東シナ海底魚漁場の漁獲物組成と投棄対象生物の混獲状況

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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* (7,800individuals, 25.6%), *Photololigo edulis* (4,017individuals, 13.2%), *Argyrosomus argentatus* (2,470individuals, 8.1%). Of the total catch in number, the discards accounted for 20.4%. The main discarded species with no commercial values were *Acanthocepola 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[1,2]. 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[3]. The by-catch of fish to be discarded wastes resources and may adversely affect the ecosystems of the fishing grounds[4].

In the fishing grounds of the East China Sea, a mesh size regulation on the cod-end was enacted in 1963[5]. 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[3].

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

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discarded[6-10]. 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[1,2], 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^2.

Handling of Catch

After trawling, the catch was identified to species level and the individuals of each species were counted and weighed[11]. 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*

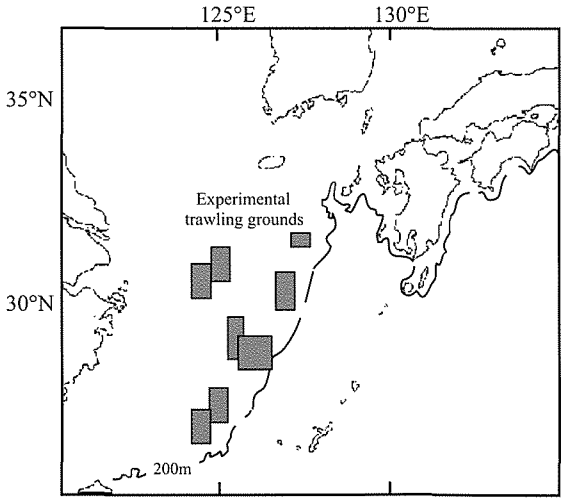

Fig. 1. Study areas for the bottom trawl.

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

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

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

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

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

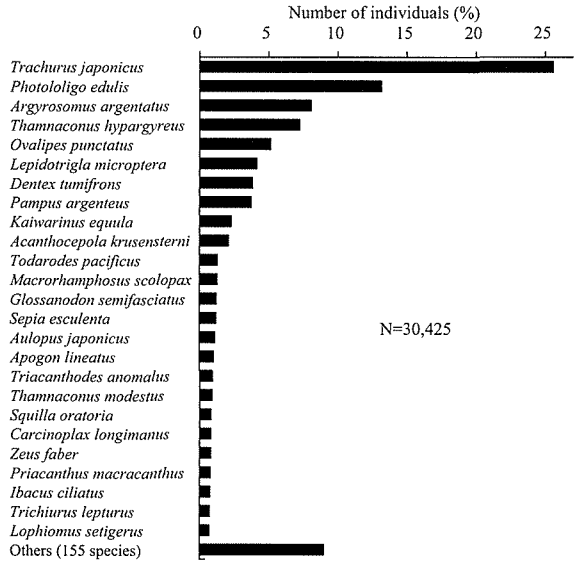

Fig. 2. Catch composition in number of individuals. Data were complied from every year.

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[13]. 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

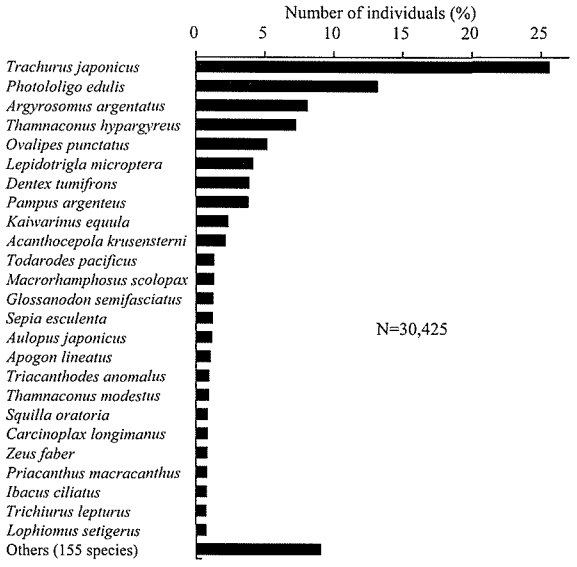

Fig. 3. Catch composition in weight. Data were complied from every year.

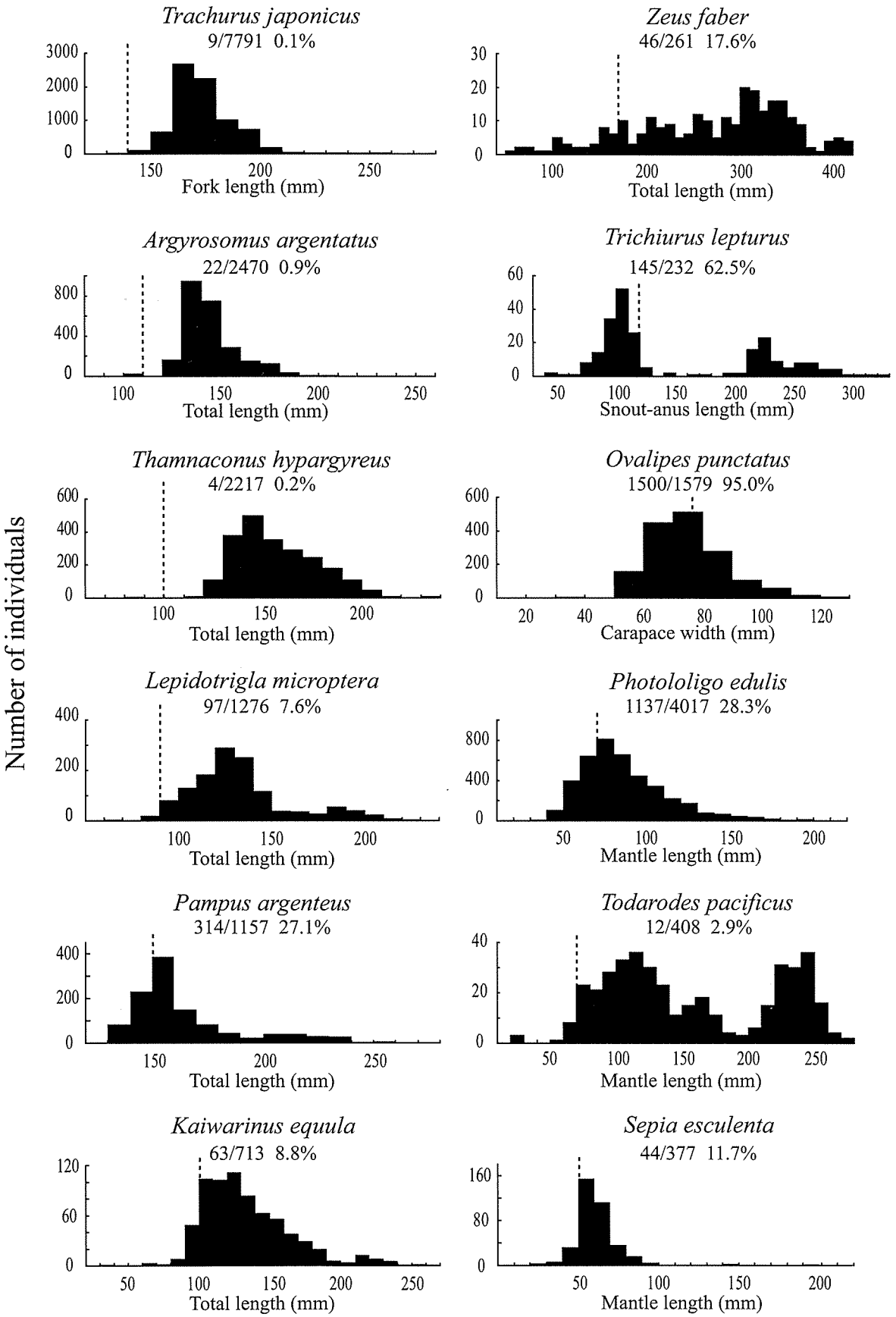

Fig. 4. Body size distribution for major marketable species. Data were compiled from every year.

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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