DISCARDS IN JAPANESE MARINE CAPTURE FISHERIES AND THEIR ESTIMATION

by

Tatsuro Matsuoka
Kagoshima University, Japan

1. INTRODUCTION

This report reviews discards in Japanese fisheries and methodology for discard assessment. Bycatch focused here is incidental catch to be discarded at sea and those utilised is dealt little. This is because, as widely stated, bycatch is not necessarily a negative practice as there are many fisheries which are feasible with bycatch in addition to the principal species. It is important to segregate bycatch and discard issues. It may provoke unnecessary and unproductive contradiction, if bycatch as a whole is dealt in the same line with discards.

This report firstly overviews the structure of the fishing industry of Japan and its statistics in view of its sectors and landing. This aims at illustrating its basic characters and changes for the recent years. Secondly, the report summarises available information on discards from a sector to sector. It estimates, then, the amounts of discards by individual sectors and, subsequently, the total discard by the Japanese marine capture fishery as a whole. The last part of the report discusses improvement of methodology in discard researches.

Discard ratios in this report are defined in a way different from Alverson *et al.* (1994). A ratio is defined against the total amount of retention or landing by each sector. It is not defined in reference with target species. This is because a majority of Japanese fisheries are multi-species oriented and, consequently, a single target species hardly appears in many sectors. Discard ratios in this report refer those as weight to weight in principle, while ratios obtained as number to number are connoted as N/N ratios following Alverson *et al.* (1994). Discard rates are defined also following Alverson *et al.* (1994).

In this report, only publicised data were utilised for discard estimation with exceptions of those recorded by the author or the author's group. Discard ratios were either directly adopted or secondarily evaluated from those records. All estimations were made on the basis of those ratios and the fisheries statistics officially published by the Ministry of Agriculture, Forestry and Fisheries of Japan for 1994 (Anon. 1996) unless specified otherwise, e.g. discards estimated in average over 1988, 1989 and 1990, when Alverson *et.al.* (1994) made their assessment.

2. OVERVIEW OF FISHING INDUSTRY OF JAPAN

2.1 Sectors in Marine Capture Fisheries

Japanese marine capture fisheries are categorised into sectors which belong to; distantwater, off-shore and coastal fisheries on the basis of combined criteria of gear and methods, fishing grounds, principal species and vessel sizes for the legislative and statistical purposes.

The distant-water fisheries are composed of distant-water trawls (further divided into several sub-sectors), trawl in the East China Sea, large and medium (L/M) surrounding net operated by one boat in the Central Pacific and Indian Oceans for skipjack and tunas, North Pacific longline and gillnet, distant-water tuna longline, distant-water skipjack pole and line and distant-water squid jigging.

The off-shore fisheries include the sectors which are operated by defined medium-sized vessels and are categorised in neither distant-water fisheries nor set net and beach seine fisheries. Typical ones are off-shore trawls, L/M surrounding nets for other than tunas, offshore tuna longline and off-shore skipjack pole and line.

The coastal fisheries are composed of the sectors operated by vessels less than 10GT and set net and beach seine fisheries. Even each sector in the category is hardly uniform from a view point of locally adapted fishing gear and methods. This character is expounded by a range of organisms in a large variation in aquatic environment over the Japanese archipelago.

2.2 Recent Trend in Marine Capture Fisheries

Japanese fishing industry had contributed over one tenth of the world fisheries production for the 1970's and 1980's, however, its characters had changed around the mid 1970's and have been changing since the late 1980's drastically.

The distant-water fisheries had declined through the 1970's since their production was maximised at 3.99 million tons in 1973, when they contributed to the marine capture fisheries of Japan at 40.7%. Both distant-water and off-shore fisheries have declined since then, though increasing production of marine capture fisheries had continued until it leveled off around 12 million tons from 1984 to 1988. The total production of the marine capture Fisheries in 1994 was 6.59 million tons. This was composed of 1.06 million tons (16.1%) by distant-water, 3.72 million tons (56.5%) by off-shore and 1.81 million tons (27.4%) by coastal fisheries.

Withdrawal from high-sea fishing grounds is another large change appeared for the recent years. The harvest from high seas declined from 1.63 million tons.in 1988 to only 0.44 million tons in 1994. Japanese fishing industry has been turning to an industry more oriented to coastal waters.

2.3 Products by Sectors and their Characters

2.3.1 Industrial Fisheries

SURROUNDING NET: The surrounding net fisheries form the largest component, or 37.3%, of the total landing by the marine capture fisheries of Japan (referred to as the total landing hereinafter) in 1994. The sectors in this industry are re-categorised into three; (1) L/M surrounding net for skipjack and tunas, (2) L/M surrounding net for other species and purse seine (medium surrounding net), and (3) other (small) surrounding net fisheries.

Category (1) entirely aims at tunas. This is one of the most important fisheries in Japan today from the landing-value view point, however, it produces only 3.5% of the total landing of Japan. Category (2) harvests other pelagic species. It produces 33.6% of the total landing. Between two sub-sectors operated by different sizes of vessels, the product species are similar, which are composed of mainly sardine (43.3% and 54.6% in the two sectors respectively), mackerel and horse mackerel. Category (3) is conducted by smallest vessels for a variety of species in a variety of fashions, of which contribute to the total landing at 0.2%.

TUNA LONGLINE: This fishery is composed of; distant-water, off-shore and coastal sectors, which are registered on the basis of respective vessel sizes. This is one of the most important fisheries for Japan, however, its landing amount is only 4.3% of the total landing in 1994. The three sectors aim at relatively different species, as the distant water sector for bigeye, while, the coastal sector for albacore. However, it is a similar trend overall that they land mainly tunas at 64.9% to 84.5% with minor catch of swordfishes and marlins, sharks and others.

INDUSTRIAL TRAWL: Large-scale trawl fisheries by Japan have reportedly declined for the past decade. The mother-ship trawl and medium trawl both in the North Pacific have entirely ceased. The remaining industrial trawl fisheries are; the large trawl in the North Pacific (0.4% of the total landing), small trawl in the North Pacific (1.8%), South Pacific otter trawl (2.7%), trawl in the East China Sea (0.7%) and off-shore trawl operated by either one boat (6.2%) or two boats (0.5%).

The large and small distant-water trawls in the North Pacific are oriented to walleye pollock (66.2% and 86.5% of landing by each sector). The trawl in the East China Sea lands diverse species as; squids and cuttlefishes (24.0%), sea breams, pike conger and silver jewfish. The South Pacific otter trawl includes a range of operations

over the world, which is principally oriented to cod-like fishes (45.2%) such as Cape hake together with squids and jacks. The industrial shrimp trawl which is operated overseas mainly as joint venture has been almost ceased (much less than 0.01%).

The landing species of the off-shore trawl is also diverse because this sector is composed of a variety of sub-sectors operating in different parts of Japan. Landing by the one-boat offshore trawl is composed of walleye pollock (36.2%), arabesque greening, squids and cuttlefishes and sand lance. The two-boat off-shore trawl, which is smaller than the former in vessel size, lands squids and cuttlefishes (36.8%), flatfishes, sea breams and walleye pollock.

SAIMON DRIFT GILLNET: The salmon drift gillnet fishery has reportedly declined and it is operated only within the 200 n.mile zone of Japan nowadays. It produces only 0.4% of the total landing. The landed products are entirely salmon and trout species.

2.3.2 Small Scale Fisheries

SMALL TRAWL: This category is composed of a variety of coastal trawls and bottom seine nets operated with different gears and methods around the country. There are such subsectors as; small Danish seine, small otter and beam trawls and small sail trawl. These three sub-sectors contribute to the total landing in Japan at 0.8%, 6.3% and less than 0.01%. Their product species are diverse. The small Danish seine fishery harvests flatfishes (12.4%), cuttlefish, squids and cuttlefishes and octopus. The small otter and beam trawl sub-sector includes a highly specialised portion which harvests mainly extensive-maricultured scallops (64.9% of this sub-sector). The remaining portion of the products after excluding shellfishes is composed of shrimps (17.7% of the remaining portion), flatfishes, octopus, squids and cuttlefishes and a variety of other organisms.

SET-NET: The set-net fishery produces 9.2% of the total landing and it is one of the most important component of coastal fisheries. This is composed of three sectors as; large set-nets for salmon, large set-nets for other species and small set-nets. The salmon set-net fishery is highly specialised in northern Japan for salmon and trout, which comprise 93% of landing by this sector. The large set-nets for others harvest a variety of species locally and seasonally. Even sardine which is the principal species comprises only 21.7% of the landing by this sector and is followed by mackerel, salmons, squids, horse mackerel, anchovy and yellowtail. Small set-nets have a greater variation. There are as many as 200 species landed in a set-net fishery in a Pacific coastal water of central Japan (Ishidoya and Ishizaki 1995).

OTHER GILLNETS: This sector includes a variety of small-scale gillnet operations around the country, which produces 3.2% of the total landing. Because of the nature of the fishing gear and methods, there is only one common major catch such as flatfishes (12.1%) with exceptions of walleye pollock and arabesque greenling which occur specifically in northern waters.

BOAT SEINE: This sector harvests 2.9% of the total landing. The products are composed of non-finfish organisms (39.3%), sand lance, early-stage juveniles of anchovies and a variety of finfishes.

3. BYCATCH AND DISCARD RECORD

Sound scientific information of discards is very limited in Japan, because there have been a small number of observer programmes. Discard ratios are evaluated on a variety of definitions, though this is not unique over the world (Alverson 1994). They have been reported against unit effort, landing of a concerned species and whole landing. They have been reported also either on number or weight basis and either on species or summed-discard basis. Lack of basic information, such as discard ratios and corresponding landing amounts, while only reporting estimated discards, is also one of the weaknesses frequently seen in many discard researches in Japan, which makes a greater-scale assessment difficult.

3.1 Industrial Fisheries

L/M SURROUNDING NET (for skipjack and tunas): According to Takeuchi (1995), this sector involves a small quantity of incidental catch only when it is set for schools associated with floating objects. Such operations produce approximately 70% of landing of this fishery. The species to be discarded or fish-mealed are small individuals of the species which are aggregated around floating objects, such as sharks, trigerfish, filefish, dolphinfish, trevally, amberjack and so forth. The discard ratio for these species is evaluated to be 0.000423 even on the basis of a limited survey by Takeuchi (1995).

L/M SURROUND NET (for other species) AND PURSE SEINE: According to Hara (1995), these operations involve almost no chance of discard because of the mixed capture of a large amount of small individuals of commercial species, such as horse mackerel (Hara 1995), are readily taken into account in the procedure from capture to marketing

TUNA LONGLINE (distant, off-shore and coastal waters): According to Kobayashi and Yamagachi (1978), the N/N bycatch rate of sharks was nearly 0.16 in the eastern tropical Pacific, though it was obtained through fishing practical by a training vessel for 19 years. The bycatch sharks were composed of blue (59.8%), Walbeem's sharpnose, oceanic whitetip and other sharks, which are mostly discarded (Kobayashi and Yamaguchi 1978). On the other

hand, sharks comprise 2.9%, 17.0% and 5.2% of respective landing in weight in the three sectors (distant-water to coastal). Therefore, though the bycatch rates in weight are unknown, caught sharks are conceivable to be discarded in part. The discard ratio to noncommercial shark-bitten tuna is estimated to be 0.088 according to Kobayashi and Yamaguchi (1978). There are no data from reliable observation of commercial fishing on the potential bycatch of marine reptiles and sea birds.

DISTANT WATER TRAWL: Inoue (1995) described that sculpins, snailfishes, sharks and stingrays caught in the distant-water trawl in the North Pacific are mostly discarded, where its ratio was not availed. Small individuals of major species, walleye pollock, are discarded in order to retain large ones mainly due to allocated quota. According to Inoue (1995), the N/N and W/W specific discard ratios for walleye pollock are assessed to be some 0.43 and 0.17. Small ones of commercial species other than thornyheads, rockfishes and Pacific cod, which comprise only a small portion of landing by this fishery, are also discarded in the same manner, or being attributable to a fishing regulation.

Observer programmes were applied when the distant-water trawl was operated in the Bering high-sea region. It was reported that bycatch in the pelagic trawl which aimed at walleye pollock in the region was mainly smooth lumpsucker (93.6% and 97.1% of the total bycatch in number) with few commercial species (Anon. 1993b). The N/W bycatch ratio is, accordingly, assessed as 9.61 and 34.63 individuals per ton of walleye pollock.

Discards in the trawl in the East China Sea is composed of mainly small individuals of commercial species, such as hairtail, flatfishes and tongue soles and non-commercial species, such as starfishes, according to Fuwa (unpublished). The discard ratio is 0.618 on the basis of his on-board survey.

OFF-SHORE TRAWL: A discard ratio of 0.0811 was reported for a variety of species which were unidentified, where walleye pollock was the principal catch (42.9%) off the North Pacific coast of Honshu Is. The specific discard ratio to walleye pollock was 0.175 (Anon. 1995a). This is very close to the ratio in the distant-water trawl in the North Pacific.

Lee *et al.* (1982) reported that trawlers off the Pacific coast of central Japan land as many as 100 species, therefore, a majority of captured species are utilised in principle and discards are attributable to their small sizes. Inoue (1995) also reported that some fishes, such as sharks and stingrays which are discarded in the North Pacific distant-water trawl are retained in part in this sector.

Partly discards of small and soft-shelled individuals and female of tanner crabs in a subsector in the Sea of Japan were reported, though the discard ratio is not available. Survival of discarded red snow crab from deep water is hardly expectable (Kanemaru 1990).

DRIFT NETS: The salmon drift gillnet fishery was bycatches Dall's porpoise, shairwater and puffin (Yatsu 1995). According to Yatsu (1994), bycatch rates per 1,000 tans of nets were 0.25 for fur seal and 0.75 for white-sided dolphin in the North Pacific, though these were recorded in a small-scale experimental operation. According to Yatsu (1994), bycatch rates per 1,000 tans of swordfish drift-nets were 6.76 for fur seal and 3.38 for small cetaceans in the North Pacific. These were also derived from a small-scale experimental fishing. Discards of both finfishes and other animals around Japanese waters are unknown.

3.2 Small Scale Fisheries

SET-NET: A potential problem in set-net fisheries is bycatch of seasonally migrating juveniles of commercial species (Miura 1995). In the case of set-nets in northern Japan the species of the above potential are salmon and walleye pollock, of which incidentally caught juveniles are hardly thought to survive after being released. The salmon set-net fishery is reported, however, to be free from this problem, due to its relatively large meshes and the regulation of fishing seasons (Miura 1995).

The set-nets for other than salmons are operated for multi-species. Discards are mainly juveniles of highly commercial species, such as grunt, striped beakperch and barracuda as well as other marketable species such as red bulleye, anchovy, leatherjacket and sardines. Ishidoya and Ishizaki (1995) reported that the discard ratio, including possible utilisation in part for no direct human consumption, is 0.014 in set-nets around the Pacific coast of central Japan.

OTHER (SMALL) SURROUNDING NETS: No researches have been conducted, however, this sector is highly possible to bycatch, because it is operated in coastal waters and light fishing is partly allowed (Hara 1995). Their discard ratios may be, however, relatively low because of the main target of surface species and the common nature of small-scale fisheries.

SMALL TRAWL(excluding small sail trawl): According to Kitazawa and Oaku (1992), the discard ratio by small Danish seiners in coastal water of the central Sea of Japan is estimated as 1.22. The discards were composed of 42% of small individuals of commercial species, 28% of non-commercial finfishes and 30% of other organisms. The N/N discard ratios were around 1.0 for several species of commercial flounders and tanner crab.

Fujiishi (1995) recorded discard ratios of 2.55 and 0.67 for small beam trawlers in coastal waters of the western Sea of Japan. Discards of highly, less and no commercial values comprised 25.3%, 4.9% and 69.9%. The discard ratios for highly and less commercial species were 0.186 and 0.350, while, the N/N ratios for respective groups were 0.238 and 0.686.

Matsuoka *et al.* (unpublished) observed that small Danish seiners for deep-water prawn in the East China Sea off southern Kyushu Is. discard no-commercial finfishes, such as grenadiors, greeneye and conger eel, while, prawns were all retained. The discard ratio was approximately 0.5.

Takagi (1994) estimated that discards of mainly non-commercial species such as cloudy dogfish and cardinalfish by small trawlers in coastal water of the western Sea of Japan were 940.8t over 2,106 operational day vessels. The discard ratio is estimated to be some 2.42, taking the production and the total operational day vessels in this fishery over Japan into consideration, though this estimation is very rough.

Tokai (1993) estimated that 500 small trawlers operating around the western Seto Inland Sea discarded 66t and 560t of small individuals of marbled sole and finespotted flounder a year, which are commercially important species. The discard ratios for the two species to the summed landing are estimated as 0.0067 and 0.057 on the basis of the same method as applied to the data from Takagi (1994) above.

Tokai (1994) also reported that major finfish species discarded by small beam trawlers for shrimp and mantis shrimp in the Seto Inland Sea were less or no commercial species such as dogfish, cardinalfish, ponyfish, gobies and dragonet.

Otomi *et al.* (1992) reported that mortality ratio among small mantis shrimp discarded by small trawlers in Tokyo Bay is high in summer, approximately 0.7, and low in winter, 0.2. No discard ratio was reported.

SMALL SAIL TRAWL: A small sail trawl operated in the southern most part of Japan for shallow water shrimps was assessed to involve a variety of species of discards as much as 22.4 times of shrimp catch (Kawamura unpublished).

BOAT SEINE: Discard ratios varied from 0.13 to 3.0 among gochi-am'-seine (similar to small Danish seine but not dragged) operations for different species in coastal water off southern Kyushu Is (Matsuoka and Miura unpublished). The integrated discard ratio in the fishery as a whole was estimated as 1.12. Discarded small individuals of red seabream and olive flounder are stock-enhanced ones.

OTHER GILLNETS: It is obvious that there are many species of bycatch including those other than finfishes in coastal gillnet fisheries, however, no scientific record of discard ratio is available. Torisawa (1995) reported that a coastal bottom gillnet fishery principally for mantis shrimp in northern Japan discards juveniles of brown sole, longsnout flounder and pointed flounder because of size regulations. A cuttlefish trammelnet fishery in the southern most Japan discards juveniles of olive flounder due to the same reason

(Matsuoka and Ono unpublished). The specific N/N discard ratio was 1.31 to flatfishes, 0.36 to cuttlefish and 0.28. The olive flounder resource in the surveyed water is partly stock-enhanced. Discards of enmeshed organisms, which are spoiled due to accidentally long soaking, are sometimes more than retention.

OTHER LONGLINES: According to Ogura *et al.* (1980) the N/N discard ratio in small bottom longline fishing at 150m - 250 depths in the Pacific coast of central Japan is assumed to be 0.54, where saucod (rosefish), seaperch, beardfish and hakeling were commercial catch, while, sharks, stingrays, puffers, black escolar and hagfish were non-commercial. The same group reported another set of experimental data of the same fishing (Arimoto *et al.* 1983a, Arimoto *et al.* 1983b), from which a N/N discard ratio, 0.33, is estimated.

OTHER ANGLING: There is no discard record for the other angling fishery such as handling. Although in a tropical lagoon water, Matsuoka *et a/.* (1992) reported that the number of handlinined species was smaller than a half in comparison to those bottomlonglinined in the simultaneous test fishing, or handlining is regarded more species-selective. Bycatch ratios in handlining are, therefore, conjectured to be no greater than those in bottom longlining.

OTHER FISHERIES: In trapping (categorised in other fisheries in statistics) for tanner crab in deep waters in the Sea of Japan, female and small individuals are discarded or released because of a landing regulation, however, their survival is hardly expectable (Kanemaru 1990). The amount and ratio of discard are unavailable. There are no data of discards in the beach seine fishery. This fishery remains mainly just for fishery-tourism, therefore, it is hardly thought to involve serious discard problems.

3.3 Other Information

Discards in off-shore fisheries around 1974 were estimated to be 10% to 20% to their landings (Fukuda 1981), although the process of assessment was not detailed. These values appear ironically reliable because this was expected for potential exploitation. The major portions of the discards were 30,000t of flyingfishes by driftnetters and 150,000t of leatherjacket by trawlers. On the basis of 4,180,000t of off-shore fishery landing in 1974, the discard ratios for these species to the whole off-shore commercial landing are roughly estimated to be 0.0072 and 0.036.

There is entirely no information of discards in the remaining sectors; the South Pacific otter trawl, other lift-nets, salmon longline, North Pacific longline and gillnets and *patch-am)* type (small-meshed) boat seine fisheries.

4. ESTIMATES OF DISCARDS

4.1 Methods

A discard ratio, Ri, for the i-th fishery was defined as the ratio between weights of summed discards, di, and summed landing, ci, as;

$$Ri = di / ci \quad \text{----- (1)}$$

The summed discard amount, Di, in each sector was assessed on the discard ratio and the summed landing, Ci as;

$$Di = Ri\ Ci \quad \text{-----(2)}$$

The partial total discard, Dt', by the sectors to which the discard ratios are available, was assessed as;

$$Dt' = \sum_{i=1}^{I'} Di \quad \text{-----(3)}$$

where I' is the number of sectors for which the discard ratios are available. The total discards, Dt, by the marine capture fisheries as a whole, where are a total of I sectors, was assessed as;

$$Dt = Dt' . \sum_{i=1}^{I} Ci / \sum_{i=1}^{I'} Ci \quad \text{----- (4)}$$

A specific discard amount, Dij, of the j-th species in the i-th fishery was also assessed, when its specific discard ratio, rij, was available;

$$Dij = rij . Ci \quad \text{----- (5)}$$

4.2 Materials for Calculation

A discard ratio in each fishery was determined as either the value found in the Section *2* or an average of the minimum and maximum of those values (Alverson *et al.* 1994). Some ratios were adjusted in reference with additional information or adopted from similar fisheries in other regions.

SECTORS ASSUMED TO INDUCE NO DISCARDS: The following sectors were assumed to induce practically no discards because of the nature of their fishing gear and methods; skipjack pole-and-line, saury stick-held dip-net, mackerel angling, shellfish collection and seaweed collection.

DISCARD RATIOS FROM REPORTS: On the basis of the reports reviewed in Section 2, discard ratios in the following sectors were approximated to be 0.0 (Table 1); L/M surrounding net for other than tunas, purse seine and small trawl partly for shellfishes. In the same way, the discard ratios assessed in Section 2 were adopted for the following sectors (Table 1); L/M surrounding net for tunas, trawl in the East China Sea, small sail trawl, boat seine, large set-net for other than tunas and small set-net.

The discard ratio for the off-shore trawl fishery was assessed as an average of the assessed values, 0.0811 and 0.20. The discard ratio for the small trawl fisheries (excluding sail trawl) was an average of the minimum and maximum values, 0.5 to 2.55. The amount of landing of shellfish was excluded from the products of the above sector, because of the specialised mainly for scallops which are stock-enhanced in extended mariculture.

DISCARD RATIOS ADJUSTED AND FROM OTHER SOURCES: The discard ratio for the shrimp trawl was approximated with the rough average in tropical operations (Matsuoka 1995). The reported discard ratio for the tuna longline fishery, 0,088, was that assessed in part only for shark-bitten tuna. If bycatch sharks are assumed to be roughly twice heavier per capita than tunas, the bycatch rate is estimated to be 0.38. Taking these value and the reported landing amount of sharks in this fishery into account, the discard ratios in the three longline sectors were estimated to be 0.672, 0.496 and 0.646 (from distant-water to coastal).

The discard ratio in the distant-water trawl fisheries in the North Pacific, 0.17, was derived from the values for walleye pollock and discards of other species were not fully taken into account. Therefore, a ratio in the Northeast Pacific, 0.190 (Alverson *et al.* 1995) was adopted. A ratio from the same source, 0.0435, in mid-water trawl was adopted for the highsea operation during 1988 to 1990. Although no discard of juveniles was reported in the large set-net for salmon, there is no description on other species, therefore, the ratio in the other set-net sectors, 0.014 was applied. For the squid angling sector, the discard ratio, 0.0004, around Falkland Is. (Nolan and Yau 1996) was adopted.

SECTORS NOT ASSESSED: There are no reliable data to estimate the discard ratio for the South Pacific otter trawl, other surrounding nets, salmon drift gillnets, swordfish drift gillnets, other gillnets, other lift-nets, beach seine, *patch-am)* type boat seine, salmon longline, other longlining, other angling, North Pacific longlines and gillnets and other fisheries. The total landing by these sectors was 892,752t, which comprised13.5% of the total amount of landing by the Japanese marine capture fisheries in 1994 (Table 1).

PARTIAL DISCARD RATIOS: There are a couple of specific discard ratios (Table 2). The estimation based on the following ratios are inclusive in summed discards. The ratio of discards of walleye pollock (against the species landing) in the distant-water trawl fisheries in the North Pacific is 0.17. That in

the off-shore trawl fishery is 0.175. As the discard ratio for flatfishes in small trawl fisheries (against the summed landing), 0.054 which is the sum of the reported ratios, 0.0067 and 0.057 for two flatfishes was adopted.

4.3 Discard Estimation and Assessment

4.3.1 Calculated Results

The amount of discards in Japanese fisheries by the sectors to which the discard ratios were assessed was estimated to be 793,240t in 1994 (Table 1). These sectors contributed to the total landing by the Japanese marine capture fisheries at 86.5%. Accordingly, the total discard was estimated as 917,550t. An overall discard ratio is 0.139, in other wards, catch was discarded at 12.2%. Within the assessment, the discards by shrimp trawl, distant-water tuna longline and distant-water squid angling, or a total of 139,139t, occurred mainly in the waters other than Region-61. The Japanese discard in Region-61 is estimated to be some 778 thousand tons.

During the period from 1988 to 1990, an averaged annual discard was estimated to be 1,003,663t. The overall discard ratio is 0.0962, or 8.77% of catch was discarded. Excluding the discards by the distant-water sectors as above and the distant-water trawl in the North Pacific (high seas), or a total of 164,759t, the discard occurred in Region-61 is estimated to be some 839 thousand tons in average.

4.3.2 Characteristic Discards in Japanese Fisheries

RESPONSIBLE SECTORS: The sectors most responsible to discards in Japan are the small trawl and boat seine fisheries in coastal waters (Fig. 1). These sectors contribute to the Japanese total landing at 5.4% but are responsible to the total discards at as much as 52.1% in 1994. The discards by this group include juvenile flatfishes of some 9 thousand tons (Table 2). The second responsible group is the industrial trawl fishery which is composed of the distant-water trawl in the North Pacific, trawl in the East China Sea and off-shore trawl. They produce 9.6% of the total landing, however, are responsible to the total discards at 12.9%. Their discards include some 47 thousand tons of juvenile walleye pollock. The discards by the trawl and seine net fisheries as a whole comprise 65.0% of the total discards.

The above analysis depicts that problems are serious in trawl and seine net fisheries and/or around coastal waters. These assessments are simply based on weights. These must be further considered, of course, on the basis of ecological and bioeconomical consequences.

DISCARD ORGANISMS AND MECHANISM TO INDUCE DISCARDS: The discard issue has been discussed with respect to

either discarded organisms (Arimoto 1995) or the mechanisms to induce them (Inoue 1995). These are related to each other, however, the two factors must be separated in order to examine appropriate countermeasures.

Discarded organisms were categorised with regard to consequences in resource conservation and utilisation as Table 3. The most distinctive category of discards in Japan seems to be juveniles of commercial species as (6). Discards of walleye pollock by the distant-water trawl in the North Pacific and flatfishes by the small trawlers are typical examples. Discards of stock-enhanced species as category (3), so as juveniles of red seabream and olive flounder frequently occur in small trawl and seine net fisheries, are immense waste in coastal fisheries. The category (1), discards of protected species have been reported only in drift gillnet and shrimp trawl fisheries. It is probable in some other sectors, too, however, no scientific data confirm it.

Discards occur due to different reasons (Table 4). Not to mention no and less commercial values in view of size and species as (5) and (6), there are many cases of discards due to fishing/landing regulations such as (2) and (3). It is ironic that discards are provoked by regulations which were established for the purpose of rational use of aquatic resources. This issue must be re-evaluated, because discarded bycatch organisms have been reported to be hardly survival in many fisheries, though this practice is seldom referred to positively as 'release'.

4.3.3 Overall Assessment and Required Countermeasures

One of the largest constrains in countermeasure against discards in Japan is that most of basic researches have been conducted on individual-researcher basis, perhaps due to lack of a policy regarding the discard issue. The present analysis is assessed to have depicted only a very crude picture of the problems and it is far inadequate to discover problems unique in individual sub-sectors. This is true in particular in coastal fisheries in view of their variation of fishing techniques and catches. Systematic observation and research programme on discards over the country are required.

It may be a character that the major reason of discards is size rather species. Discards of under-sized ones of stock-enhanced species are, in particular, negative characteristic of coastal fisheries in Japan. This has an especial consequence in Japanese fisheries, because the importance of coastal fisheries management must be further proliferated, regarding the remarkable trends in the recent Japanese fisheries, such as decline of distant-water fisheries and decrease of harvests in high-sea fishing grounds.

These facts suggest, on the other hand, that a majority of problems can be practically eased at the level of technical countermeasures. In fact, this is reflected in that size-selectivity researches have been carried out actively in Japan. There are, however, several factors beyond the range of technical improvement. The examples are that many discards are induced by fishing Landing regulations. Possible utilisation of organisms discarded at present is also mainly a non-technical matter, though their utilisation seems an issue in food technology. It is rather a matter of fisheries management and development policy, because a majority of the currently non-commercial species have not been utilised due to difficult access to markets rather than non-edibility.

Discard issues in Japan are assessed as that only technical countermeasures are proceeded in part, while, overall policy to co-ordinate identification of problems and revision of management has not been established.

5. DISCUSSION

5.1 Over-Estimate in Report 339

The presently estimated discard of some 778 thousand tons in 1994 by Japanese fisheries in Region-61 is quite small in comparison to the regional discard of 9,132 thousand tons estimated in Report 339 (Alverson 1994). Some 839 thousand tons of the average discard during 1988-1990 does not make the situation different. The portion to which Japanese fisheries are responsible is not clear in Report 339, however, inconsistency between the two estimates is apparent, even taking other countries in the region into account.

The inconsistency is attributable to over-estimates by Report 339. Its discard estimation is based on a target species to which the discard ratio, Rj, seems to be defined as;

$$Rj = dj / cj \text{ ----- } (6)$$

where cj *is* the observed retention of target species-j and dj *is* the associated summed-discards. The summed discard, Dj, when targeting species-j was assessed on the basis of the Rj or an average of Rjs and landing statistics of species-j, Cj, as;

$$Dj = Rj \, . \, Cj \text{ ------- } (7)$$

This is correct when a sector catches only single target species and the species is caught exclusively by the sector, however, a different consideration is required, if otherwise.

If a discard ratio, Rij, in sector-i is defined on the basis of retention of species-j, the summed discard. Di, in sector-i must be represented as:

$$Di = Rij \, . \, Cij \text{ ----- } (8)$$

where Cij *is* landing of species-j in sector-i. When there are bycatch of species-j in other sectors, summed-discard, Dj', estimated in association with species-j becomes;

$$Dj' = Rij \,.\, Cj'$$

$$= Rij.(C1j + C2j + C3j + ... + Cij + ... + CIj)$$

$$= Di + Rij.\ (C1j + C2j + ... + C(i-1)j + C(i+1)j + ... + CIj) \quad \text{----- (9)}$$

$$\neq Di$$

where Cj' is the total catch of species-j , including bycatch, $C1j$, $C2j$, ... $C(I\text{-}1)$, $C(i+1)j$ ...., Clj, by sectors-1, 2, ... (i-1), (i+ 1) .... I, and I is the number of sectors which catch species-j. As apparent in the above, the approximated discard, Dj', falls to exceed the discard to be estimated for sector-i, or Di.

The magnitude of over-estimate in the sector-i is evaluated as;

$$\frac{Dj'}{Di} = \frac{Rij \,.\, (C1j + C2j + C3j + ... \; Cij .... + CIj)}{Rij \,.\, Cij}$$

$$= 1.0 + \frac{C1j + C2j + ... \; C(i\text{-}1),j + C(i+1,)j .... + Cij}{Cij} \quad \text{-----(10)}$$

Equation (10) indicates that over-estimate is exaggerated where a concerned sector is smaller in scale, the portion of target species in the sector is smaller and bycatch of the concerned species in other sectors is greater. This over-estimate is unavoidable in multi-species fisheries as far as an estimate for a sector is substituted with that for a target species. Bycatch in a sector affects estimates of discards in other sectors each other and, consequently, this results in an over-estimate of the total discard.

The factors in Equation (10) for the species which are assumed to be 'targets' in fishing sectors in Japan were reviewed. For example, tunas which are the major or target species in tuna longline fisheries comprise 64.6% to 84.5% of their landing, however, landing of tunas as bycatch in other sectors is equivalent to 49.5% of the landing by the longline sectors. Roughly, Equation (10) becomes some 2.6 in average over major species. This suggests that Report 339 may have estimated discards by the Japanese fisheries in Region-61 as some 2.1 thousand tons (in 1988-90). The reason to have estimated 9.1 thousand tons of discards in Report 339 could be conceivable, taking the above over-estimates and landing by the other nations around the region. Although discards by other countries in the Region are unknown, the total discard in the region is roughly conjectured to be some 4 thousand tons.

5.2 Methodology for Discard Estimate

It is generalised from the above analysis that; (1) discard estimation on target-species is appropriate only where bycatch of targeted species are peripheral in other sectors and, (2) the target-species concept may be effective in single-species fisheries, but the concept and subsequent estimation are not applicable for multi-species fisheries. These have special consequences in tropical/subtropical and Asian fisheries, where fisheries are conducted with a variety of fishing gears and for a variety of species. It is concluded that discards in multispecies fisheries must be estimated for individual sectors defined according to fishing gear and methods (the concepts for mutt-species can be generalised for single species inclusive).

Discard ratios were defined against whole landing in respective sectors in this report. This reflects that a discard ratio is not necessarily a ratio between discard and retention of a species. It is important to recognise that a discard ratio must be evaluated on the factor which is best correlated to a discard amount in a sector and a discard ratio is an indecent to represent fishing effort to induce discards in each sector.

Despite the present analysis, the author does not reject estimation of specific discards. Partial estimate of specific discards in a sector or across sectors is, of course, possible when required as Equation (5). However, estimation of total discards in individual sectors based on summation of specific discards is beyond reality in multi-species fisheries due to a range of species. Specific discard estimation may be applied to only important species when required, e.g. as assessment of the impact of discards to resources and aquatic fauna. This must be taken into account to establish practical and realistic approaches toward respectively appropriate countermeasures, such as technical improvement of fishing gear, revision of regulations and utilisation of presently non-commercial size/species on discard assessments.

Methods of discard estimation depend on available landing statistics, too. Landing statistics must be organised to individual sectors, no matter if landing as a whole or of individual species (species groups) in each sector. If only statistics on species are available where each species is harvested with many types of fishing gears, discard estimation is impossible. Even in such a case, target species must not be a substitute of a sector.

Methodology for discard survey and estimation differs according to the purposes, available information and situations of fishing industries in different areas over the world. Discard research strategy must be established on the basis of this fact. It is strongly recommended that the strategy and methodology against discards must give due consideration to multispecies fisheries which prevail in a large number of Asian countries.

6. REFERENCES

Anon. 1993a, Report on development of selective trawl fishing techniques, p.24, Japan Association of Trawl Fisheries and Fishing Vessel Association, Tokyo.

Anon. 1993b, Reports on the research and stock assessments of groundfish in the North Pacific in 1992 and 1993, National Research Institute of Far Seas Fisheries, Shimizu, pp. 41 -53 and pp. 75-86.

Anon. 1996, 1994 Annual report of capture and culture fisheries products, Ministry of Agriculture, Forestry and Fisheries, Tokyo.

Alverson, D.L., Freeberg, M.H., Murawski, S.A., and Pope, J.G. 1994, A Global Assessment of Fisheries Bycatch and Discards, FAO Fisheries Technical Paper 339, Food and Agriculture Organisation of the United Nations, Rome, p. 233.

Alverson, D.L. and Hughes, S.E. 1995, Bycatch: From Emotion to Effective Natural Resource Management, Solving Bycatch: Consideration for Today and Tomorrow, pp. 13-28.

Arimoto, T., Ogura, M., and Inoue, Y. 1983, Catch variation with immersion time of gear in coastal set-line, Nippon Suisan Gakkaishi 49(5), 705-709.

Arimoto, T., Inoue, and Ogura, M. 1983, Diel variation of catch in coastal set-line, Nippon Suisan Gakkaishi 49(8), 1175-1181.

Arimoto, T. 1995, By-catch problem in fisheries, in By-catch in Japanese Pisheries (ea. Matsuda, K.), Koseishakoseikaku, Tokyo, pp. 11-20.

Fujiishi, A. 1995, Small trawl fisheries, in By-catch in Japanese Fisheries (ea. Matsuda, K.), Koseishakoseikaku, Tokyo, pp. 30-42.

Fukuda, Y. 1981, Potential fisheries products around Japan, Fisheries Resource Research Note, Enyo National Fisheries Research Institute, Shimizu, pp. 13-17.

Hara, I. 1995, Coastal purse seine fisheries, in By-catch in Japanese Fisheries (ed. Matsuda, K.), Koseishakoseikaku, Tokyo, pp. 80-87.

Inoue, Y. 1995, Trawl fisheries, in By-catch in Japanese Fisheries (ed. Matsuda, K.), Koseishakoseikaku, Tokyo, pp. 21-29.

Ishidoya, H. and Ishizaki, H. 1995, Setnet fisheries for horse mackerel, mackerel and sardine, in By-catch in Japanese Fisheries (ed. Matsuda, K.), Koseishakoseikaku, Tokyo, pp. 88-95.

Kanemaru, S. 1990, Status of fisheries for tanner crabs in the Sea of Japan, Northern Japan Bottom Fisheries Bulletin, No. 23.

Kitazawa, H. and Oaku, T. 1982, Study on the discards by the Danish seine fishery in western

Wakasa Bay, Nippon Suisan Gakkaishi 48(8), 1089-1093.

Kobayashi, H. and Yamaguchi, y. 1978, The hooked ratio of longline-caught fish and shark damage, Bulletin of Faculty of Fisheries, Mie University No.5, 117-128.

Lee, J., Kanda, K., and Sato, O. 1983, The relationship between fishing gear and fishing ability for offshore trawl fisheries around Choshi, Nippon Suisan Gakkaishi 49(6), 859-866.

Matsuoka, T., Mana, R., and Nagaleta, H. 1992, Application of bottom longlining in tropical shallow water, Fisheries Section, University of Papua New Guinea, Port Moresby, p. 25.

Matsuoka, T. 1995, Shrimp trawl fisheries, in By-catch in Japanese Fisheries (ed. Matsuda, K.), Koseishakoseikaku, Tokyo, pp. 43-51.

Miura. T. 1995, Salmon setnet fisheries, in By-catch in Japanese Fisheries (ed. Matsuda, K.), Koseishakoseikaku, Tokyo, pp. 88-95.

Nolan, C.P. and Yau, C. 1996, A Discussion on Discards, Resource paper submitted to the FAO Technical Consultation on Wastage in Fisheries, Tokyo, p.9.

Ogura, M., Arimoto, T., and Inoue, Y. 1980, Influence of the immersion time on the hooking rate of a small bottom long-line in coastal waters, Nippon Suisan Gakkaishi 46(8), 963-966.

Otomi, J., Nakata, N., and Shimizu, M. 1992, Discarding of Japanese mantis shrimp *Oratosquilla oratoria* by small-scale trawlers in Tokyo Bay, Nippon Suisan Gakkaishi 58(4), 665-670.

Takagi, K. 1994, Species discarded in small trawl fishery *(tatebiki* type-1), Western Region Bottom Fish Research Bulletin No.5, 8-11.

Takeuchi, S. 1995, Skipjack purse seine fisheries, in By-catch in Japanese Fisheries (ed.Matsuda, K.), Koseishakoseikaku, Tokyo, pp. 71-79.

Tokai, T. 1993, Fisheries management of a small shrimp trawl in the Seto Inland Sea, Bulletin of Nansei National Fisheries Research Institute No.26, 31-106.

Tokai, T., Omoto, S., and Matsuda, K. 1994, Mesh selectivity of unmarketable trash fish by a small trawl fishery in the Seto Inland Sea, Nippon Suisan Gakkaishi 60(3), 347-352.

Torisawa, M. 1995, Coastal gillnet fishery, in By-catch in Japanese Fisheries (ed.Matsuda, K.), Koseishakoseikaku, Tokyo, pp. 62-70.

Yatsu, A. 1994, Relationship between driftnet mesh size and bycatch rates of marine mammals taken from the North Pacific, Nippon Suisan Gakkaishi 60(1), 35-38.

Yatsu, A. 1995, High seas driftnet fisheries, By-catch in Japanese Fisheries (ed. Matsuda, K.), Koseishakoseikaku, Tokyo, pp. 52-61.

Table 1 Estimates of discards in fisheries in Japan (1988-90 and 1994)

Sectors	W/W discard ratio	1988-90 Products (MT)	Discards (MT)	1994 Products (MT)	Discards (MT)
Skipjack pole and line	0.0	228,773	0	168,870	0
Saury stick-held dip-net	0.0	279,348	0	249,950	0
Mackerel angling	0.0	3,114	0	2,882	0
Shellfish collection	0.0	106,833	0	73,836	0
Seaweed collection	0.0	195,133	0	134,458	0
L/M surrounding net for others	0.0	3,704,605	0	1,375,675	0
Purse seine	0.0	1,076,385	0	840,663	0
Small trawl (powered, shellfish portion)	0.0	220,372	0	298,125	0
L/M surrounding net for skipjack/tunas	0.000423	197,912	84	230,537	98
Tuna longline (distant waters)	0.672	185,084	124,376	196,725	132,199
(off-shore waters)	0.496	62,836	31,167	48,252	23,933
(coastal waters)	0.646	27,393	17,696	39,319	25,400
Distant water trawl in N Pacif (high seas, rounded)	0.0435	607,000	26,405	0	0
(other waters)	0.190	40,583	7,711	145,786	27,699
Distant water trawl (East China Sea)	0.618	88,957	54,975	45,420	28,070
(shrimp trawl)	10.0	1,385	13,853	687	6,870
Off-shore trawl	0.14	509,210	71,289	442,412	61,938
Small trawl (powered, other than shellfish)	1.53	209,811	321,011	166,584	254,874
(small sail trawl)	22.4	662	14,836	388	8,691
Large set-nets for salmon	0.014	110,523	1,547	146,118	2,046
Large set-net (others)	0.014	353,777	4,953	294,618	4,125
Small set-net	0.014	181,241	2,537	163,087	2,283
Boat seine	1.12	147,883	165,629	191,821	214,840
Squid angling (distant-waters)	0.0004	312,276	125	174,764	70
Squid angling (other waters)	0.0004	74,609	30	265,835	106
Distant water trawl (S Pacific otter trawl)		385,547		179,061	
Other surrounding nets		8,387		11,823	
Mother-ship type salmon fishing		1,590		0	
Salmon drift gillnet		12,944		23,628	
Squid drift gillnet		138,963		0	
Swordfish drift gillnet		8,870		4,147	
Other gillnets		348,394		210,581	
Other lift-nets		105,042		81,981	
Beach seine		3,087		2,733	
Patch-ami type boat seine		119,773		63,719	
Salmon longline		753		198	
Other longlines		94,820		69,233	
Other anglings		86,744		79,976	
North Pacific longlines and gillnets		0		23,736	
Other fisheries		197,679		141,936	
Total		10,438,297	858,224	6,589,564	793,240
Corrected estimate			1,003,663		917,550

Table 2 Partial estimates of discards of some major species in Japan (1994)

Species and sector	Products (MT)	W/W disc. ratio	Discards (MT)
walleye pollock (distant water trawl in N Pacific)	121,068	0.17	20,582
walleye pollock (off-shore trawl)	149,959	0.175	26,243
Flatfishes (small trawl)	166,584	0.054	8,996

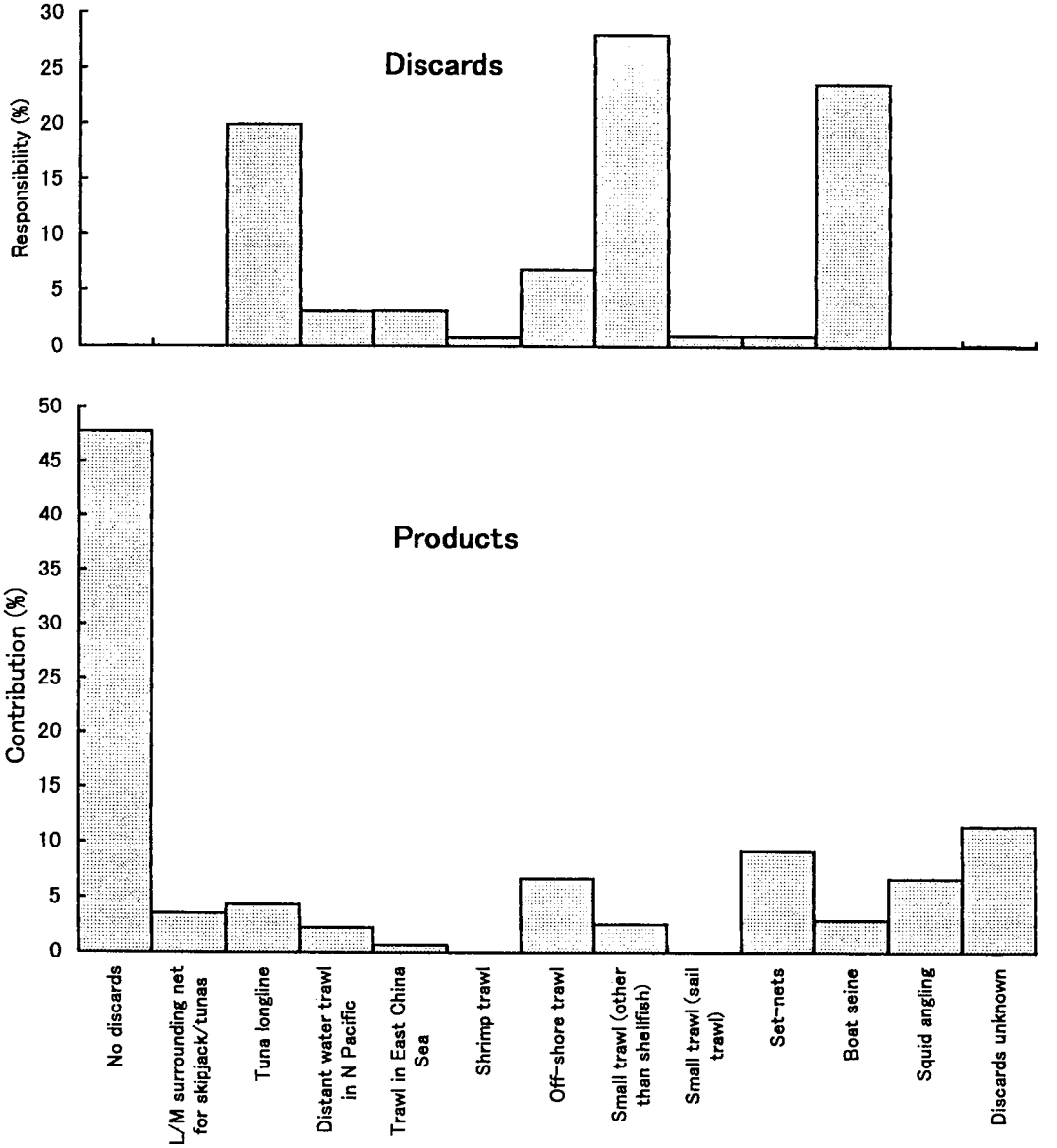

Fig. 1 Contribution by fishing sectors to landing and their responsibility to discards

Table 3 Category of organisms discarded by various sectors in Japan

	Discard organism categories							
Fishing sectors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Distant water trawl (shrimp)	+			+		+	+	+
Salmon drift gillnet	+							
Other fisheries (crab trap)		+				+		
Other gillnets			+		+	+	+	+
Small trawl (powered)			+			+	+	+
Boat seine			+			+	+	+
Distant water trawls in N.P.				+		+	+	+
Tuna longline					+		+	+
Trawl in East China Sea						+	+	+
Off-shore trawl						+	+	+
Small trawl (sail trawl)						+	+	+
L/M surrounding net (tuna)						+	+	
Large set-net (others)						+	+	
Small set-net						+	+	
Other longline								+
L/M surrounding net (others)								
Purse seine (medium surrounding)								
Large set-net (salmon)								

The category numbers atop stand for; (1) organisms commonly protected, (2) conserved species under resource management, (3) small individuals of stock-enhanced species, (4) commercial size of commerc species, (5) damaged or spoiled individuals of commecial species, (6) juveniles of commercial species, commercial species, and (8) no commercial species. Sectors are reshuffled to responsiblediscard categ

Table 4 Reason to induce discards in various sectors in Japan

	Reasons to induce discards					
Fishing sectors	(1)	(2)	(3)	(4)	(5)	(6)
Distant water trawl (shrimp)	+			+	+	+
Salmon drift gillnet	+					
Small trawl (powered)		+			+	+
Small trawl (sail trawl)		+			+	+
Boat seine		+			+	+
Other gillnets		+			+	+
Other fisheries (crab trap)		+			+	+
Distant water trawls in N.P.			+	+	+	+
Tuna longline				+		+
Trawl in East China Sea					+	+
Off-shore trawl					+	+
L/M surrounding net (tuna)					+	+
Large set-net (others)					+	
Small set-net					+	
Other longline					+	
L/M surrounding net (others)						
Purse seine (Medium surrounding)						
Large set-net (salmon)						

The numbers atop stand for reasons for discards as; (1) prohibition of catching defined species, (2) fishing/landing regulation to species, size and sex defined, (3) excess over allocated quaota, (4) retention of higher value individuals, (5) no or less commercial value in size, and (6) no or less commercial value in species.