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

## — Stomach Content Analysis* —

Takakazu OZAWA** and Hidehiko ZINNO**・***

**Abstract**

Stomachs of 15 bottom fish species in the continental slope off Makurazaki, southern Japan were examined in weight and composition of preys with 643 specimens from seven collections of commercial trawl fishing in 1978. The species were divided into the four feeding categories: nekton feeders- *Etmopterus lucifer*, *Congriscus megastomus*, *Chlorophthalmus albatrossis*, and *Synagrops japonicus*; plankton feeders- *Ventrifossa japonica*, possibly *Hymenogadus kuronumai*, and *Peristedion orientale*; benthos feeders- *Argentina kagoshimae*; and mixed feeders- *Coelorinchus kamoharai*, *Coel. anatirostris*, *Coel. longissimus*, *Ventrifossa garmani*, *Hymenocephalus striatissimus*, *Chaunax fimbriatus* and *Helicolenus hilgendorfi*. Changes of stomach contents with growth of body were recognized in a few species, but those with seasons or collections were not in any species. Among the total food consumed by bottom fishes, nekton, especially fishes occupied the highest ratios in almost all collections. Prey fishes were composed predominantly of mesopelagic ones such as myctophids.

## 1. Introduction

During the last 30 years, bottom fishes below continental shelves have been exploited by commercial fishery in several countries with developed high-sea fishery. Simultaneously, biological studies about them have been progressively accumulated. Stomach contents were examined in many localities such as off northwest Africa (MARSHALL and MERRETT, 1977), off eastern Tasmania (BLABER and BULMAN, 1987), NW Scotland and Bill Bailey Bank (DU BUIT, 1978), off Newfoundland, NW Atlantic Ocean (HOUSTON and HAEDRICH, 1986), off the Mid-Atlantic coast of USA (SEDBERRY and MUSICK, 1978), etc. In these studies, samplings were made only a few times, and rarely monthly or seasonally. Five (SEDBERRY and MUSICK, 1978) or four (GORDON, 1979) possible routes were speculated whereby organic materials from euphotic zone or of terrestrial origin might reach sea bed. According to many studies cited just above, the active transfer by organisms seems the dominant one in the routes for energetic resources of bottom fishes. For example, DU BUIT (1978) showed that 62% of food is of nektonic origin, and BLABER and BULMAN (1987) emphasized the transport of energy to benthos by vertical migration of organism.

In Japan, studies on the bottom fishes deeper than continental shelves are rare, and only one on stomach content analysis of all kinds of fishes (KUDO *et al.*, 1970). As a series of the studies on biology of bottom fishes of continental slope off Makurazaki, southern Japan, OZAWA (1983) reported the faunal composition and the variation of abundance, and the present authors examined the stomach content of 15 species caught almost monthly, the overall food composition of bottom fishes, and the prey-predator relationship in bottom fishes.

## 2. Materials and Methods

The fishing ground is located at the south of Makurazaki, southern Japan, its depth ranging

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** Faculty of Fisheries, Kagoshima University, Shimo-arata, Kagoshima 890, Japan.
*** Present address: Toshima District Fisheries Technique Improvement Center of Hokkaido, 15-18 Suehiro-cho, Hakodate 040, Japan.

from 300 to 400m (see fig. 1 of OZAWA, 1983). Bottom fishes were caught by commercial fishing boats of about 10 tons in size and with 40 to 70HP engines. Operations were usually done five times a day during daytime. The gear and fishing method are given by OZAWA (1983).

Collections of study materials were made seven times from April to December, 1978 (see Table 2). For the stomach content study, specimens of eight dominant species and seven species of the most speciose family Macrouridae (OZAWA, 1983) were sampled from the first four tows in each collection. Fishes with everted stomachs were excluded. All of the fishes of the last tow were sampled as a representative of biomass in each collection. Therefore, number of specimens for stomach content study was different from, and had a possibility to be more numerous than, that for a representative of biomass (see N and NP in Tables 2–13).

The species studied are a squalid *Etmopterus lucifer* Jordan et Snyder, a congrid *Congriscus megastomus* (Günther), an argentinid *Argentina kagoshimae* Jordan et Snyder, a chlorophthalmid *Chlorophthalmus albatrossis* Jordan et Starks, seven macrourids *Coelorinchus kamoharai* Matsubara, *Coel. anatirostris* Jordan et Gilbert, *Coel. longissimus* Matsubara, *Ventrifossa japonica* (Matsubara), *Vent. garmani* (Jordan et Gilbert), *Hymenocephalus striatissimus* Jordan et Gilbert and *Hymenogadus kuronumai* (Kamohara), a chaunacid *Chaunax fimbriatus* Hilgendorf, a percichthyid *Synagrops japonicus* (Steindachner et Döderlein), a scorpaenid *Helicolenus hilgendorfi* (Steindachner et Döderlein), and a peristediid *Peristedion orientale* Temminck et Schlegel.

Specimens for stomach content study were preserved in 20% formalin immediately after collection. In the laboratory, their body length and wet weight were measured, stomachs were cut open, and food items were sorted by taxa, counted and weighted in wet condition. For animals such as small crustaceans and polychaetes which were usually found as fragments, numerical abundance was estimated by counting special parts such as eyes (crustaceans) in fragments. Stomach contents which were fluid and had no fragments even by microscope observation were classified as digested. Stomachs shrinking and without food were regarded as empty. Prey were identified to the possible lowest taxonomic category, and divided into three food types (plankton, benthos and nekton) according to the outlines of Hokuryu-kan's New Illustrated Encyclopedia of the Fauna of Japan (OKADA *et al.*, 1969a, b, c), and Aquatic Invertebrate Zoology (SIINO, 1979).

Gravimetric, frequency of occurrence, numerical and calorific methods have been used for analysis of stomach contents. Irrespective of methods, criterion to allocate predators to particular feeding type seems to have been rarely defined. In this study where gravimetric and numerical data were obtained, gravimetric ones are mainly used for expression of the degree of dependance on food, being supplemented by presenting prey items dominant in number. Further, the criterion of allocation to a feeding type is set at about 70% occupation in weight of particular food type as in the case of KUDŌ *et al.* (1970).

Stomach contents were analyzed with respect to time (collection) and fish size (body weight). The ranges of body weight were arranged to include nearly the same number of specimens in each range.

Fishes of the last tow for a representative of biomass were preserved in 10% formalin on board, and sorted, counted and weighted in wet condition in the laboratory.

## 3. Results

### 3–1. Food organisms

Food organisms in stomach contents were identified to 8 classes, 16 orders, 29 families, 15 genera, and 7 species (Table 1). In the Mysidacea, appeared dominantly three lophogastrid species *Lophogaster pacificus*, *L. japonicus* and *Lophogaster* sp. (Murano, 1970), and mysinaed tribe Erythropini. In the Euphausiacea, euphausiids *Euphausia* species such as *E. nana* occurred abundantly. Sergestid *Sergestis* sp., pandalid *Heterocarpus sibogae*, and penaeids were dominant in the Macrura. Most of the prey fishes were identified to species.

### 3–2. Stomach contents

(1) *Etmopterus lucifer*. The total number of specimens for a representative of biomass from

Table 1. List of prey organisms. Capitals in the parenthesis indicate the food types (B, benthic; BP, benthopelagic; N, nektonic; P, planktonic; and PE, pelagic) inclusive of organisms lower than the systematic level with a capital. BP and PE follows the division by HOUSTON and HAEDRICH (1986).

| | | | |
|---|---|---|---|
| 1. | Sarcodina (B) | 5-6. | Isopoda (B or BP) |
| 1-1. | Rhizopoda | 5-6-1. | Flabellifera |
| 1-1-1. | Forminifera | 5-6-1-1. | Cymothoidae |
| | | 5-7. | Amphipoda |
| 2. | Anthozoa (B) | 5-7-1. | Gammaridea (B) |
| 2-1. | Hexacorallia | 5-7-2. | Hyperiidea (P) |
| 2-1-1. | Actiniaria | 5-7-2-1. | Phronimidae |
| | | 5-7-2-2. | Hyperiidae |
| 3. | Polychaeta (B) | 5-7-2-3. | Ancylomeridae |
| 3-1. | Errantia | 5-8. | Euphausiacea (P) |
| 3-1-1. | Aphroditidae | 5-8-1. | Euphausiidae |
| 3-1-2. | Amphinomidae | 5-8-1-1. | *Euphausia nana* |
| 3-1-3. | Nereidae | 5-8-1-2. | *Euphausia* sp. |
| 3-1-4. | Glyceridae | 5-8-1-3. | *Thysanopoda* sp. |
| 3-1-5. | Eunicidae | 5-9. | Decapoda |
| 3-2. | Sedentaria | 5-9-1. | Macrura (B) |
| | | 5-9-1-1. | Sergestidae (PE) |
| 4. | Cephalopoda (N) | 5-9-1-1-1. | *Sergestes* sp. |
| 4-1. | Tetrabranchia | 5-9-1-2. | Pandalidae |
| 4-1-1. | Decapoda | 5-9-1-2-1. | *Heterocarpus sibogae* |
| 4-1-2. | Octopoda | 5-9-1-3. | Penaeidae (PE) |
| 4-1-2-1. | Octopodidae | 5-9-2. | Anomura (B) |
| | | 5-9-3. | Bracyura (B) |
| 5. | Crustacea | | |
| 5-1. | Ostracoda (P or BP) | 6. | Ophiuroidea (B) |
| 5-1-1. | Myodocopa | 6-1. | Ophiurida |
| 5-1-1-1. | Cypridinidae | 6-1-1. | Ophiolepididae |
| 5-2. | Copepoda (P) | | |
| 5-2-1. | Calanoida | 7. | Urochorda (B) |
| 5-3. | Malacostraca | 7-1. | Ascidiacea |
| 5-3-1. | Mysidacea (P or BP) | | |
| 5-3-1-1. | Lophogastrida | 8. | Pisces (N) |
| 5-3-1-1-1. | Lophogastridae | 8-1. | Gonostomatidae |
| 5-3-1-1-1-1. | *Lophogaster pacificus* | 8-1-1. | *Maurolicus muelleri* |
| 5-3-1-1-1-2. | *Lophogaster japonicus* | 8-2. | Sternoptychidae |
| 5-3-1-1-1-3. | *Lophogaster* sp. | 8-2-1. | *Polyipnus* sp. |
| 5-3-1-2. | Mysida | 8-3. | Melanostomiidae |
| 5-3-1-2-1. | Petalophtalmidae | 8-4. | Myctophidae |
| 5-3-1-2-2. | Mysidae | 8-4-1. | *Diaphus* sp. |
| 5-3-1-2-2-1. | Boreomysinae | 8-4-2. | *Benthosema* sp. |
| 5-3-1-2-2-2. | Siriellinae | 8-4-3. | *Myctophum* sp. |
| 5-3-1-2-2-3. | Mysinae | 8-5. | Congridae |
| 5-3-1-2-2-3-1. | Erythropini | 8-5-1. | *Congriscus megastomus* |
| 5-4. | Cumacea (B) | 8-6. | Cynoglossidae |
| 5-4-1. | Diastylidae | 8-7. | Bregmacerotidae |
| 5-4-2. | Lampropidae | 8-7-1. | *Bregmaceros* sp. |
| 5-4-2-1. | *Lampros* sp. | 8-8. | Macrouridae |
| 5-5. | Tanaidacea (B) | 8-8-1. | *Coelorinchus kamoharai* |

the last tows was 49 from five collections, July 20 and October 26 having caught no specimen. Stomach contents of 70 specimens from seven collections were examined (Table 2). Body weight of specimens (B) and percent of stomach content weight to body weight (SW) were highly varied in and among collections. The average SW (0.7–10) were relatively large compared with other species. Empty stomachs were none in four collections, and 6–10% in three. Food organisms were dominated by nekton in weight, especially fishes in all collections: two collections (May 31 and July 4) showed broad food spectrum with about 50% occupation in weight (R) of other two food types, but the rest five exclusive preference of nekton (more than 79% R). In number, plankton, especially *Lophogaster* dominated in some collections. The analysis by fish body weight (Table 14) also indicated the species to be nekton feeder, though other two food types occupying higher ratios in smaller fishes than larger ones. SW was nearly similar throughout fish sizes.

KUDŌ *et al.* (1970) reported the species seemingly to be fish feeder.

(2) *Congriscus megastomus*. The number of specimens for a representative of biomass was only five from two collections (Table 3). Stomach contents of 48 specimens from five collections were examined. Body weight of the specimens was nearly constant both in averages and ranges except April 19 showing large weight both in average and range. The average SW (2.6–16) was the highest among bottom fishes studied, though highly different among specimens. Empty stomachs were less than 7% except 33% of April 19. Food organisms were exclusively nekton, especially fishes, except July 20 when other two food types occupied about 55% and SW lowered exceedingly. Comparison of food types between two size classes (Table 14) showed high dependance on nekton and large SW.

KUDO *et al.* (1970) reported that the occurrence of fishes, especially myctophids was high, being followed by cephalopods and macruras in the stomachs of the species.

(3) *Argentina kagoshimae*. Twenty specimens were caught for a representative of biomass from four collections (Table 4). Stomach contents were analyzed with 51 specimens from five collections. Body weight of the specimens was almost constant both in averages and ranges. SW was almost constant but very low, less than 0.55 in average and 1.08 in maximum, in all collec-

Table 2. *Etmopterus lucifer*. Abbreviations are: N, the number of specimens for stomach content analysis; NP, the number of specimens for representative biomass; B, body weight in gram; SW, percent of stomach content weight to B; ES, frequency (%) of empty stomach; R, ratio (%) among food types in weight; and PD, prey items dominant in weight (those dominant in number in parenthesis).

| Dates | IV/19 | V/31 | VII/4 | VII/20 | IX/5 | X/26 | XII/22 |
|---|---|---|---|---|---|---|---|
| N | 10 | 14 | 18 | 1 | 13 | 4 | 10 |
| NP | 2 | 20 | 12 | 0 | 12 | 0 | 3 |
| B (average) | 41.8 | 43.1 | 14.7 | 110.5 | 35.0 | 25.7 | 51.8 |
| B (min.) | 6.6 | 14.8 | 11.4 | 110.5 | 14.3 | 13.0 | 8.6 |
| B (max.) | 163.0 | 104.6 | 19.9 | 110.5 | 91.0 | 51.0 | 121.5 |
| SW (average) | 6.9 | 1.0 | 2.7 | 10.3 | 0.7 | 5.1 | 1.2 |
| SW (min.) | 0 | 0.1 | 0 | 10.3 | 0 | 0.1 | 0 |
| SW (max.) | 17.6 | 3.7 | 6.6 | 10.3 | 1.7 | 18.1 | 6.4 |
| ES | 0 | 0 | 5.6 | 0 | 7.7 | 0 | 10.0 |
| R (Plankton) | 5.8 | 18.7 | 21.9 | 0 | 14.1 | 2.3 | 10.3 |
| R (Benthos) | 0.1 | 30.8 | 29.7 | 0.5 | 7.0 | 0 | 0.3 |
| R (Nekton) | 94.1 | 50.5 | 48.4 | 99.5 | 78.9 | 97.7 | 89.4 |
| | Fishes (Crustacea) | Decapoda & Macrura (*Euphausia* sp.) | Fishes (*Lophogaster* sp.) | Fishes | Fishes | Decapoda (*Lophogaster* sp.) | Cephalopoda (*Lophogaster* sp.) |

Table 3. *Congriscus megastomus*. For the abbreviations, see Table 2.

| Dates | IV/19 | VII/4 | VII/20 | IX/5 | XII/22 |
|---|---|---|---|---|---|
| N | 3 | 10 | 18 | 2 | 15 |
| NP | 0 | 3 | 2 | 0 | 0 |
| B (average) | 227.8 | 25.7 | 29.4 | 20.4 | 39.8 |
| B (min.) | 53.0 | 16.7 | 16.2 | 19.7 | 25.3 |
| B (max.) | 456.5 | 30.0 | 43.9 | 21.2 | 53.5 |
| SW (average) | 16.5 | 11.7 | 2.6 | 14.5 | 8.6 |
| SW (min.) | 0.0 | 2.2 | 0.0 | 4.6 | 0.0 |
| SW (max.) | 46.1 | 20.8 | 8.4 | 24.5 | 19.1 |
| ES | 33.3 | 0 | 5.6 | 0 | 6.7 |
| R (Plankton) | 0 | 2.2 | 19.2 | 2.3 | 0.4 |
| R (Benthos) | 0 | 25.4 | 35.8 | 0.5 | 5.5 |
| R (Nekton) | 100 | 72.4 | 45.0 | 97.2 | 94.0 |
| PD | Fishes | Fishes (*Lophogaster* sp.) | Fishes & Macrura | Decapoda | Fishes |

Table 4. *Argentina kagoshimae*. For the abbreviatons, see Table 2.

| Dates | IV/19 | V/31 | VII/20 | IX/5 | X/26 |
|---|---|---|---|---|---|
| N | 4 | 14 | 20 | 12 | 1 |
| NP | 1 | 2 | 4 | 13 | 0 |
| B (average) | 29.2 | 29.5 | 32.9 | 38.5 | 38.3 |
| B (min.) | 26.0 | 23.2 | 10.2 | 24.7 | 38.3 |
| B (max.) | 34.7 | 38.2 | 63.5 | 62.5 | 38.3 |
| SW (average) | 0.4 | 0.3 | 0.4 | 0.5 | 0.6 |
| SW (min.) | 0.1 | 0.1 | 0.1 | 0.1 | 0.6 |
| SW (max.) | 0.8 | 0.6 | 0.7 | 1.1 | 0.6 |
| ES | 0 | 0 | 0 | 0 | 0 |
| R (Plankton) | 0 | 0 | 0.6 | 0.2 | 0 |
| R (Benthos) | 100 | 100 | 99.4 | 99.8 | 100 |
| R (Nekton) | 0 | 0 | 0 | 0 | 0 |
| PD | Ophiuroidea | Ophiuroidea | Errantia (Gammaridea) | Ophiuroidea | Nereidae & Sedentaria |

tions, and no empty stomach occurred. Food organisms were almost exclusively, about 100% benthos, especially ophiuroids. Therefore, analysis byfish size brought the same results on food type and SW (Table 14).

The specimens from the East China Sea fed mainly on euphausiids, followed by amphipods and copepods (YAMADA, 1986). On the related Japanese species *Glossanodon semifasciatus*, was reported that its main prey were euphausiids in Hyuga Nada, polychaetes in Tosa Bay (KUDŌ *et al.*, 1970), and euphausiids, amphipods, copepods and smaller fishes in the East China Sea (YAMADA, 1986). It will be an interesting study to find out the reasons why these species show clearly different food preference among places.

(4) *Chlorophthalmus albatrossis*. The species was always the most dominant for a representative of biomass, a total of 1851 specimens being caught from seven collections (Table 5). One hundred and ten specimens were used for stomach content analysis. Their body weight became larger in summer (July 20 and September 5) than other seasons in averages and ranges. Average SW changed irregularly between the lowest (0.1) on December 22 and the highest (2.6) on July 4. Empty stomachs were none in five collections and about 7% in two. Prey organisms were

Table 5. *Chlorophthalmus albatrossis*. For the abbreviations, see Table 2.

| Dates | IV/19 | V/31 | VII/4 | VII/20 | IX/5 | X/26 | XII/22 |
|---|---|---|---|---|---|---|---|
| N | 16 | 14 | 13 | 14 | 13 | 14 | 26 |
| NP | 82 | 16 | 55 | 396 | 711 | 583 | 8 |
| B (average) | 21.2 | 25.3 | 25.1 | 36.0 | 32.3 | 26.1 | 18.4 |
| B (min.) | 11.0 | 16.9 | 15.0 | 24.3 | 22.8 | 18.5 | 11.6 |
| B (max.) | 39.8 | 37.8 | 41.7 | 49.2 | 45.8 | 38.0 | 29.9 |
| SW (average) | 1.1 | 0.4 | 2.6 | 0.2 | 1.6 | 1.1 | 0.1 |
| SW (min.) | 0.0 | 0.0 | 0.3 | 0.1 | 0.1 | 0.1 | 0.0 |
| SW (max.) | 5.5 | 1.3 | 5.4 | 0.5 | 5.5 | 5.1 | 0.7 |
| ES | 6.3 | 0 | 0 | 0 | 0 | 0 | 7.7 |
| R (Plankton) | 11.7 | 34.2 | 7.0 | 0 | 1.6 | 0 | 20.1 |
| R (Benthos) | 4.6 | 3.6 | 22.9 | 2.3 | 0.8 | 4.1 | 6.0 |
| R (Nekton) | 83.7 | 62.2 | 70.1 | 97.7 | 97.6 | 95.9 | 73.8 |
| PD | Fishes (Forminifera) | Fishes & *Euphausia* sp. | Fishes | Fishes | Fishes | Fishes | Fishes |

predominantly nekton (62–98% R), especially fishes in all collections with plankton and benthos occupying 20–34% in three collections. The analysis by fish size (Table 14) indicated that both nekton preference and average SW became larger with the growth of fish.

The specimens from Tosa Bay fed the most frequently on small macruras, together with euphausiids and small fishes such as myctophids (KUDŌ *et al.*, 1970).

(5) *Coelorinchus kamoharai*. The species appeared the most abundantly for a representative of biomass among macrourids (Table 6). Stomach contents were examined with 45 specimens from six collections. Body weight of specimens was nearly constant both in averages and ranges throughout collections. Empty stomach was none, and SW was varied irregularly in averages and ranges with the least value of 0.15 and the highest of 6.69. Food types were also not constant: nekton, especially fishes highly dominated on July 4, September 5 and October 26, but none on July 20 and December 22 when benthos were main food items. Plankton also occupied significant ratios in four collections. Therefore, the species can be regarded as generalist in feeding. The analysis by fish size (Table 14) showed that food type progressively transferred from plankton via benthos to nekton, and SW became higher with the growth of fish. These seem to have resulted partly from low SW and high R of plankton and benthos for many smaller fishes on July 4 (Table 6).

OKAMURA (1970) recorded, in the order of numerical abundance, euphausiids, isopodes, fishes, squids and polycaetes from the stomachs of 15 specimens of the species.

Among continental slope bottom fishes, macrourids have received special interest because of their abundance in biomass and species. Most of them are considered generalists in feeding with a few specialists (PEARCY and AMBLER, 1974; MARSHALL and MERRETT, 1977; MCLELLAN, 1977; HUREAU *et al.*, 1979; MAUCHLINE and GORDON, 1984). It is also supported by the present study: among the seven species studied, *C. kamoharai* shown here is the typical generalist consuming almost equally three food types, and *Ventrifossa japonica* and possibly *Hymenogadus kuronumai* the specialist, with the rest four species feeding on two food types (see below).

(6) *Coelorinchus anatirostris*. The species was the second abundant fishes for a representative of biomass among macrourids (Table 7). A total of 25 specimens from six collections were used for stomach content analysis. Their body weight changed irregularly both in averages and ranges. SW was low both in averages and ranges, and empty stomach was none. Main food type was apparently benthos, especially polycaete Eunicidae in three collections, but nekton in two when the specimens were very few. Plankton were fed significantly except two collections when only one specimen was examined.

Table 6. *Coelorinchus kamoharai*. For the abbreviations, see Table 2.

| Dates | IV/19 | VII/4 | VII/20 | IX/5 | X/26 | XII/22 |
|---|---|---|---|---|---|---|
| N | 1 | 2 | 16 | 7 | 15 | 4 |
| NP | 6 | 3 | 4 | 7 | 79 | 6 |
| B (average) | 40.2 | 30.8 | 23.6 | 32.6 | 28.9 | 36.0 |
| B (min.) | 40.2 | 22.9 | 13.8 | 15.3 | 19.3 | 22.3 |
| B (max.) | 40.2 | 38.7 | 42.4 | 71.0 | 52.5 | 48.2 |
| SW (average) | 0.2 | 2.5 | 0.3 | 1.6 | 1.2 | 0.2 |
| SW (min.) | 0.2 | 1.1 | 0.1 | 0.4 | 0.2 | 0.2 |
| SW (max.) | 0.2 | 3.8 | 0.7 | 6.7 | 6.7 | 0.2 |
| ES | 0 | 0 | 0 | 0 | 0 | 0 |
| R (Plankton) | — | 11.1 | 48.3 | 0.0 | 25.2 | 23.6 |
| R (Benthos) | — | 2.9 | 51.7 | 5.6 | 12.6 | 76.4 |
| R (Nekton) | — | 86.1 | 0 | 94.3 | 62.3 | 0 |
| PD | Crustacea | Fishes (Gammaridea) | *Lophogaster* sp. & Errantia (Gammaridea) | Fishes (Calanoidea) | Fishes (Gammaridea) | Gammaridea |

Table 7. *Coelorinchus anatirostris*. For the abbreviations, see Table 2.

| Dates | IV/19 | V/31 | VII/4 | IX/5 | X/26 | XII/22 |
|---|---|---|---|---|---|---|
| N | 11 | 1 | 5 | 1 | 2 | 5 |
| NP | 64 | 2 | 19 | 0 | 2 | 3 |
| B (average) | 13.3 | 30.1 | 12.6 | 24.5 | 38.2 | 26.7 |
| B (min.) | 11.7 | 30.1 | 9.5 | 24.5 | 35.8 | 19.1 |
| B (max.) | 15.4 | 30.1 | 14.9 | 24.5 | 40.6 | 50.5 |
| SW (average) | 0.6 | 0.5 | 0.8 | 1.0 | 0.4 | 0.9 |
| SW (min.) | 0.1 | 0.5 | 0.2 | 1.0 | 0.2 | 0.4 |
| SW (max.) | 1.1 | 0.5 | 1.8 | 1.0 | 0.6 | 1.6 |
| ES | 0 | 0 | 0 | 0 | 0 | 0 |
| R (Plankton) | 14.9 | 0 | 29.0 | 0 | 30.8 | 9.3 |
| R (Benthos) | 85.1 | 100 | 71.0 | 0 | 16.3 | 90.7 |
| R (Nekton) | 0 | 0 | 0 | 100 | 52.9 | 0 |
| PD | Eunicidae | Gammaridea | Eunicidae | Fishes | Fishes (*Lophogaster* sp.) | Eunicidae (Gammaridea) |

The analysis by fish size indicated the species to be benthos feeder (Table 14). The species is a benthos feeder supplemented by nekton and plankton.

The species was reported to feed mainly on amphipods with a few example of polychaete and euphausiid ingestion (KUDŌ *et al.*, 1970). OKAMURA (1970) listed three kinds of preys, polycaetes (55% in number), euphausiids (29%) and fishes (16%) from 16 stomachs of the species.

(7) *Coelorinchus longissimus*. The specimens were small in number both for a representative of biomass (13 from two collections) and stomach content analysis (10 from four) (Table 8). Body weight of specimens was almost constant both in averages and ranges throughout collections. SW was also constant except July 4 with only one specimen and highest among macrourids, and empty stomach was none. Food types were dominated by benthos in two collections and by plankton in one, and were shared in equal ratios with them in the rest. Nekton was rarely ingested. Therefore, the species can be considered benthos and plankton feeder. The analysis by

Table 8. *Coelorinchus longissimus* and *Ventrifossa japonica.* For the abbreviations, see Table 2.

| Dates | *Coelorinchus longissimus* IV/19 | V/31 | VII/4 | VII/20 | *Ventrifossa japonica* VII/4 | XII/22 |
|---|---|---|---|---|---|---|
| N | 2 | 4 | 1 | 3 | 2 | 1 |
| NP | 12 | 0 | 1 | 0 | 0 | 0 |
| B (average) | 38.3 | 35.0 | 42.4 | 44.4 | 12.9 | 29.8 |
| B (min.) | 37.6 | 21.5 | 42.4 | 22.8 | 11.8 | 29.8 |
| B (max.) | 39.1 | 50.5 | 42.4 | 60.5 | 14.0 | 29.8 |
| SW (average) | 1.3 | 1.3 | 4.1 | 2.0 | 1.4 | 1.1 |
| SW (min.) | 0.8 | 0.3 | 4.1 | 0.3 | 1.1 | 1.1 |
| SW (max.) | 1.8 | 3.6 | 4.1 | 5.3 | 1.7 | 1.1 |
| ES | 0 | 0 | 0 | 0 | 0 | 0 |
| R (Plankton) | 95.8 | 7.1 | 6.3 | 48.3 | 100 | 90.7 |
| R (Benthos) | 4.2 | 92.9 | 89.7 | 51.7 | 0 | 3.1 |
| R (Nekton) | 0 | 0 | 4.0 | 0 | 0 | 6.2 |
| PD | Crustacea | Crustacea (Gammaridea) | Macrura | Macrura | *Lophogaster* sp. | *Lophogaster* sp. |

fish size was not done because of scarcity of specimens.

OKAMURA (1970) found euphausiids (84% in number) and polychaetes (16%) in four stomachs of the species.

(8) *Ventrifossa japonica.* The specimens were none for a representative of biomass and only three for stomach content analysis (Table 8). Though limited in samples, the species fed exclusively on plankton, especially *Lophogaster* sp. The analysis by fish size was not done because of scarcity of specimens.

(9) *Ventrifossa garmani.* The specimens were rarely caught: 22 for a representative of biomass and only four for stomach content analysis from three collections (Table 9). Plankton, especially *Lophogaster* sp. occupied 50–82% of R, benthos 19–50%, and nekton 0%. Gammaridea occurred as dominant prey in number in all collections. The species is a plankton feeder supplemented by benthos. Stomach contents were not analyzed by fish size because of scarcity of specimens.

KUDŌ *et al.* (1970) reported that in the stomachs of the species, euphausiids occurred frequently, macruras relatively frequently, and myctophid fishes in only larger specimens.

(10) *Hymenocephalus striatissimus.* Only 15 specimens for a representative of biomass and three for stomach content analysis were collected from two collections (Table 9). SW was quite low, and main food types were different between collections: plankton on July 4 with 30% R of benthos, and completely benthos at September 5. Nekton did not appear at all in the stomachs. Though limited in the specimens, the species seems plankton and benthos feeder.

KUDŌ *et al.* (1970) reported that euphausiids and macruras occurred frequently in the stomachs of the species. OKAMURA (1970) recorded euphausiids (89% in number) and fishes (11%) from 20 stomachs of the species.

(11) *Hymenogadus kuronumai.* The species was caught only at December 22: 21 specimens for a representative of biomass and three for stomach content analysis (Table 9). The main food type was plankton (84%) followed by benthos (16%). The species is tentatively considered a plankton feeder because of scarcity of specimens.

OKAMURA (1970) found only euphausiids in 15 stomachs of the species.

(12) *Chaunax fimbriatus.* Twenty three specimens were caught for a representative of biomass from six collections (Table 10). Stomach contents were analyzed with 55 specimens from all collections. Body weight of the specimens and SW were highly varied irregularly both in averages and ranges among collections. Empty stomachs occurred in high rates (28–56%) with

Table 9. *Ventrifossa garmani*, *Hymenocephalus striatissimus* and *Hymenogadus kuronumai*. For the abbreviations, see Table 2.

| | *Ventrifossa garmani* | | | *Hymenocephalus striatissimus* | | *Hymenogadus kuronumai* |
|---|---|---|---|---|---|---|
| Dates | IV/19 | V/31 | XII/22 | VII/4 | IX/5 | XII/22 |
| N | 2 | 1 | 1 | 2 | 1 | 3 |
| NP | 7 | 9 | 6 | 13 | 2 | 21 |
| B (average) | 12.2 | 9.7 | 15.8 | 5.4 | 13.4 | 14.6 |
| B (min.) | 12.0 | 9.7 | 15.8 | 4.8 | 13.4 | 10.7 |
| B (max.) | 12.4 | 9.7 | 15.8 | 6.0 | 13.4 | 19.0 |
| SW (average) | 0.9 | 0.6 | 1.3 | 0.8 | 0.5 | 1.9 |
| SW (min.) | 0.5 | 0.6 | 1.3 | 0.8 | 0.5 | 0.4 |
| SW (max.) | 1.2 | 0.6 | 1.3 | 0.8 | 0.5 | 2.9 |
| ES | 0 | 0 | 0 | 0 | 0 | 0 |
| R (Plankton) | 72.7 | 81.1 | 50.0 | 70.8 | 0 | 84.0 |
| R (Benthos) | 27.3 | 18.9 | 50.0 | 29.2 | 100 | 16.0 |
| R (Nekton) | 0 | 0 | 0 | 0 | 0 | 0 |
| PD | *Lophogaster* sp. (Gammaridea) | *Lophogaster* sp. (Gammaridea) | *Lophogaster* sp. (Gammaridea) | *Lophogaster* sp. (Gammaridea) | Gammaridea | *Lophogaster* spp.(Gammaridea) |

Table 10. *Chaunax fimbriatus*. For the abbreviations, see Table 2.

| Dates | IV/19 | V/31 | VII/4 | VII/20 | IX/5 | X/26 | XII/22 |
|---|---|---|---|---|---|---|---|
| N | 7 | 3 | 2 | 18 | 10 | 6 | 9 |
| NP | 5 | 0 | 1 | 6 | 1 | 7 | 3 |
| B (average) | 128.9 | 46.3 | 24.9 | 25.2 | 25.1 | 50.4 | 22.2 |
| B (min.) | 11.7 | 10.3 | 18.1 | 8.5 | 8.5 | 17.3 | 12.6 |
| B (max.) | 418.0 | 90.5 | 31.7 | 62.5 | 84.5 | 103.0 | 41.1 |
| SW (average) | 1.1 | 5.6 | 0.7 | 0.6 | 0.4 | 0.0 | 0.7 |
| SW (min.) | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| SW (max.) | 5.8 | 16.8 | 1.3 | 3.2 | 3.2 | 0.1 | 5.3 |
| ES | 42.9 | 33.3 | 0 | 27.8 | 40.0 | 50.0 | 55.6 |
| R (Plankton) | 0 | 0 | 0 | 6.1 | 1.3 | 20.0 | 2.4 |
| R (Benthos) | 0.6 | 0 | 100 | 23.8 | 18.2 | 80.0 | 6.4 |
| R (Nekton) | 99.4 | 100 | 0 | 70.1 | 80.5 | 0 | 91.2 |
| PD | Fishes | Octopoda | Errantia | Octopoda (Errantia) | Fishes | Brachyura | Fishes |

one exception (0%). Main food type was also variable: nekton was main prey in five collections (fishes in three collections and octopods in two), but completely absent in other two collections; benthos was main prey in two collections and occupied 6-24% R in other three; plankton appeared in the last four collections with low rates (1-20% R). The species seems opportunistic feeder depending mainly on nekton and benthos. According to the analysis by fish weight (Table 14), nekton was ingested in the highest rates throughout fish weight, with plankton being preyed in the same rate at the intermediate weight range.

(13) *Synagrops japonicus*. The species was the second abundant fishes for a representative of biomass, 423 specimens in total being caught from six collections (Table 11). Stomach contents were analyzed with 96 specimens from seven collections. Body weight of the specimens was

nearly constant with relatively narrow ranges except the first and last collections. SW was relatively high and constant with relatively narrow ranges throughout collections. Empty stomachs were none except 7% of December 22. Food types were exclusively dominated by nekton, especially fishes with each one dominance of plankton (April 19) and benthos (September 5). In other collections, plankton appeared in low rates (0.2–3.8%) and benthos in moderate rates (2–29%) with 0% of May 31. Stomach content analysis by four fish weight ranges (Table 14) indicated that the species had broad food spectrum with nekton as main food followed by benthos. The high rate (88%) of plankton in the least size range was mainly due to the collection of April 19 (Table 11). That its value (88%) was less than 90% of April 19 means that the smallest fishes do not necessarily prefer plankton. The high abundance of plankton on April 19 seems accidental because other nekton feeders such as *C. albatrossis* and *E. lucifer* did not show any decrease in rates of nekton in that collection.

KUDŌ *et al.* (1970) reported that fishes, especially myctophids and paralepidids appeared frequently in the stomachs of the species with rare cases of ingestion of euphausiids, macruras and cephalopods.

(14) *Helicolenus hilgendorfi.* Only 22 specimens were collected for a representative of biomass from seven collections (Table 12). Stomach contents were examined with 60 specimens from all collections. Body weight in average was relatively similar among collections, but its range was very broad in three collections. SW was relatively low both in averages and ranges with the maximums on September 5. The frequency of empty stomach was about 10% in three collections, and none in other four. Benthos and nekton were the main food types: benthos, especially ophiuroids dominated in six collections; nekton occupied high ratios (29–77%) in four collections with the highest on cap. September 5. Plankton shared the dominance with benthos on May 31, but appeared rarely or not at all in other collections. The species is apparently a benthos and nekton feeder. In the analysis by three body weight classes (Table 14), two smaller classes showed higher ingestion rates of nekton than benthos, but larger class the reverse. The higer rates of nekton seem biased by significantly high SW on September 5 (Tabe 12) compared with other SW.

The species was reported to feed frequently on fishes, especially myctophids with ingestion cases of ophiuroids and macruras (KUDŌ *et al.*, 1970). The congeneric species *H. dactylopterus* from the continental slope of NW Scotland and Bill Bailey Bank was benthos feeder (DU BUIT, 1978), and *H. percoides* from the upper continental slope of eastern Tasmania consumed abundantly

Table 11. *Synagrops japonicus.* For the abbreviations, see Table 2.

| Dates | IV/19 | V/31 | VII/4 | VII/20 | IX/5 | X/26 | XII/22 |
|---|---|---|---|---|---|---|---|
| N | 16 | 8 | 16 | 16 | 13 | 13 | 14 |
| NP | 151 | 0 | 85 | 31 | 16 | 72 | 8 |
| B (average) | 21.8 | 37.8 | 31.8 | 37.3 | 32.3 | 32.6 | 52.7 |
| B (min.) | 12.5 | 13.6 | 16.7 | 24.6 | 14.9 | 17.6 | 31.6 |
| B (max.) | 46.5 | 48.3 | 42.0 | 65.0 | 52.0 | 50.5 | 78.5 |
| SW (average) | 0.7 | 1.1 | 1.4 | 0.9 | 0.8 | 1.3 | 1.3 |
| SW (min.) | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 0.0 |
| SW (max.) | 3.0 | 4.0 | 9.0 | 3.9 | 3.8 | 9.1 | 6.8 |
| ES | 0 | 0 | 0 | 0 | 0 | 0 | 7.1 |
| R (Plankton) | 90.4 | 1.4 | 3.3 | 3.7 | 2.8 | 0.2 | 3.6 |
| R (Benthos) | 8.2 | 0 | 2.0 | 2.8 | 62.0 | 12.5 | 28.8 |
| R (Nekton) | 1.5 | 98.6 | 95.1 | 93.5 | 35.2 | 87.3 | 67.6 |
| PD | Euphausiidae | Fishes | Fishes | Fishes | *Heterocarpus* sp. & Fishes | Fishes | Decapoda & *Heterocarpus* sp. |

Table 12. *Helicolenus hilgendorfi*. For the abbreviations, see Table 2.

| Dates | IV/19 | V/31 | VII/4 | VII/20 | IX/5 | X/26 | XII/22 |
|---|---|---|---|---|---|---|---|
| N | 10 | 5 | 2 | 12 | 12 | 16 | 3 |
| NP | 5 | 1 | 2 | 2 | 9 | 2 | 1 |
| B (average) | 55.8 | 53.0 | 39.1 | 81.5 | 54.2 | 44.4 | 66.8 |
| B (min.) | 23.7 | 22.2 | 34.4 | 23.7 | 24.5 | 14.6 | 44.3 |
| B (max.) | 101.0 | 84.5 | 43.9 | 239.0 | 163.0 | 79.5 | 84.5 |
| SW (average) | 0.8 | 0.3 | 0.3 | 1.4 | 2.4 | 0.3 | 0.3 |
| SW (min.) | 0 | 0 | 0.2 | 0 | 0.1 | 0 | 0.1 |
| SW (max.) | 2.8 | 0.8 | 0.4 | 4.5 | 11.2 | 1.1 | 0.5 |
| ES | 10.0 | 0 | 0 | 8.3 | 0 | 12.5 | 0 |
| R (Plankton) | 3.1 | 46.2 | 0 | 0 | 0 | 0 | 9.3 |
| R (Benthos) | 68.4 | 49.2 | 54.6 | 88.4 | 23.0 | 59.3 | 90.7 |
| R (Nekton) | 28.5 | 4.6 | 45.5 | 11.6 | 77.0 | 40.7 | 0 |
| PD | Ophiuroidea & Fishes | Ophiuroidea & *Euphausia* sp. (Fish scales) | Ophiuroidea & Fishes | Macrura | Fishes (Ophiuroidea) | Ophiuroidea | Ophiuroidea |

Table 13. *Peristedion orientale*. For the abbreviations, see Table 2.

| Dates | IV/19 | VII/4 | VII/20 | X/26 | XII/22 |
|---|---|---|---|---|---|
| N | 15 | 5 | 27 | 10 | 3 |
| NP | 29 | 12 | 4 | 20 | 0 |
| B (average) | 12.6 | 13.2 | 18.6 | 21.7 | 20.2 |
| B (min.) | 8.1 | 8.6 | 13.9 | 13.4 | 15.8 |
| B (max.) | 18.1 | 18.4 | 23.3 | 35.8 | 24.4 |
| SW (average) | 0.5 | 0.8 | 0.7 | 0.9 | 1.1 |
| SW (min.) | 0.1 | 0.3 | 0.2 | 0.2 | 0.3 |
| SW (max.) | 2.0 | 1.4 | 1.5 | 1.6 | 1.9 |
| ES | 0 | 0 | 0 | 0 | 0 |
| R (Plankton) | 67.5 | 90.7 | 82.7 | 92.6 | 96.3 |
| R (Benthos) | 32.5 | 9.3 | 14.7 | 6.4 | 3.7 |
| R (Nekton) | 0 | 0 | 2.7 | 1.0 | 0 |
| PD | *Lophogaster* sp. (Gammaridea) | *Lophogaster* sp. (Gammaridea) | *Lophogaster* sp. (Gammaridea) | *Lophogaster* sp. | *Lophogaster* sp. |

fishes supplemented by crustaceans and a thaliacean *Pyrosoma atlanticum* (BLABER and BULMAN, 1987).

(15) *Peristedion orientale*. Relatively large number of specimens, 65 was obtained from four collections for a representative of biomass (Table 13). Nearly the same number of specimens, 60 was examined on stomach contents. Body weight of specimens and SW were constant both in averages and ranges throughout collections. Empty stomachs were none. The species was predominantly plankton, especially *Lophogaster* feeder (67–96%) followed by benthos (4–32%), and fed rarely on nekton. The analysis by fish weight (Table 14) showed the same result, though indicating stronger preference of plankton and higher SW with the growth of fish.

YAMADA (1986) reported the diets of the species to be small crustaceans such as mysids and macruras.

Table 14. The food type ratio (%) in weight, R, and the average percent of stomach content weight to body weight, SW, by body weight in gram, B, in ten benthic fishspecies. N indicates the number of specimens.

| | *Etmopterus lucifer* | | | | *Congriscus megastomus* | |
|---|---|---|---|---|---|---|
| B | 6.6–15 | 15–20 | 20–40 | 40–163 | 16.2–30 | 30–174.0 |
| N | 21 | 15 | 15 | 19 | 24 | 24 |
| R (Plankton) | 20.1 | 19.9 | 9.8 | 4.6 | 1.9 | 0.5 |
| R (Benthos) | 19.3 | 20.2 | 4.9 | 7.7 | 14.5 | 12.3 |
| R (Nekton) | 60.6 | 59.8 | 85.3 | 87.7 | 83.6 | 86.9 |
| SW (average) | 2.5 | 3.2 | 2.8 | 2.2 | 8.7 | 6.8 |

| | *Synagrops japonicus* | | | | *Coelorinchus anatirostris* | |
|---|---|---|---|---|---|---|
| B | 12.5–20 | 20–30 | 30–40 | 40–78.5 | 9.5–15 | 15–50.5 |
| N | 14 | 25 | 30 | 27 | 15 | 10 |
| R (Plankton) | 88.3 | 6.0 | 3.1 | 0.7 | 14.5 | 15.2 |
| R (Benthos) | 8.4 | 5.3 | 21.3 | 17.1 | 85.5 | 62.8 |
| R (Nekton) | 3.4 | 88.7 | 75.6 | 82.2 | 0 | 22.0 |
| SW (average) | 0.7 | 0.6 | 1.3 | 1.4 | 0.6 | 0.8 |

| | *Coelorinchus kamoharai* | | | *Chlorophthalmus albatrossis* | | |
|---|---|---|---|---|---|---|
| B | 13.8–20 | 20–30 | 30–71.0 | 11.0–20 | 20–30 | 30–45.8 |
| N | 8 | 24 | 13 | 39 | 37 | 34 |
| R (Plankton) | 51.4 | 35.5 | 2.9 | 21.8 | 4.4 | 2.7 |
| R (Benthos) | 32.1 | 52.9 | 1.8 | 17.9 | 13.8 | 9.4 |
| R (Nekton) | 16.5 | 11.6 | 95.4 | 60.3 | 81.8 | 87.9 |
| SW (average) | 0.3 | 0.5 | 0.9 | 0.7 | 0.9 | 1.2 |

| | *Chaunax fimbriatus* | | | *Argentina kagoshimae* | | |
|---|---|---|---|---|---|---|
| B | 10.3–20 | 20–50 | 50–418 | 10.2–30 | 30–35 | 30–63.5 |
| N | 26 | 16 | 13 | 19 | 16 | 16 |
| R (Plankton) | 0.5 | 42.5 | 0.2 | 0.6 | 0.5 | 0.1 |
| R (Benthos) | 39.3 | 15.9 | 0.5 | 99.5 | 99.5 | 99.9 |
| R (Nekton) | 60.3 | 41.6 | 99.3 | 0 | 0 | 0 |
| SW (average) | 0.6 | 0.2 | 2.2 | 0.4 | 0.3 | 0.5 |

| | *Helicolenus hilgendorfi* | | | *Peristedion orientale* | | |
|---|---|---|---|---|---|---|
| B | 14.6–40 | 40–60 | 60–239 | 8.1–15 | 15–20 | 20–35.8 |
| N | 21 | 20 | 19 | 15 | 30 | 15 |
| R (Plankton) | 0.4 | 0.4 | 0.7 | 63.9 | 83.7 | 97.7 |
| R (Benthos) | 41.3 | 33.5 | 84.2 | 34.8 | 13.6 | 7.3 |
| R (Nekton) | 58.4 | 66.1 | 15.2 | 1.3 | 2.7 | 0 |
| SW (average) | 0.6 | 1.5 | 1.0 | 0.5 | 0.7 | 0.8 |

### 3–3. Total food consumption by bottom fishes

To estimate total prey organisms consumed by bottom fishes in each collection, average SW of 15 species examined above was multiplied by the average body weight, the ratios (%) among food types and the number of specimens for a representative of biomass (B, R and NP respectively in Tables 2–13). Then, those three values were summed up for all of the species studied for stomach content analysis. The ratios of the summed up values were calculated to show the total food type composition in weight (%) in each collection (Table 15).

Table 15. Total food type composition in weight (%) for the representative biomass of all the species examined on stomach content. That for nekton is divided into those for fishes and other nekton. RS (%) indicates the ratio of total number of representative specimens from 15 species studied to all specimens collected by the last tow in collection.

| Dates | IV/19 | V/31 | VII/4 | VII/20 | IX/5 | X/26 | XII/26 |
|---|---|---|---|---|---|---|---|
| RS | 92.1 | 62.5 | 75.4 | 91.6 | 93.9 | 94.4 | 60.1 |
| Plankton | 43.8 | 23.3 | 7.9 | 2.7 | 1.7 | 4.6 | 37.5 |
| Benthos | 13.7 | 29.8 | 17.1 | 9.2 | 3.0 | 6.2 | 26.6 |
| Nekton | 42.5 | 46.9 | 75.0 | 88.2 | 95.3 | 89.2 | 35.9 |
| (Fishes) | 42.4 | 25.0 | 60.8 | 84.1 | 95.1 | 80.3 | 10.2 |
| (Others) | 0.1 | 21.9 | 14.1 | 4.1 | 0.2 | 8.9 | 25.6 |

Total numbers of specimens for a representative of biomass of 15 species studied accounted for 81.5% in average (60.1–94.4%) of total numbers of specimens collected by the last tows in collections. Therefore, the food type composition in Table 15 can be regarded as that of all bottom fishes in each collection.

Nekton occupied the highest ratios in all collections, especially more than 75% in four collections from July 4 to October 26 when the nekton feeder *C. albatrossis* and *S. japonicus* were the most abundant (Tables 5 & 11). Nekton was divided into fishes and other nekton: compared with other nekton, fishes were ingested exclusively in all collections except December 26 when other nekton occupied higher ratio than fishes. Plankton shared the same high ratios with nekton in the first and last collections: the high ratio of the first was mainly due to *S. japonicus* which was the most abundant and preyed exclusively plankton only in that collection (Table 11), and that of the last was partly due to the most abundant capture of plankton feeder *H. kuronumai* in that collection (Table 9). In other five collections, plankton occupied the lowest ratios (1.7–23.3%) among three types. Benthos shared the intermediate ratios (3.0–29.8 %) except the first and last collections. Both the ratios of benthos and plankton were significantly low in three collections from July 20 to October 26 when nekton occupied more than 88 % of food.

From the above examination, it can be concluded that the bottom fishes are dependant largely on nekton, especially fishes for food organisms.

### 3-4. Prey-predator relationship among bottom fishes

As summarized just above, bottom fishes ingested fishes the most abundantly in almost all collections. With seven species which fed abundantly on fishes, prey-predator relationship among bottom fishes was examined by the frequency of occurrence (%) of prey fishes in all specimens used for stomach content analysis (Fig. 1).

Prey fishes were classified to 11 taxa. Among them, the following seven are pelagic inhabitants: melanostomiids, *Bregmaceros* sp., *Polypnus* sp., three myctophids (*Diaphus* sp., *Benthosema* sp., and *Myctophum* sp.), and *Maurolicus muelleri*. The bottom fishes ingested exclusively pelagic fishes with some rare consumption of bottom fishes. Three myctophid species appeared the most frequently in the stomachs of six bottom fish species, especially *C. albatrossis*, being followed by *Bregmaceros* sp. and *M. muelleri*. Melanostomiids and *Polypnus* sp. were consumed only by *E. lucifer*. Inclusive of a few bottom fish prey, *C. fimbriatus* and *E. lucifer* ingested five kinds of fishes with the maximum occurrence of 20%. *C. megastomus* was prey of *C. fimbriatus*, and itself fed on *Bregmaceros* and three myctophid species with 10–20% occurrence and on *M. muelleri* with 1–10%. *C. albatrossis* consumed predominantly three myctophid species with low occurrence of other two pelagic species. *S. japonicus* fed on four kinds of fishes with low rates of occurrence. *C. anatirostris* and *H. hilgendorfi* consumed a few kinds of fishes with low occurrence rates.

From the above examination, it can be concluded that prey-predator relationship rarely occurs among bottom fishes, and instead the bottom

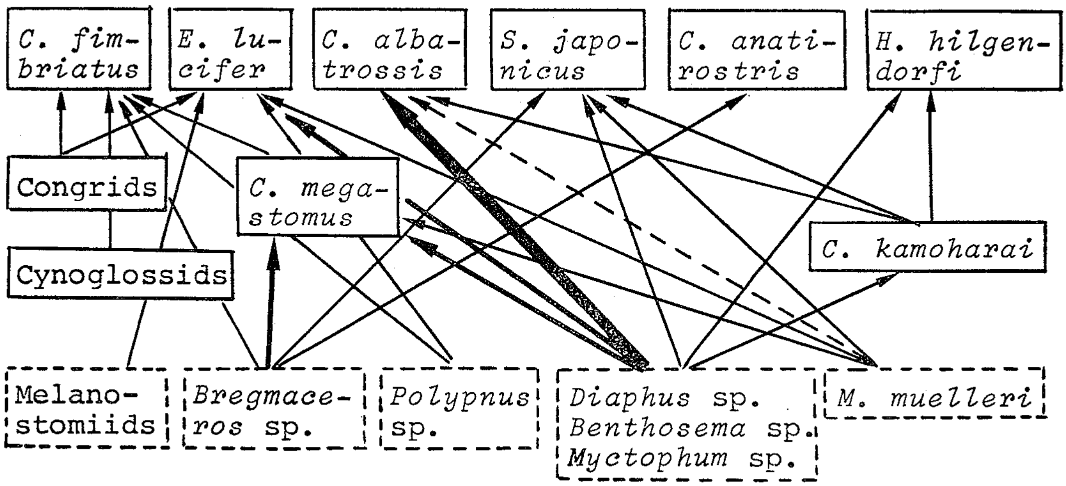


Fig. 1. The frequency of occurrence (%) of prey fishes in the stomachs of bottom fishes. Broken line indicates 0–1% frequency, solid ones 1–10%, thicker solid ones 10–20%, and thickest solid one 20–40%. Predatory fishes are shown with arrows, bottom fishes with closed rectangular frames, and mesopelagic fishes with broken ones. See the text for the intact scientific name of fishes.

fishes depend largely on pelagic fishes, especially myctophids for prey.

## 4. Discussion

The terms pelagic, benthopelagic and benthic have been usually used in the studies of feeding ecology of bottom fishes. "Pelagic" is equivalent with "plankton" of this study, and "benthopelagic" has been applied to those organisms that swimm freely and habitually near the ocean floor (MARSHALL, 1965). Therefore, parts of plankton and benthos in this study can be categorized into benthopelagic organisms, and fishes foraging them can be considered benthopelagic feeder. In spite of frequent use of the terms, prey organisms have been rarely categorized in the manner presented in Table 1 where the divison by HOUSTON and HAEDRICH (1986) is shown only in cases different from the present one.

The organisms different between the present and their studies are as follows: Ostracoda and Mysidacea (planktonic in the present study vs. benthopelagic in HOUSTON and HAEDRICH one); Isopoda (benthic vs. benthopelagic); and two macruras Sergestidae and Penaeidae (benthic vs. pelagic or planktonic).

Referring to dominant prey items (PD in Tables 2–13), it is surveyed wherher the feeding type defined in this study changes with the use of division by HOUSTON and HAEDRICH (1986). *E. lucifer* (Table 2) and *C. megastomus* (Table 3) fed dominantly on macruras in weight and the mysid *Lophogaster* sp. in number in a few collections. However, these preys shared minor ratios among food types, nekton being predominant one throughout collections. *C. kamoharai* (Table 6) and *C. anatirostris* (Table 7) fed abundantly on *Lophogaster* sp. in each one collection. Compared with other five macrourid species (see Tables 8 and 9), they are truly opportunistic feeders foraging all kinds of food types, and therefore the alteration of prey category has no significance for these species. The other five macrourid species (Tables 8 and 9) ingested predominantly macruras or *Lophogaster* sp. in almost all collections. They fed not at all or rarely on nekton. In two collections, *C. longissimus* (Table 8) showed abundant consumption of macruras which could not be identified to lower taxa. Although there is a possibility of transfer of some benthos to plankton, the present feeding type (plankton and benthos feeder) does not alter at all. *V. japonica* (Table 8) and *H. kuronumai* (Table 9) can be regarded as benthopelagic feeder because benthopelagic prey *Lophogaster* spp.

shared more than 80% in the diets. Dominant preys of *V. garmani* (Table 9) were *Lophogaster* sp. in weight and gammarids in number. Therefore, the species can be regarded as the benthopelagic and benthic feeder. In one of two collections, *H. striatissimus* (Table 9) also fed dominantly on *Lophogaster* sp., and in the other on gammarids. Therefore, the species is also regarded as the benthopelagic and benthic feeder. In one collection, *H. hilgendorfi* (Table 12) fed dominantly on macruras which could not be identified further. Therefore, parts of benthos may be transferred to plankton. Even so, the present conclusion on feeding type as the benthos and nekton feeder does not change at all. *P. orientale* (Table 13) fed predominantly on *Lophogaster* sp. supplemented by benthos. Therefore, the species can be regarded as the benthopelagic and benthic feeder.

From the above survey on the use of different food category, the ratios of total food consumption by bottom fishes (Table 15) change undoubtedly for plankton and benthos, but not for nekton, which means the conclusion from that table, i.e. large dependance of bottom fishes on nektonic preys, is unaffected at all.

The food consumption may change by season and/or size of predators. On the latter, brief comments are noted in the descriptions of stomach contents. GORDON (1979), recognizing the importance of mesopelagic fauna for food of two gadiform families Macrouridae and Moridae, speculated that food supply is a factor in inducing periodicity in the benthopelagic fauna. MAUCHLINE and GORDON (1984) showed quite distinctive difference in the diets of two macrourid species *Corypaenoides rupestris* and *Nezumia aequalis* in different months, but could not determine whether it was regular seasonal changes or resulted from opportunistic feeding. BLABER and BULMAN (1987) found seasonal changes in diets on eight species among 15 studied, and related them to changes in abundance of particular prey organisms. Among 15 species of the present study, the following five were examined with more than 50 specimens from all collections: *E. lucifer* (Table 2), *C. albatrossis* (Table 5), *C. fimbriatus* (Table 10), *S. japonicus* (Table 11) and *H. hilgendorfi* (Table 12). Both the indices of stomach content weight (SW) and empty stomach (ES) did not show any regular changes in these species. For example, throughout collections, *S. japonicus* (Table 11) showed nearly constant body weight (B), but did not show any significant changes in the ratios of stomach content weight (SW) and of emply stomachs (ES), and in dominant prey items (PD).

From their results combined with others such as PEARCY and AMBLER (1974) and SEDBERRY and MUSICK (1978), HOUSTON and HAEDRICH (1986) suggested that feeding from the pelagial by demersal fishes at upper continental slope is probably the general rule. It is reconfirmed by the present study. Judging from the results of MAUCHLINE and GORDON (1984) and the present study, GORDON's (1979) speculation that food supply is a factor in inducing periodicity in the benthopelagic fauna remains for the future study.

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# 枕崎沖陸棚斜面底魚の研究－II

## －胃内容物分析－

小沢　貴和*・神野　英彦**

1978年枕崎沖陸棚斜面における商業底曳船での7回の採集で得た15種634個体の底魚胃内容物の量と餌生物を調べた。15種の中でフジクジラ，オキアナゴ，アオメエソとスミクイウオはネクトン食，カガミヒゲ，確定的ではないがヤリダラとキホウボウはプランクトン食，カゴシマニギスはベントス食，イチモンジヒゲ，ネズミヒゲ，トンガリヒゲ，サガミソコダラ，スジダラ，ホンフサアンコウ，そしてユメカサゴは複合食であった。餌生物は体重の増加に伴い変化することが少数の魚種で認められたが，時期即ち採集を通して変化することは全ての魚種で認められなかった。全底魚による捕食餌生物の中でネクトン，特に魚類は最も高い比率をほぼ全ての採集で占めた。被食魚の多くはハダカイワシ科のような中層性魚類で構成されていた。

* 鹿児島大学水産学部 〒890 鹿児島市下荒田4-50-20
** 現住所：北海道渡島支庁渡島中部地区水産技術普及指導所 〒040 函館市末広町 15-18