

# By-catch Discards from a bottom trawl in the East China Sea

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**Abstract** : The East China Sea is one of the best fishing grounds in the world based on high productivity and has been utilized cooperatively by the surrounding countries. The fisheries resources are, however, decreasing and an effective resource management strategy is required. However, the species composition of the catch and discards of the by-catch from the bottom trawl fishery in the East China Sea have not yet been fully understood. For sustainable utilization of the demersal resources, the experiments with a bottom trawl were carried out to investigate this quantitatively. Forty one experimental trawling with the gear were carried out in the East China Sea aboard the training vessel Koyo-maru in every April from 1997 to 2003. A total of 30,425 individuals composed of 180 species were caught during the research period. The numerically dominant species were *Trachurus japonicus* (7,800 individuals, 25.6%), *Photololigo edulis* (4,017 individuals, 13.2%), *Argyrosomus argentatus* (2,470 individuals, 8.1%). Of the total catch in number, the discards accounted for 20.4%. The main discarded species with no commercial values were *Acanthocephala krusensterni* and *Macrorhamphosus scolopax*, while those with commercial value was a swimming crab (*Ovalipes punctatus*), which is a target fish of bottom trawl fishery in the East China Sea. To manage resources and promote a sustainable fishery in the fishing grounds, Japan and surrounding countries should create opportunities of discussing the survey fishing gear and techniques and for conducting surveys to assess catches accurately.

**Key words** : By-catch, Catch composition, Bottom trawls, East China Seavessels

## INTRODUCTION

The East China Sea is one of the best fishing grounds in the world based on high productivity and has been utilized cooperatively by the surrounding countries. Japan's bottom trawl fishery production in the area, however, peaked in 1961 and had decreased to approximately 9,000 tons by 2001<sup>1,2)</sup>. The decrease in the fishery resources that has led to this drop in catch may have been caused by catch pressure by Japan and the surrounding countries or irrational fishing behaviors.

The bottom trawl fishery tends to catch multiple species in small quantities. A large proportion of the fish are discarded at sea without. The by-catch, or fish discarded at sea are not limited to unmarketable fish but also include individuals of marketable fish species that are too small to fetch a price on the markets that is comparable to those

brought into market.

Large by-catches mean a waste in time spent sorting and discarding fish on the fishing vessel, thus reducing work efficiency<sup>3)</sup>. The by-catch of fish to be discarded wastes resources and may adversely affect the ecosystems of the fishing grounds<sup>4)</sup>.

In the fishing grounds of the East China Sea, a mesh size regulation on the cod-end was enacted in 1963<sup>5)</sup>. The mesh size regulations are thought to be effective for allowing the escape of small individuals from the net. However, these regulations also have many problems, such as reducing the catch of small but marketable fish and also the survival rate of small fish that escape through the cod-end mesh<sup>3)</sup>.

To maintain the demersal fish resources, many research organizations have been studying technologies for selective fishing to reduce the by-catch of fish that would be

discarded<sup>6-10</sup>). The research and development of fishing gear to reduce the by-catch will promote the rational use of resources and a reduction in time spent sorting on the fishing vessel. This is essential for the sustainability of the fishery.

Since the fish fauna in the demersal fishing grounds of the East China Sea is rich in species diversity, the composition of the catches is also predicted to be diverse. There are many references on the volume of catches from the fishing grounds<sup>1,2</sup>), but the reports on catches, including discards, are limited. To provide basic data for the protection of resources in the demersal fishing grounds of the East China Sea, we surveyed the species composition of catches and by-catches.

## MATERIALS AND METHODS

### Fishing Gear Used for the Experimental Trawling

For the experimental trawling survey, we used a bottom trawl net based on the design of a trawl net used by the training vessel *Koyo-maru*. This trawl net was 44.8 m in full length, 29.6 m in head rope length, and 60 mm in cod-end mesh size. The mouth of the trawl net had a vertical span (net mouth height) of 10.5 m and a horizontal span (net mouth span) of 13.5 m.

### Outline of the Experimental Trawling

In April from 1997 to 2003, the experimental trawling was conducted on a continental shelf area at a depth of 60 to 150 m in the East China Sea (Fig. 1). Table 1 shows an outline of the sample areas and trawl net conditions. The area was investigated 41 times in daytime only. Towing speed was 2.3 to 3.8 knots and the duration of towing was 60 to 180 minutes for each tow. The total towing distance was 267 miles and the total sampled area was 6.68 km<sup>2</sup>.

### Handling of Catch

After trawling, the catch was identified to species level and the individuals of each species were counted and weighed<sup>11</sup>). For a species with fewer than 100 individuals, body measurement was conducted on all individuals. For species with 100 or more individuals, body measurement was conducted on about 100 individuals per tow following

a sampling method. The total length, fork length, or snout-anus length was measured for fish, the carapace width for crustaceans, and the mantle length for cephalopods. Hereafter, these parameters are referred to as body size. Using reference materials of Yamada Fishery Co., Ltd. (Nagasaki City, Japan), the catch was classified into marketable fish and unmarketable fish.

## RESULTS

### Outline of the Composition of Catches

The catches in the experimental trawling were roughly classified into fish, crustaceans, and cephalopods. Table 2 gives the numbers of individuals and the weight of the catches. The catches over 41 tows totaled 180 species, 30,425 individuals, and 2,673 kg.

Fish accounted for 140 species (22,901 individuals, 2,196.5 kg), crustacean accounted for 34 species (2,671 individuals, 241.9kg), and cephalopods accounted for 6 species (4,853 individuals, 234.6 kg). Fig.2 shows the composition of catches by number of individuals per species.

The fish species for which more than 1,000 individuals (percent of total catch is shown in parentheses) were caught are *Trachurus japonicas* (7,800 individuals, 25.6%), *Photololigo edulis* (4,017 individuals, 13.2%), *Argyrosomus argentatus* (2,470 individuals, 8.1%), *Thamnaconus*

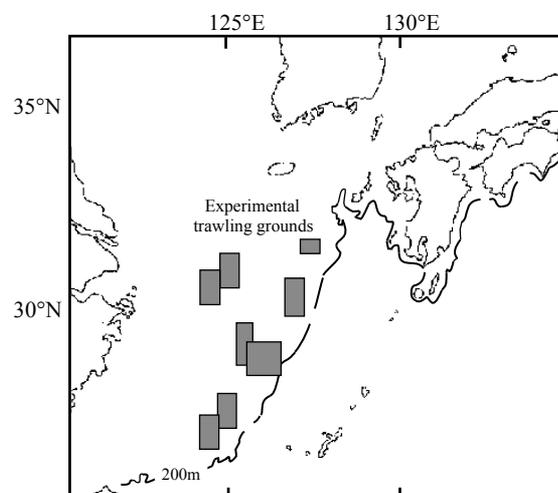


Fig. 1. Study areas for the bottom trawl.

**Table 1.** Outline of experimental operations

| Haul No. | Date         | Position to start towing | Time to start towing | Towing duration (min) | Depth ( ) | Towing speed | Towing distance |
|----------|--------------|--------------------------|----------------------|-----------------------|-----------|--------------|-----------------|
| 1        | 11 Apr. 1997 | 31-15.8N, 127-43.3E      | 07:00                | 126                   | 140.5     | 3.1          | 6.2             |
| 2        |              | 31-11.2N, 127-50.9E      | 10:01                | 120                   | 148.0     | 3.2          | 6.3             |
| 3        |              | 31-08.0N, 127-57.1E      | 12:57                | 120                   | 149.5     | 3.1          | 6.3             |
| 4        |              | 31-15.7N, 127-54.6E      | 15:50                | 60                    | 140.5     | 3.1          | 3.5             |
| 5        | 12 Apr. 1997 | 30-09.8N, 127-20.0E      | 07:05                | 120                   | 120.0     | 3.1          | 6.3             |
| 6        |              | 30-01.2N, 127-20.4E      | 10:08                | 120                   | 123.0     | 3.1          | 6.4             |
| 7        |              | 29-56.0N, 127-20.1E      | 12:55                | 120                   | 124.0     | 3.2          | 6.5             |
| 8        | 14 Apr. 1998 | 28-54.1N, 125-43.9E      | 07:10                | 120                   | 117.0     | 3.2          | 6.7             |
| 9        |              | 28-48.6N, 125-40.4E      | 09:59                | 155                   | 107.0     | 3.7          | 8.7             |
| 10       |              | 29-02.4N, 125-41.6E      | 13:59                | 120                   | 105.0     | 3.7          | 6.5             |
| 11       | 15 Apr. 1998 | 27-56.3N, 125-27.2E      | 06:51                | 120                   | 110.0     | 3.3          | 6.5             |
| 12       |              | 27-47.2N, 125-26.8E      | 09:36                | 150                   | 113.0     | 3.5          | 8.6             |
| 13       |              | 27-36.1N, 125-28.6E      | 12:57                | 120                   | 113.0     | 3.5          | 7.0             |
| 14       | 14 Apr. 1999 | 28-42.2N, 126-24.6E      | 07:42                | 123                   | 123.0     | 3.2          | 6.9             |
| 15       |              | 28-32.8N, 126-29.6E      | 10:16                | 124                   | 134.0     | 3.1          | 7.3             |
| 16       |              | 28-24.4N, 126-28.0E      | 13:08                | 122                   | 136.0     | 3.0          | 7.1             |
| 17       | 15 Apr. 1999 | 27-08.0N, 125-04.5E      | 06:55                | 125                   | 112.0     | 3.5          | 7.0             |
| 18       |              | 27-08.5N, 124-54.9E      | 09:41                | 139                   | 107.0     | 2.7          | 5.6             |
| 19       |              | 26-58.5N, 124-52.7E      | 13:28                | 122                   | 111.0     | 3.5          | 7.7             |
| 20       | 15 Apr. 2000 | 28-52.5N, 126-40.2E      | 07:03                | 129                   | 131.0     | 3.5          | 7.4             |
| 21       |              | 28-48.9N, 126-38.5E      | 10:01                | 119                   | 137.0     | 3.5          | 6.9             |
| 22       |              | 28-50.1N, 126-41.6E      | 12:54                | 120                   | 139.0     | 3.5          | 7.1             |
| 23       | 16 Apr. 2000 | 27-47.0N, 125-23.7E      | 06:55                | 120                   | 110.0     | 3.3          | 5.9             |
| 24       |              | 27-38.1N, 125-23.5E      | 09:38                | 137                   | 112.0     | 3.6          | 8.6             |
| 25       |              | 27-26.3N, 125-24.3E      | 12:43                | 137                   | 115.0     | 3.0          | 7.2             |
| 26       | 14 Apr. 2001 | 30-15.6N, 125-16.5E      | 06:54                | 126                   | 59.6      | 3.8          | 8.0             |
| 27       |              | 29-54.8N, 125-14.5E      | 10:54                | 91                    | 62.6      | 3.5          | 5.6             |
| 28       | 15 Apr. 2001 | 27-40.0N, 125-09.0E      | 06:55                | 120                   | 105.0     | 3.3          | 6.6             |
| 29       |              | 27-29.5N, 125-07.5E      | 09:58                | 120                   | 105.0     | 3.1          | 6.2             |
| 30       |              | 27-19.7N, 125-04.7E      | 12:57                | 107                   | 107.0     | 2.8          | 6.1             |
| 31       | 13 Apr. 2002 | 30-25.3N, 125-52.5E      | 06:38                | 179                   | 78.5      | 3.5          | 7.0             |
| 32       |              | 30-31.2N, 125-45.4E      | 10:42                | 120                   | 72.3      | 2.1          | 4.5             |
| 33       | 14 Apr. 2002 | 27-16.2N, 125-14.3E      | 06:55                | 120                   | 115.0     | 2.7          | 5.3             |
| 34       |              | 27-11.2N, 125-05.7E      | 09:54                | 120                   | 112.0     | 2.3          | 5.2             |
| 35       |              | 27-03.9N, 124-59.8E      | 13:04                | 120                   | 114.0     | 2.7          | 5.8             |
| 36       | 15 Apr. 2003 | 30-15.6N, 125-39.9E      | 06:53                | 120                   | 74.7      | 3.0          | 6.8             |
| 37       |              | 30-23.4N, 125-41.5E      | 09:56                | 128                   | 67.0      | 3.0          | 5.0             |
| 38       |              | 30-23.0N, 125-48.6E      | 13:13                | 122                   | 73.3      | 3.2          | 6.5             |
| 39       | 16 Apr. 2003 | 27-16.9N, 125-10.5E      | 06:45                | 120                   | 114.0     | 2.8          | 4.8             |
| 40       |              | 27-11.1N, 125-08.0E      | 09:44                | 136                   | 116.0     | 3.4          | 7.5             |
| 41       |              | 27-07.1N, 125-12.0E      | 12:58                | 122                   | 116.0     | 3.0          | 5.9             |

**Table 2.** Catches in the two-level trawl and their landing sizes for those with commercial values. The landing sizes are based on the landing standard table of Yamada Fishery Co. Ltd., Nagasaki.

| Category | English name                   | Scientific name                     | Number of individual | Weight (kg) | Landing size (mm)     |
|----------|--------------------------------|-------------------------------------|----------------------|-------------|-----------------------|
| Fish     | Japanese horse mackerel        | <i>Trachurus japonicus</i>          | 7800                 | 626.0       | 140(FL)* <sup>1</sup> |
|          | Silver croaker                 | <i>Argyrosomus argentatus</i>       | 2470                 | 82.1        | 110(TL)               |
|          | Lesser-spotted leatherjacket   | <i>Thamnaconus hypargyreus</i>      | 2217                 | 148.8       | 100(TL)               |
|          | Gurnard                        | <i>Lepidotrigla microptera</i>      | 1276                 | 45.2        | 100(TL)               |
|          | Yellowback seabream            | <i>Dentex tumifrons</i>             | 1187                 | 109.3       | 80(FL)                |
|          | Butterfish                     | <i>Pampus argenteus</i>             | 1157                 | 155.4       | 150(FL)               |
|          | Whitefin kingfish              | <i>Kaiwarinus equula</i>            | 713                  | 49.1        | 100(FL)               |
|          | Bandfish                       | <i>Acanthocephala krusensterni</i>  | 653                  | 124.0       | Uncommercial          |
|          | Longspine snipefish            | <i>Macrorhamphosus scolopax</i>     | 404                  | 5.8         | Uncommercial          |
|          | Deepsea smelt                  | <i>Glossanodon semifasciatus</i>    | 386                  | 9.6         | all* <sup>2</sup>     |
|          | Japanese aulopus               | <i>Aulopus japonicus</i>            | 359                  | 18.9        | all                   |
|          | Verticalstriped cardinalfish   | <i>Apogon lineatus</i>              | 326                  | 3.0         | Uncommercial          |
|          | Red spikefish                  | <i>Triacanthodes anomalus</i>       | 299                  | 5.3         | Uncommercial          |
|          | Black scraper                  | <i>Thamnaconus modestus</i>         | 291                  | 41.1        | all                   |
|          | John dory                      | <i>Zeus faber</i>                   | 261                  | 94.2        | 180(TL)               |
|          | Rad bigeye                     | <i>Priacanthus macracanthus</i>     | 254                  | 39.2        | all                   |
|          | Hairtail                       | <i>Trichiurus lepturus</i>          | 232                  | 30.3        | 150(SAL)              |
|          | Blackmouth angler              | <i>Lophiomus setigerus</i>          | 227                  | 163.5       | all                   |
|          | Belanger's croaker             | <i>Johnius belengerii</i>           | 222                  | 13.6        | 110(TL)               |
|          | Japanese Spanish mackerel      | <i>Scomberomorus niphonius</i>      | 184                  | 116.9       | all                   |
|          | Pacific mackerel               | <i>Scomber japonicus</i>            | 162                  | 31.1        | 150(FL)               |
|          | Yellow croaker                 | <i>Pseudosciaena polyactis</i>      | 148                  | 11.0        | 110(TL)               |
|          | Red tongue sole                | <i>Cynoglossus joyneri</i>          | 129                  | 16.5        | all                   |
|          | Nibe croaker                   | <i>Nibea mitsukurii</i>             | 126                  | 17.1        | 110(TL)               |
|          | Frog flounder                  | <i>Pleuronichthys cornutus</i>      | 115                  | 10.9        | 120(TL)               |
|          | Lizardfish                     | <i>Saurida wanieso</i>              | 99                   | 18.4        | all                   |
|          | Gurnard                        | <i>Lepidotrigla abyssalis</i>       | 81                   | 3.4         | 100(TL)               |
|          | Lantern-belly                  | <i>Acropoma japonicum</i>           | 70                   | 0.5         | Uncommercial          |
|          | Skate                          | <i>Raja acutispina</i>              | 69                   | 22.7        | all                   |
|          | Stripedfin goatfish            | <i>Upeneus bensasi</i>              | 61                   | 6.1         | all                   |
|          | Spearnose grenadier            | <i>Coelorinchus multispinulosus</i> | 48                   | 3.6         | Uncommercial          |
|          | Pinkgray goby                  | <i>Amblychaeturichthys hexanema</i> | 47                   | 1.0         | Uncommercial          |
|          | Tile-colored righteye flounder | <i>Poecilopsetta plinthus</i>       | 40                   | 1.3         | 200(TL)               |
|          | Jellynose fish                 | <i>Ateleopus japonicus</i>          | 35                   | 9.0         | Uncommercial          |
|          | Brush-tooth lizardfish         | <i>Saurida undosquamis</i>          | 34                   | 4.4         | all                   |
|          | Izu scorpionfish               | <i>Scorpaena neglecta</i>           | 33                   | 6.4         | all                   |
|          | Cinnamon flounder              | <i>Pseudorhombus cinnamoneus</i>    | 32                   | 1.8         | 200(TL)               |
|          | Gurnard                        | <i>Lepidotrigla guentheri</i>       | 31                   | 2.6         | 100(TL)               |
|          | Largescale flounder            | <i>Engyprosopon grandisquama</i>    | 27                   | 1.2         | Uncommercial          |
|          | Japanese stargazer             | <i>Uranoscopus japonicus</i>        | 26                   | 3.1         | all                   |
|          | Brotula                        | <i>Hoplobrotula armata</i>          | 25                   | 7.8         | all                   |
|          | Devil searobin                 | <i>Lepidotrigla kishinouyei</i>     | 25                   | 0.8         | 100(TL)               |
|          | Gurnard                        | <i>Pterygotrigla hemisticta</i>     | 23                   | 2.8         | Uncommercial          |
|          | Grey goblinfish                | <i>Minous monodactylus</i>          | 21                   | 1.1         | Uncommercial          |
|          | Japanese splitfin              | <i>Synagrops japonicus</i>          | 21                   | 1.0         | Uncommercial          |
|          | Shortnose dogfish              | <i>Squalus brevirostris</i>         | 20                   | 6.1         | all                   |

|                         |                                      |    |      |              |
|-------------------------|--------------------------------------|----|------|--------------|
| Sea toad                | <i>Chaunax abei</i>                  | 19 | 3.9  | Uncommercial |
| Red flathead            | <i>Bembras japonica</i>              | 17 | 1.6  | Uncommercial |
| Brown-spotted catshark  | <i>Halaelurus buergeri</i>           | 15 | 4.2  | all          |
| Gurnard                 | <i>Lepidotrigla kanagashira</i>      | 15 | 0.7  | 100(TL)      |
| Comb goby               | <i>Ctenotrypauchen microcephalus</i> | 14 | 0.3  | Uncommercial |
| Graceful catshark       | <i>Proscyllium habereri</i>          | 13 | 5.3  | all          |
| Sepia stingray          | <i>Urolophus aurantiacus</i>         | 13 | 3.5  | Uncommercial |
| Largescale flounder     | <i>Psettina tosana</i>               | 13 | 0.9  | Uncommercial |
| Purple flying gurnard   | <i>Dactyloptena orientalis</i>       | 12 | 2.2  | Uncommercial |
| Marbled rockfish        | <i>Sebastiscus marmoratus</i>        | 12 | 0.9  | all          |
| Fivespot flounder       | <i>Pseudorhombus pentopthalmus</i>   | 12 | 0.7  | Uncommercial |
| Gurnard                 | <i>Lepidotrigla japonica</i>         | 12 | 0.4  | 100(TL)      |
| Brotula                 | <i>Neobythites sivicola</i>          | 11 | 3.6  | all          |
| Mi-iuy croaker          | <i>Miichthys miiuy</i>               | 10 | 11.6 | 110(TL)      |
| Acutenose skate         | <i>Raja tengu</i>                    | 9  | 5.0  | all          |
| Gurnard                 | <i>Lepidotrigla hime</i>             | 9  | 0.3  | 100(TL)      |
| Brown-backed toadfish   | <i>Lagocephalus wheeleri</i>         | 8  | 4.4  | 100(TL)      |
| Large-scale flounder    | <i>Citharoides macrolepidotus</i>    | 8  | 0.6  | Uncommercial |
| Blackfoot firefish      | <i>Parapterois heterurus</i>         | 8  | 0.3  | Uncommercial |
| Red tilefish            | <i>Branchiostegus japonicus</i>      | 7  | 3.8  | all          |
| Pacific rudderfish      | <i>Psenopsis anomala</i>             | 7  | 1.4  | 130(FL)      |
| Japanese barracuda      | <i>Sphyrna japonica</i>              | 7  | 1.0  | all          |
| Pineconefish            | <i>Monocentris japonica</i>          | 7  | 0.7  | 300(TL)      |
| Japanese sillago        | <i>Sillago japonica</i>              | 7  | 0.4  | all          |
| Greater amberjack       | <i>Seriola dumerili</i>              | 6  | 12.0 | all          |
| Banjo fish              | <i>Banjos banjos</i>                 | 6  | 2.0  | all          |
| Kwangtung skate         | <i>Dipturus kwangtungensis</i>       | 6  | 2.0  | all          |
| Cornetfish              | <i>Fistularia commersonii</i>        | 6  | 0.9  | all          |
| Sabre-gills             | <i>Champsodon snyderi</i>            | 6  | 0.6  | Uncommercial |
| Rat-tail                | <i>Hoplichthys gilberti</i>          | 6  | 0.4  | Uncommercial |
| Striated frogfish       | <i>Phrynelox tridens</i>             | 6  | 0.4  | Uncommercial |
| Daggertooth pike conger | <i>Muraenesox cinereus</i>           | 5  | 5.8  | all          |
| Blunthead puffer        | <i>Sphoeroides pachygaster</i>       | 5  | 2.2  | 100(TL)      |
| Starry handfish         | <i>Halieutaea stellata</i>           | 5  | 0.5  | Uncommercial |
| Grouper                 | <i>Chelidoperca hirundinacea</i>     | 5  | 0.3  | all          |
| Largescale flounder     | <i>Engyprosopon multisquama</i>      | 5  | 0.3  | Uncommercial |
| Red dragonet            | <i>Foetorepus altivelis</i>          | 5  | 0.3  | 100(TL)      |
| Bluefin searobin        | <i>Chelidonichthys spinosus</i>      | 4  | 1.1  | 100(TL)      |
| Japanese sleeper ray    | <i>Narke japonica</i>                | 4  | 0.8  | Uncommercial |
| Sailfin armourhead      | <i>Histioporus typus</i>             | 4  | 0.6  | all          |
| Black-throat seaperch   | <i>Doederleinia berycoides</i>       | 4  | 0.4  | 120(FL)      |
| Red firefish            | <i>Pterois lunulata</i>              | 4  | 0.4  | Uncommercial |
| Velvetfish              | <i>Erisphex potti</i>                | 4  | 0.3  | Uncommercial |
| Whitespotted conger     | <i>Conger myriaster</i>              | 3  | 1.2  | all          |
| Japanese bullhead shark | <i>Heterodontus japonicus</i>        | 3  | 0.9  | all          |
| Japanese anchovy        | <i>Engraulis japonicus</i>           | 3  | 0.3  | all          |
| Cockscomb firefish      | <i>Ebosia bleekeri</i>               | 3  | 0.2  | Uncommercial |
| Longnose seabat         | <i>Malthopsis annulifera</i>         | 3  | 0.1  | Uncommercial |
| Hammerhead shark        | <i>Sphyrna zygaene</i>               | 2  | 13.0 | all          |
| Bull eye                | <i>Cookeolus boops</i>               | 2  | 0.8  | 150(TL)      |

|            |                         |                                    |      |       |              |
|------------|-------------------------|------------------------------------|------|-------|--------------|
|            | Flying gurnard          | <i>Daicocus peterseni</i>          | 2    | 0.8   | Uncommercial |
|            | White flower croaker    | <i>Nibeia albiflora</i>            | 2    | 0.8   | 110(TL)      |
|            | Ocellate spot skate     | <i>Raja kenoei</i>                 | 2    | 0.7   | all          |
|            | Scorpionfish            | <i>Sebastiscus tertius</i>         | 2    | 0.6   | all          |
|            | Japanese parrotfish     | <i>Oplegnathus fasciatus</i>       | 2    | 0.5   | 130(FL)      |
|            | Dragonets               | <i>Bathycallionymus kaianus</i>    | 2    | 0.2   | Uncommercial |
|            | Redtail scad            | <i>Decapterus Akaadsii</i>         | 2    | 0.2   | 140(FL)      |
|            | Stonefish               | <i>Minous quincarinatus</i>        | 2    | 0.2   | all          |
|            | Tongue flounder         | <i>Plagiopsetta glossa</i>         | 2    | 0.2   | Uncommercial |
|            | Roughscale flounder     | <i>Pseudorhombus oligodon</i>      | 2    | 0.2   | 200(TL)      |
|            | Dragonet                | <i>Repomucenus richardsonii</i>    | 2    | 0.2   | Uncommercial |
|            | Snake mackerel          | <i>Rexea prometheoides</i>         | 2    | 0.2   | all          |
|            | Scalloped hammerhead    | <i>Sphyrna lewini</i>              | 1    | 5.0   | all          |
|            | Atlantic Bonito         | <i>Sarda orientalis</i>            | 1    | 2.1   | all          |
|            | Striped jack            | <i>Pseudocaranx dentex</i>         | 1    | 1.2   | all          |
|            | Brown-backed toadfish   | <i>Lagocephalus gloveri</i>        | 1    | 1.0   | 100(TL)      |
|            | Bamboo sole             | <i>Heteromycteris japonicus</i>    | 1    | 0.4   | all          |
|            | Cobia                   | <i>Rachycentron canadum</i>        | 1    | 0.3   | all          |
|            | Japanese codlet         | <i>Bregmaceros japonicus</i>       | 1    | 0.2   | Uncommercial |
|            | Belted beard grunt      | <i>Hapalogenys mucronatus</i>      | 1    | 0.2   | all          |
|            | Stripey                 | <i>Microcanthus strigatus</i>      | 1    | 0.2   | all          |
|            | Striped eel catfish     | <i>Plotosus lineatus</i>           | 1    | 0.2   | Uncommercial |
|            | Triangular boxfish      | <i>Tetrosomus concatenatus</i>     | 1    | 0.2   | Uncommercial |
|            | Stargazer               | <i>Uranoscopus tosae</i>           | 1    | 0.2   | all          |
|            | Dragonets               | <i>Bathycallionymus formosanus</i> | 1    | 0.1   | Uncommercial |
|            | Croaker                 | <i>Collichthys niveatus</i>        | 1    | 0.1   | all          |
|            | Genko sole              | <i>Cynoglossus interruptus</i>     | 1    | 0.1   | all          |
|            | Lizardfish              | <i>Harpadon microchir</i>          | 1    | 0.1   | Uncommercial |
|            | Redfin velvetfish       | <i>Hypodytes rubripinnis</i>       | 1    | 0.1   | Uncommercial |
|            | Devil stringer          | <i>Inimicus japonicus</i>          | 1    | 0.1   | all          |
|            | Lance flounder          | <i>Laeops kitaharae</i>            | 1    | 0.1   | all          |
|            | Lumpfish                | <i>Lethotremus awae</i>            | 1    | 0.1   | Uncommercial |
|            | Saddled weever          | <i>Parapercis sexfasciata</i>      | 1    | 0.1   | all          |
|            | Threeband sweetlip      | <i>Plectorhynchus cinctus</i>      | 1    | 0.1   | all          |
|            | Frog flounder           | <i>Pleuronichthys</i> sp.          | 1    | 0.1   | 120(TL)      |
|            | Wavyband sole           | <i>Pseudaesopia japonica</i>       | 1    | 0.1   | Uncommercial |
|            | Largetooth flounder     | <i>Pseudorhombus arsuis</i>        | 1    | 0.1   | Uncommercial |
|            | Dragonet                | <i>Repomucenus huguenini</i>       | 1    | 0.1   | Uncommercial |
|            | Oilfish                 | <i>Ruvettus pretiosus</i>          | 1    | 0.1   | all          |
|            | Slender lizardfish      | <i>Saurida elongata</i>            | 1    | 0.1   | all          |
|            | Bigeye scad             | <i>Selar crumenophthalmus</i>      | 1    | 0.1   | 140(FL)      |
|            | Deepwater scorpionfish  | <i>Setarches guentheri</i>         | 1    | 0.1   | all          |
|            | Red barracuda           | <i>Sphyraena pinguis</i>           | 1    | 0.1   | all          |
|            | Crossmark lizardfish    | <i>Synodus macropus</i>            | 1    | 0.1   | Uncommercial |
| Crustacean | Swimming crab           | <i>Ovalipes punctatus</i>          | 1579 | 163.9 | 100(CW)      |
|            | Mantis shrimp           | <i>Squilla oratoria</i>            | 267  | 9.3   | all          |
|            | Crab                    | <i>Carcinoplax longimanus</i>      | 266  | 16.8  | Uncommercial |
|            | Japanese fan lobster    | <i>Ibacus ciliatus</i>             | 247  | 27.6  | all          |
|            | Crimson swimming crab   | <i>Charybdis miles</i>             | 84   | 7.6   | Uncommercial |
|            | Whiskered velvet shrimp | <i>Metapenaeopsis barbata</i>      | 24   | 0.5   | all          |

|                        |                                  |                                |      |              |              |
|------------------------|----------------------------------|--------------------------------|------|--------------|--------------|
| Southern velvet shrimp | <i>Metapenaeopsis palmensis</i>  | 24                             | 0.4  | Uncommercial |              |
| Chinese mud shrimp     | <i>Solenocera koelbeli</i>       | 23                             | 0.6  | Uncommercial |              |
| Shrimp                 | <i>Solenocera melantho</i>       | 20                             | 0.4  | all          |              |
| Spider crab            | <i>Leptomithrax edwardsi</i>     | 19                             | 1.0  | Uncommercial |              |
| Shrimp                 | <i>Plesionika narval</i>         | 16                             | 1.5  | all          |              |
| Fleshy prawn           | <i>Penaeus orientalis</i>        | 15                             | 0.5  | all          |              |
| Mantis shrimp          | <i>Squilla raphidea</i>          | 13                             | 0.5  | all          |              |
| Crab                   | <i>Calappa lophos</i>            | 12                             | 4.5  | Uncommercial |              |
| Mantis shrimp          | <i>Odontodactylus japonicus</i>  | 11                             | 3.2  | Uncommercial |              |
| Japanese swimming crab | <i>Charybdis japonica</i>        | 8                              | 0.3  | Uncommercial |              |
| Morotoge shrimp        | <i>Pandalopsis japonica</i>      | 8                              | 0.2  | all          |              |
| Swimming crab          | <i>Charybdis riversandersoni</i> | 7                              | 0.4  | Uncommercial |              |
| Swimming crab          | <i>Portunus trituberculatus</i>  | 6                              | 0.9  | all          |              |
| Mantis shrimp          | <i>Kempina mikado</i>            | 3                              | 0.2  | all          |              |
| Swimming crab          | <i>Portunus hastatoides</i>      | 3                              | 0.2  | Uncommercial |              |
| Spotted swimming crab  | <i>Charybdis bimaculata</i>      | 2                              | 0.2  | Uncommercial |              |
| Red banded lobster     | <i>Metanephrops thomsoni</i>     | 2                              | 0.1  | all          |              |
| Japanese sand shrimp   | <i>Crangon affinis</i>           | 1                              | 0.2  | Uncommercial |              |
| Spider crab            | <i>Achaeus japonicus</i>         | 1                              | 0.1  | Uncommercial |              |
| Crab                   | <i>Actaea orientalis</i>         | 1                              | 0.1  | Uncommercial |              |
| Crab                   | <i>Actaea savignyi</i>           | 1                              | 0.1  | Uncommercial |              |
| Crab                   | <i>Dromia dehaani</i>            | 1                              | 0.1  | Uncommercial |              |
| Crab                   | <i>Hepatoporus orientalis</i>    | 1                              | 0.1  | Uncommercial |              |
| Crab                   | <i>Leucosia</i> sp.              | 1                              | 0.1  | Uncommercial |              |
| Crab                   | <i>Myra fugax</i>                | 1                              | 0.1  | Uncommercial |              |
| Kuruma prawn           | <i>Penaeus japonicus</i>         | 1                              | 0.1  | all          |              |
| Kinglet rock shrimp    | <i>Sicyonia cristata</i>         | 1                              | 0.1  | Uncommercial |              |
| <hr/>                  |                                  |                                |      |              |              |
| Cephalopod             | Swordtip squid                   | <i>Photololigo edulis</i>      | 4017 | 149.3        | 70(ML)       |
|                        | Pacific flying squid             | <i>Todarodes pacificus</i>     | 408  | 50.8         | 70(ML)       |
|                        | Golden cuttlefish                | <i>Sepia esculenta</i>         | 377  | 14.5         | 50(ML)       |
|                        | Common octopus                   | <i>Octopus vulgaris</i>        | 34   | 15.4         | all          |
|                        | Grass octopus                    | <i>Octopus minor</i>           | 13   | 1.4          | Uncommercial |
|                        | Bigfin squid                     | <i>Sepioteuthis lessoniana</i> | 3    | 2.2          | all          |
|                        | Kisslip cuttlefish               | <i>Sepia lycidas</i>           | 2    | 1.0          | all          |

\*1: FL: Fork length, TL: Total length, SAL: Snout-anus length, CW: Carapace width, ML: Mantle length

\*2: All in the column of landing size means that all catches are brought to market.

*hypargyreus* (2,217 individuals, 7.3%), *Ovalipes punctatus* (1,579 individuals, 5.2%), *Lepidotrigla microptera* (1,276 individuals, 4.2%), *Dentex tumifrons* (1,187 individuals, 3.9%), and *Pampus argenteus* (1,157 individuals, 3.8%). These eight species accounted for about 70% of the total catches.

The 100 species with the number of individuals caught being less than 10 accounted for about half of the total catch. The diversity of catches was investigated from the number of individuals by species (Table 2). The Simpson's index of diversity was 0.105<sup>12)</sup>.

#### Catch of Unmarketable Fish

The catches were classified into marketable fish and unmarketable fish and evaluated by numbers of individuals and weights of catches. Fig. 3 shows the composition of catches by weight per species.

Of the 180 species caught, 113 species were marketable fish totaling 28,000 individuals and 2,500 kg. While 67 species were unmarketable fish totaled 2,600 individuals and 220 kg. Unmarketable fish accounted for 8.7% in the number of individuals and 8.1% of the total weight of the catches. The main species of unmarketable fish by number

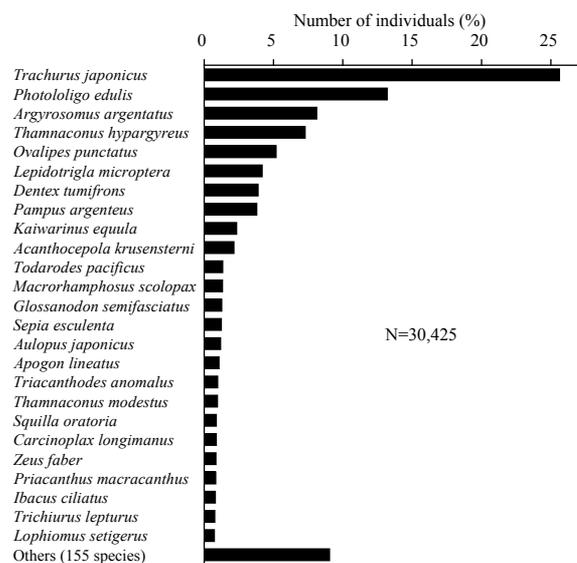


Fig. 2. Catch composition in number of individuals. Data were compiled from every year.

of individuals were *Acanthocepola krusensterni* (653 individuals, 2.1%) and *Macrorhamphosus scolopax* (404 individuals, 1.3%). These two species accounted for about 40% of the unmarketable fish by number of individuals.

#### Catch of Marketable Fish Discarded

Based on the landing body size, individuals of the main marketable fish species were classified into individuals to be landed and those to be discarded and the ratios were investigated.

Of the 113 species of marketable fish, 12 species comprised a comparatively large proportion of the number of individuals: *Trachurus japonicus*, *Argyrosomus argentatus*, *Thamnaconus hypargyreus*, *Lepidotrigla microptera*, *Pampus argenteus*, *Kaiwarinus equula*, *Zeus faber*, *Trichiurus lepturus*, *Ovalipes punctatus*, *Photololigo edulis*, *Todarodes pacificus*, and *Sepia esculenta*.

Fig. 4 shows the body size composition of these 12 species. In the figure, the broken line indicates the marketable size. Individuals of marketable size or greater were landed and ones smaller than this size were discarded. Based on this standard, the discard rate of each species was investigated. Here, the discard rate equals the percentage of discarded individuals among the total number of individuals by species.

The species with discard rates over 50% were *Ovalipes punctatus* (95.0%) and *Trichiurus lepturus* (62.5%). The

species with discard rates below 10% were *Trachurus japonicus*, *Argyrosomus argentatus*, *Thamnaconus hypargyreus*, *Lepidotrigla microptera*, *Kaiwarinus equula*, and *Todarodes pacificus*.

For the 113 species of marketable fish, the number of discarded individuals was investigated by the same method. The individuals too small for landing totaled 3,559 and accounted for 12.8% of the total number of marketable fish.

## DISCUSSION

Compared with other fishing grounds, the fishing grounds of the East China Sea have a diversity of species. According to other reports, the fishing grounds have complicated ecosystems resulting from this diversity of species.

We investigated species diversity by using Simpson's index to characterize the composition of the fish catch. Kishida et al. (1980) reported great diversity at 0.2 or less on Simpson's index of diversity<sup>13</sup>. Judging from this report, the shoal distribution is complicated and the catch diversity is very great in the area of the sea surveyed this time.

This survey clarified that of the total 6,200 individuals

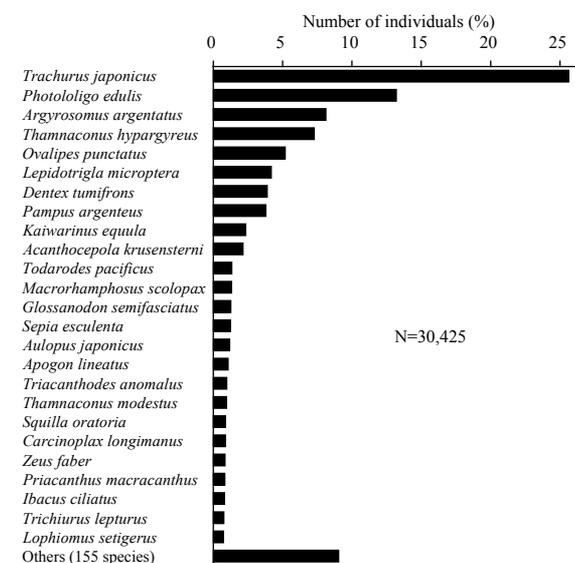


Fig. 3. Catch composition in weight. Data were compiled from every year.

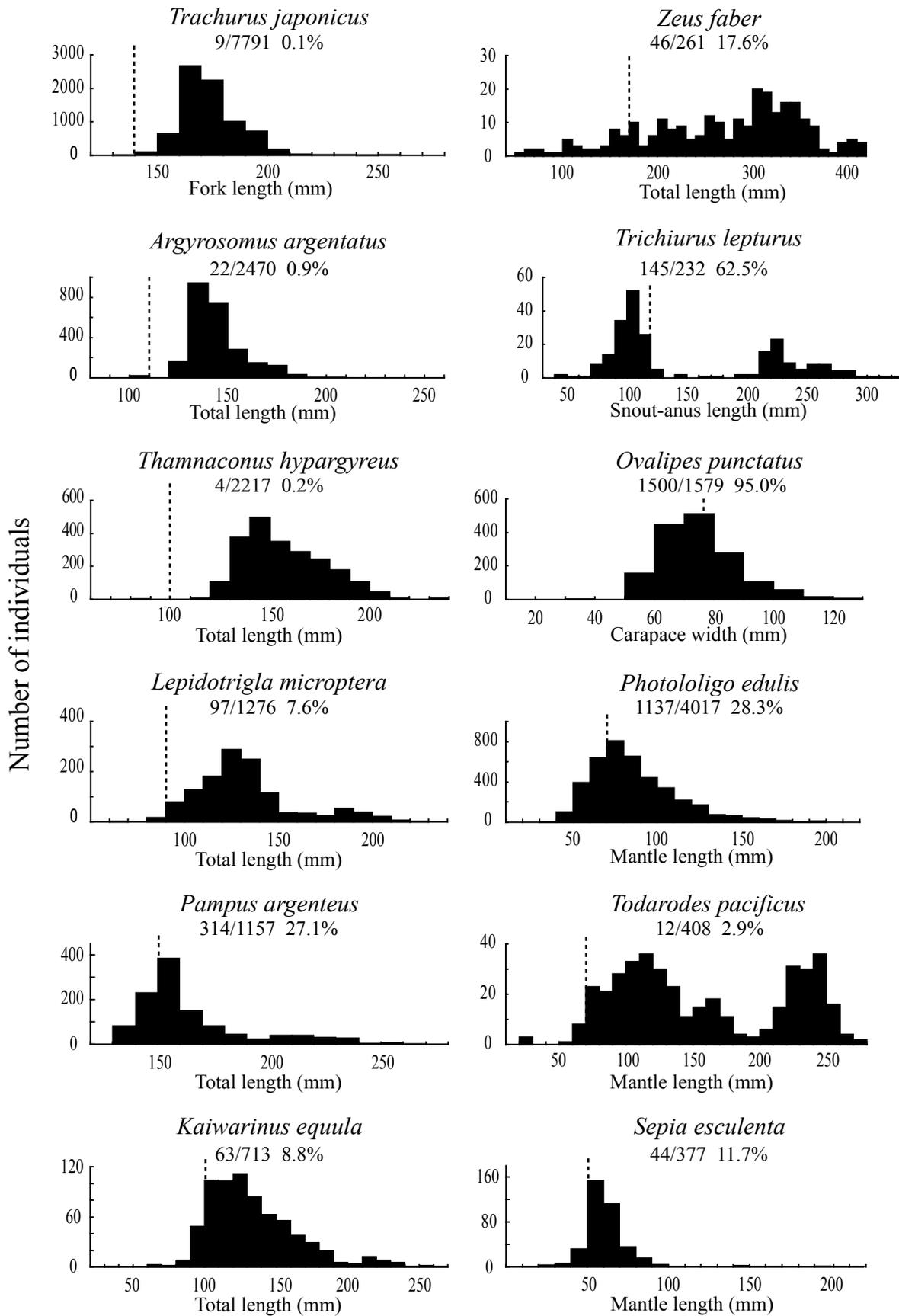


Fig. 4. Body size distribution for major marketable species. Data were compiled from every year.

discarded, which account for 20% of the total number of individuals caught, 2,600 were unmarketable and 3,600 were too small for landing. In the sea area, however, the fish fauna changed seasonally and the composition of catches changed accordingly. As the composition of catches changes, the volume of discarded and the composition of discarded species also changed. In particular, the discard rate of marketable fish is predicted to fluctuate by season, according to the stage of growth. To clarify the actual conditions of discard in the East China Sea, a year-round survey is necessary.

Among the species of marketable fish, *Ovalipes punctatus* and *Trichiurus lepturus* showed high discard rates.

In particular, the discard rate of *Ovalipes punctatus* was 95%, indicating a waste of resources. Individuals discarded at sea are expected to survive. However, considering temperature differences between habitats near the seabed and on the fishing vessels and also damage to fish during sorting, the survival rate of discarded individuals may be low.

If these individuals can escape from a trawl net during towing, they will grow to landing body sizes and increase the fishery production. In addition to the mesh size regulation, which is expected to result in size selectivity by the cod-end size, the research and development of fishing gear for species and size selectivity are expected to be promoted and implemented.

The East China Sea is shared by Japan and surrounding countries. To manage resources and promote a sustainable fishery in the fishing grounds, these countries should create opportunities of discussing the survey fishing gear and techniques and for conducting surveys to assess catches accurately.

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