Gilbert): Sagamisokodara

Lophiiformes: Ankō-moku
Lophioidei: Ankō-amoku
Lophiidae: Ankō-ka
Lophiodes moseleyi (Regan): Himeankō
Lophiodes japonicus (Kamohara): Medamaankō

Antennarioidei: Izariuo-amoku
Chaunacidae: Fusaankō-ka
Chaunax fimbriatus Hilgendorf: Fusaankō
Ogcocephalidae: Akagutsu-ka
Malthopsis lutea Alcock: Fūryuuo
Malthopsis jordani Gilbert: Kowanukefūryuuo
Malthopsis annulifera Tanaka: Wanukefūryuuo
Halieutaea stellata (Vahl): Akagutsu
Halieutaea fumosa Alcock: Himeakagutsu
Halicmetes reticulatus Smith et Radcliffe: Amimefūryuuo

sively decreased throughout the study and only 4 were seen in the samples of the last 9 months. Therefore, the list in Table 1 can be regarded as the fauna in the area caught by shrimp Danish seine.

The following orders are richest in species: perciformes (22 spp.), scorpaeniformes (18 spp.) and gadiformes (16 spp.). The family Macrouridae is composed of the most numerous species (14), followed by Ogcocephalidae (6 spp.) and Percichthyidae (6 spp.). The gadiformes with many species, especially macrourids seems to characterize the bottom fish fauna of the continental slope along the Pacific coast of southern Japan (see KUDŌ *et al.*, 1970 and KITAJIMA *et al.*, 1981), as they are rare in the continental shelves nearby, for example the East China Sea.

The appearance of abundant species are summarized in Table 2. Their ranks in abundance

Table 2. Average number of individuals per month ($\bar{X}$) and their ranks (R) of the dominant species for 5 years. n: number of samples.

	1976(n=9)		1977(n=10)		1978(n=7)		1979(n=9)		1980(n=9)	
	$\bar{X}$	R	$\bar{X}$	R	$\bar{X}$	R	$\bar{X}$	R	$\bar{X}$	R
C. albatrossis	1282.2	1	406.3	1	265.0	1	554.3	1	169.3	1
P. orientale	127.2	2	39.6	4	11.3	5	71.8	2	38.8	4
E. lucifer	95.9	3	49.6	2	7.0	6	66.4	3	63.9	3
S. japonicus	76.6	4	46.2	3	51.9	2	27.1	7	33.2	6
C. fimbriatus	41.2	5	9.0	9	3.3	11	4.8	13	8.7	10
A. kagoshimae	30.8	6	10.9	8	3.3	11	10.2	10	4.9	12
V. garmani	16.7	8	17.5	7	5.9	7	26.8	8	35.4	5
C. kamoharai	12.3	10	33.1	5	15.7	3	53.7	4	65.6	2

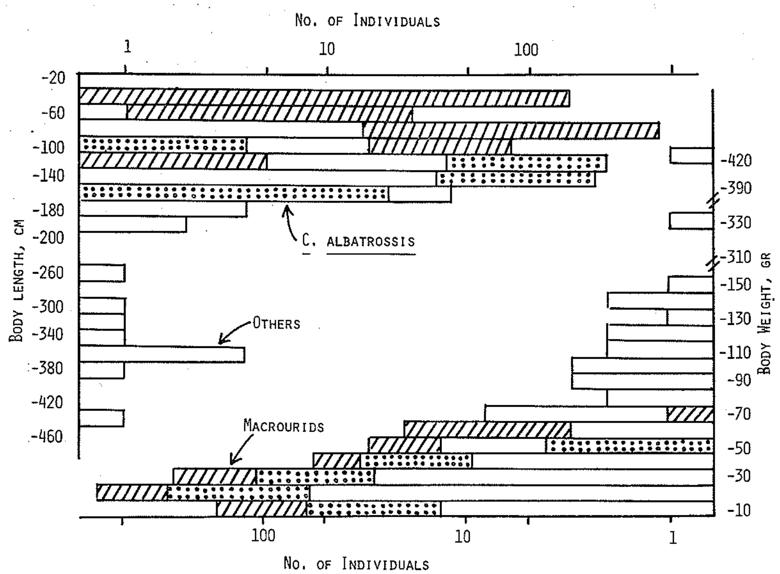

Fig. 2. Frequency distributions of body length and weight based on the sample of July, 1980.

are rather stable throughout the study: a chlorophthalmid *Chlorophthalmus albatrossis* is the most abundant, and a peristediid *Peristedion orientale*, a squalid *Etmopterus lucifer*, a percichthyid *Synagrops japonicus*, and a macrourid *Coelorhynchus kamoharai* occupy higher ranks. The other main species are a argentinid *Argentina kagoshimae*, a macrourid *Ventrifossa garmani* and a chaunacid *Chaunax fimbriatus*.

The frequency distributions of body length and weight of the fishes caught in July of 1980 are shown in Fig. 2. Dominant fishes are *C. albatrossis* and macrourids. Both fishes as well as others are small-sized, and the great majority of fishes are less than 16 cm in body length and 40 gr in weight. Representatives of fishes larger than these sizes are elasmobranchs and anguilliformes. Except for *E. lucifer*, the dominant fishes throughout the study (see Table 2) are nearly equal in size with those shown in Fig. 2. It can be said that the fauna caught by shrimp Danish seine in the study area is dominated by small fishes, namely less than 20 cm in length and 100 gr in weight.

The variation of species composition was estimated by Kimoto's Similarity Index, C_{Π} (KIMOTO, 1967):

$$C_{\Pi}=\frac{2\sum_{i=1}^{S} n_{1i}\cdot n_{2i}}{(\sum \Pi_1^2+\sum \Pi_2^2)N_1\cdot N_2} \qquad 0\leqq C_{\Pi}\leqq 1$$

$$\sum \Pi_1^2=\frac{\sum_{i=1}^{S} n_{1i}^2}{N_1^2}, \qquad \sum \Pi_2^2=\frac{\sum_{i=1}^{S} n_{2i}^2}{N_2^2}$$

where N_1 and N_2, total number of individuals of samples 1 and 2; n_{1i} and n_{2i}, number of individuals of i species of samples 1 and 2; S, number of species.

The indices were calculated with the samples for 6 years from 1976 to 1981 as those of 1975 were concentrated to collect newly appeared fishes. Almost all of the C_{Π} are over 0.5, and

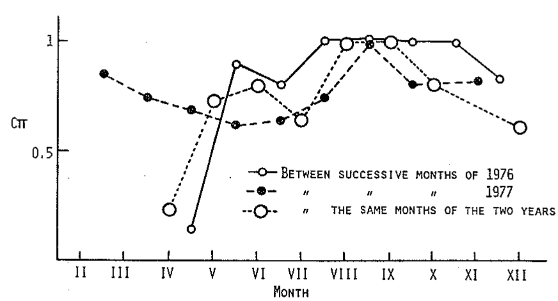

Fig 3. Change of similarity index, C_{Π}, calculated from the monthly samples of 1976 and 1977.

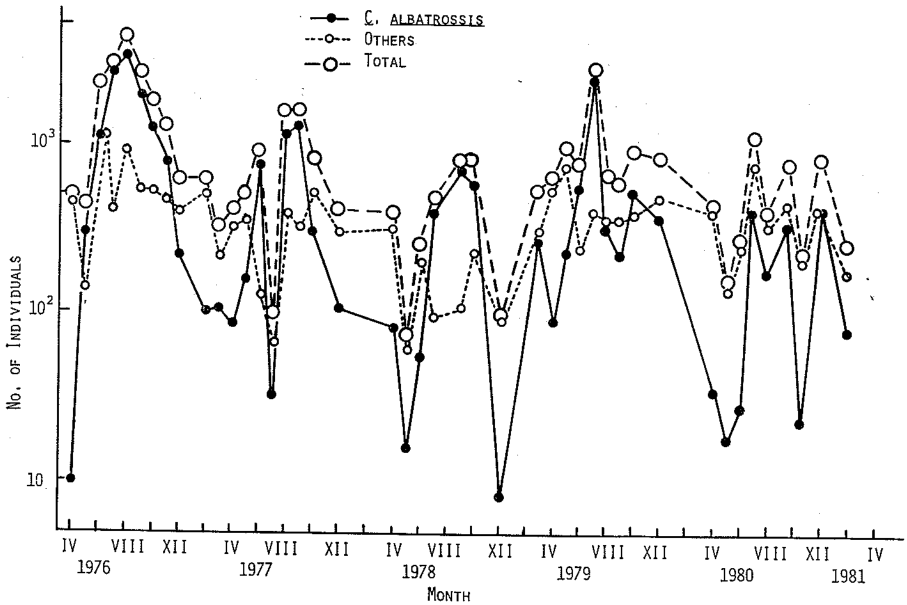

Fig. 4. Fluctuations of monthly catches of total fishes, *C. albatrossis*, and other fishes.

the results of 1976 and 1977 are shown in Fig. 3 as an example. The C_{II} values between months and between years are larger than 0.6 except for those of April, 1976, indicating the close similarities of species composition among samples. It is concluded that the species composition in the study area is almost constant regardless of seasons and years.

Fig. 4 shows monthly change of catches of total fishes, *C. albatrossis* (the most abundant species) and the other fishes from 1976 to 1981. These catches fluctuate largely, and that of *C. albatrossis* is greatest and that of the others is least.

Although some unclearness exists because of sudden increase or decrease as in July of 1977, and of annual variation, there is a large seasonal fluctuation in total fish catches. They are higher in summer and lower in winter, and the summer catches are about 10 times as large as the winter ones every year. On the other hand, year to year fluctuation in catches seems to be less, as indicated by the difference in summer catches that the highest catch (1976) is only 1.5 times the lowest one (1978).

The catches of *C. albatrossis* fluctuate much more markedly in both cases of season and year than those of the total fishes (Fig. 4). For instance, in 1976 the highest catch (September) exceeds 100 times the lowest one (April), and in summer the highest catch (1976) amounts to about 10 times the lowest one (1980). It is clear that seasonal fluctuation is larger than annual one (also see Table 2). The peak abundances of *C. albatrossis* and the total fishes co-occur in every summer. The regression line between them is expressed by

$$y=0.833x-216.9 \quad (n=44;\ r=0.972)$$

where y, number of *C. albatrossis*; x, number of total fishes; n, number of samples; r, correlation coefficient. The regression coefficient, 0.83, explains that the fluctuation of the total catch is caused by that of *C. albatrossis*.

The fluctuation of the catches of other fishes is less than those of total fishes and *C. albatrossis* in both cases of monthly and yearly changes, and any regular seasonal change can not be found (Fig. 4). When these catches are splitted into species, each of the main fishes shows the same level of year to year fluctuation, i. e. about 10 times, with that of *C. albatrossis* (see Table 2).

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枕崎沖陸棚斜面底魚の研究－I

― 魚種構成および個体数変化 ―

小 沢 貴 和*

一連の本研究は枕崎市沖陸棚斜面（300～400m 深）の底魚群集の資源生物学的調査を目的とする。本報告では魚種構成および個体数変化を述べる。1975年より1981年にかけて毎月エビ底曳網で漁獲された魚類を採集し，体長，体重および個体数を調べた。結果を以下に示す。

1. 111種の底魚が出現し，ソコダラ科の種類が最も多い。
2. 最も個体数の多い種はアオメエソで，以下キホウボウ，フジクジラ，スミクイウオ，イチモンジヒゲ，サガミソコダラ，等が多い。大多数は体長 20 cm，体重 100 gr 以下の小型魚である。
3. 種組成は調査期間中ほぼ安定していたと判断される。
4. 全採集個体数とアオメエソ個体数はともに夏期増加冬期減少の傾向がある。即ち，底魚の個体数はアオメエソの変動によって大きく影響されている。

* 鹿児島大学水産学部
〒890 鹿児島市下荒田 4-50-20