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A Review of Bycatch and Discard Issue Toward Solution

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A total of 27 million tons and a revised value of 6.8 million tons of global discards have been estimated, however, there is still no reliable discard estimation globally. The reason is the fuddled definitions of the terms used in this field such as bycatch and discards and methodological mystification in their applications. Despite the concerns, factual problems of discards have been limitedly discussed scientifically. The survival possibility for discarded organisms is a major subject, where high survival rates are found for matured individuals and large species of finfishes and crustaceans but low, for juveniles and small finfish species. The subsequent energy flow after discards is also a large research topic. Externalisation of discards by seabirds on surface and scavenging on seabed do not support the hypothesis of enrichment of surface water by nutrients from discards. Approaches toward solutions to discards include exclusion of bycatches underwater by improvement in fishing technology such as selectivity enhancement and development of bycatch exclusion devices and promotion of landing of discards otherwise. A simple analysis on the commonness between bycatch and discards is encouraged in realistic approach toward exclusion of juveniles of useful species and promotion of landing of unutilised species.

KEYWORDS bycatch; discard; incidental catch; capture fishery; resource; management; mortality; survival

1. Introduction

Discarding bycatch began drawing attention as the most serious wastage in capture fisheries against rational utilisation of marine resources during the 1970's. Researches on bycatch and discards of fisheries organisms has been actively conducted around the world after that FAO promoted conversion from discards to utilisation in 1982 (FAO 1982). It has become an international issue in fisheries management since the estimation of global discards by FAO Technical Paper

339 (Alverson *et al*. 1994) and adoption of FAO Code of Conduct for Responsible Fisheries in 1995, where bycatch and discards were dealt repeatedly. A variety of researches have been conducted, such as *in situ* surveys of discard practices, development of technology to reduce bycatch and discards, and studies on the consequences of discarding in the ecosystem and formulation of the scientific basis approaching through sensory and behaviour of aquatic organisms. The orientation toward these researches during the mid 1980's was conjectured to be a reflection of, at least in part, the world-wide trends toward conservation of aquatic environment and resources those days. It is also a character of this issue that efforts have been devoted to the estimation of the discard amount in par with the researches toward solutions, because FAO Technical Paper 339 reported an estimate of a large amount of discards in regions. An increasing number of case studies are still being conducted in the 2000's globally, including those in the third world countries.

The bycatch issue involves those of both fisheries organisms such as finfishes, crustaceans, etc. and non-fisheries animals which are not aimed in fishing, such as marine mammals, marine reptiles and seabirds. The latter is referred to as an incidental catch, although the term of bycatch implies both. The bycatch and discard issue tends to refer only to the former. Two groups of animals have different characters both in implications in the fisheries management and from the viewpoint of the required technology toward solutions, therefore, it is difficult to deal with in one context. This paper deals with mainly the bycatch and discards of fisheries organisms and reviews the historical progress in the issue.

2. Definition of Terms

Definitions of the terms used in this field are chaotic. Catch is defined as those hauled up once onto deck with fishing gear, then retained in part, while the remainder is discarded. Retention and landing are almost synonymous in the case of industrial fisheries, however, self-consumption in retention seldom appears in landing statistics. The definition of discard as those non-retained in catch is almost consensus, however, there are still different opinions such that release in sport fishing or safe returning to the sea after friendly sorting onboard should be excluded. Discard also takes place on land, which is not included in the landing.

Despite the title of this paper, bycatch is hardly defined scientifically. The definition of bycatch is different among countries and researchers (Alverson *et al*. 1994), and common basis is hardly pertained. Alverson used a concept of a set of target catch and bycatch, however, target catch is subjective and it is not a realistic approach to identify a single target species and to define all the others as bycatch. According to this definition, there is a landed bycatch, which could be referred to as by-products. The concept is hardly applicable to multi-species fisheries which are prevailing over Asian region and tropical waters. An enormous effort has been, therefore, devoted by e.g. SEAFDEC to define the terms applicable in Asian fisheries (SEAFDEC 1998). This paper temporalily defines bycatch as is the irrational catch rather than the catch of species, sizes and sex acceptable in resource conservation and management.

3. Estimation of Bycatch and Discard Amounts

The amount of discards was first estimated in the prawn trawl fishery (Slavin 1982). A total of 5 million tons of annual discards in the world prawn trawl fishery was estimated on the basis of the discard ratios against the catch of prawns, which are usually 5 to 10, and are multiplied by a total production of prawns (a discard ratio and its application will be explained in detail later). This method

Table 1. Global and regional discards estimated in 1994.

Region No.	Nominal regions	Discards (1000MT)	(%)
61	Northwest Pacific	9,132	33.8
27	Northeast Atlantic	3,671	13.6
71	Central-west Pacific	2,777	10.3
87	Southeast Pacific	2,602	9.6
31	Central-west Atlantic	1,601	5.9
51	West Indian	1,471	5.4
67	Northeast Pacific	925	3.4
41	Southwest Atlantic	803	3.0
57	East Indian	802	3.0
77	Central-east Pacific	767	2.8
	Others	2,461	9.1
	Total	27,012	100

*Tabulated from Alverson (1994)

was applicable only because the anticipated prawns and unwanted finfishes so-called as bycatch are distinctively segregated in this sector. The estimation of discards in later researches was unconsciously affected by this method.

FAO Fisheries Technical Paper 339 estimated 27 million tons of global discards annually (Alverson *et al*. 1994). Though discard estimates by country were concealed, it was presented that 47% of the global discards occurred in Asian waters, in particular, 9.13 million tons in Region-61, or Northwest Pacific, which was unrealistically large (Table 1). Responding to the criticisms, FAO convened an expert consultation meeting (FAO 1996). It was revealed that Paper 339 had methodological weakness which did not take the landings as non-target catches into account and fell into over-estimation of discards (Matsuoka 1996), although it was not described in the conclusion of the meeting (FAO 1996).

A revised estimation of global discards of 6.8 million tons was publicised by FAO (Kelleher 2005). This report included unacceptably unnatural assessments, for example, that the discard amount estimated for Korea was the smallest among Asian countries and less than that for North Korea, despite no scientific data available for this criticism (Table 2). There is still no reliable estimation of global discards even nowadays.

Table 2. Estimation of global and national discards revised in 2005.

Countries (Asia)	Discards (1000MT)	(%)
Cambodia	0.0	0.0
China	74.3	1.1
Indonesia	270.4	4.0
Japan	918.4	13.5
Korea	1.0	0.0
Malaysia	10.4	0.2
Myanmar	27.4	0.4
North Korea	1.1	0.0
Philippines	7.5	0.1
Thailand	27.8	0.4
Viet Nam	17.8	0.3
Others	5463.1	80.1
Global Total	6819.2	100.0

*Tabulated from Kelleher (2005)

There are several reasons of the confusion in discard estimation. One is the fuddled definitions of bycatch and discards as explained above. The other is that less logical consideration was given to the estimation methodology, perhaps, because it is too simple for scientific studies. In order for discard estimation, a discard ratio r in a certain fishing sector is found by field survey as Eq. (1) (Alverson *et al.* 1994; Matsuoka 1999) where d_k and c_k are discard and landing amounts at the k-th sampling in K times. The total amount of discards D in the concerned sector is estimated as Eq. (2), with the total amount of landing C in the sector, which is usually available in landing statistics. However, a variety of discard ratios are definable, because the landing of either summed species, target species, or an individual species is adoptable as a denominator. In application of the Eq. (2), a discard ratio must be multiplied only by the corresponding landing statistics, e.g. where an individual species is used as a denominator, landing statistics of the particular species must be used as C.

$$r = \frac{1}{K}\sum_{k=1}^{K}\frac{d_k}{c_k} \tag{1}$$

$$D = r \cdot C \tag{2}$$

Matsuoka (1999) proposed that a discard estimation method with the discard ratio against summed species in each sector is the best in order to avoid the confusion. Though Alverson (1994) also defined the difference between the discard ratio and the discard rate, these are still disorderly used. This is partly attributed to improper translation of the results of bycatch and discards surveys published in local languages.

Another method based on 'discards per unit effort' (DPUE) q is also possible as Eqs. (3) and (4) where E is the total unit of fishing effort in a concerned sector (Matsuoka 1999). It is advantageous to use DPUE together with CPUE for an assessment of a fishing sector, however, Eq. (4) is applicable only where the fishing effort statistics are available.

$$q = \frac{1}{K}\sum_{k=1}^{K} d_k \tag{3}$$

$$D = q \cdot E \tag{4}$$

4. True Problems of Bycatch and Discards

Despite the prevailing concerns to bycatch and discards with emotional warnings sometimes, there had been a few scientific discussions on what are the problems in reality. Bycatch was detested as a hazard in trawl operations in early days (High *et al.* 1969) and smells of catches in bottom fishing due to rotten discard fish and contamination on beaches have been reported, however, most concerns were raised from a viewpoint of protection of wild life and management of resources (Seidel 1975). Bycatch includes the endangered or protected species or juveniles of commercially important species usually, therefore, the criticism is appropriate. Discarding juveniles of highly commercial species due to landing size regulations undermines the principal purpose of fishing regulations. There are many suggestions which indicate that mortality by discards may provoke negative impacts to aquatic ecosystems and biodiversity, consequently, discards of even non-utilised species are unacceptable. A variety of conflictions have been reported where bycatch species are those aimed in other fishing sectors (Juhl and Drummond 1976; Watson and McVea 1977). In developing countries, when bycatch and discards by industrial fisheries occur to the species utilised in subsistent fishing by nearby villagers, a unique problem arises against a national development policy such as conservation of the basis for rural life (Sujastani 1984; Matsuoka and Kan 1991).

Regarding the above deliberations, there is an essential subject if the discarded organisms cannot survive, because all the criticisms are based on a presumption of mortality of discards. This is the issue on which the largest research effort has been devoted recently. The first experiment in this field was conducted in the Gulf of Carpentaria. Survivability after exposure for 10 to 15 minutes in air was higher than 50% for only crustaceans and matured fish of large species, while, many small finfishes and juveniles almost all died (Wassenberg and Hill 1989). Many researches have shown that the mortality of discarded small fishes and those with gas bladders is high (Suuronen 2005), e.g. 100% for whiting (Berghahn *et al.* 1992), and over 85% for juvenile snapper after 15 minutes of air exposure (Sumpton and Jackson 2005), while, the survival rate is high for large fishes, e.g. 100% for lingcod discarded immediately after the codend opened and 50% after 30 min exposure on deck (Parker *et al.* 2003), 78% to 90% for catshark (Rodriguez-Cabello *et al.* 2005), and 98% for dogfish (Revill 2005). Survival of discarded crustaceans is high, e.g. estimated 80.4% or 96.1% for snow crabs (Warrenchuk and Shirley 2002), 100% for brown-shrimp under low temperatures after stay on deck for a short time (Gamito and Cabral 2003), and 78 and 80% for discarded juvenile shrimps *Crangon crangon* (Lancaster and Frid 2002). Survival may be adversely affected by delayed effects by damages including injury and stress due to exposure in air and surface water (Bergmann and Moore 2001a, b; Bergmann *et al.* 2001; Harris and Ulmestrand 2004). Survival depends on the species, sex and size of animals, maximum fishing depth, sorting time on deck and deck conditions such as temperature, wetness, etc.

There are counter disputes as bycatch and discards are not problems, e.g. (1) bycatch may reduce predators to juveniles of high-value species and contribute to human utilisation of resources, (2) discards of demersal species contribute to vertical circulation of nutrients and enhance the productivity of fishing grounds, and (3) flat mortality to all the species is rather friendly to ecosystem. These disputes appear mainly in media and at meeting floors, however, seldom, in scientific papers.

The above criticism has encouraged researches on the consequences of discards recently. Brewer (Brewer *et al.* 1991) first analysed stomach contents of bycatch finfishes by prawn trawlers in the Gulf of Carpentaria and found that they eat small non-commercial shrimp species. Mortality of small finfishes reduces the predation pressure to shrimps other than commercial prawn species and this does not support the hypothesis (1) above.

The energy flow from discards to subsequent consumption by organisms is one of the largest research subjects recently. Externalisation of discarded fishes by e.g. seabirds are actively studied, where discarded benthic-mesopelagic prey fishes are consumed by seabirds as supporting their population (Blaber 1995; Bertellotti and Yorio 2000; Pedrocchi 2002). Hill and Wassenberg (2000) conducted a precise investigation on the probable fate of discards from prawn trawlers. Floating fish was scavenged by dolphins, sharks and seabirds on the surface and 14% of discards were estimated to be available to seabirds. Discards over 80% by weight sink, where the majority are scavenged on the seabed mainly by fishes, small sharks and possibly cirolanid isopods. Catchpole *et al.* (2006) demonstrated that seabirds utilise the estimated 57% of the discarded material and populations of scavenging species in the fishing ground is supported by sank materials. Mid-water scavenging of discards is relatively unimportant (Erzini *et al.* 2003). All these suggest that discards could not enrich surface waters in nutrients and do not support the hypothesis (2).

Poiner and Harris (Poiner and Hallis 1986) compared bycatch finfish compositions between before starting the prawn trawl industry and 20 years later in the Gulf of Carpentaria and found that species such as ponyfishes *Leiognathus* spp. distinctively declined. This result suggests that the impacts of bycatch and discards are different among species and denies the hypothesis (3). Regardless of this analysis, such an assumption that bycatch induces flat mortality over all the organisms in an ecosystem is far from a reality, because of the biased sampling by selectivity of fishing gear.

There is no scientific evidence to refuse another assumption that bycatch mortality may give a positive effect such as the density of valuable species or nutrient condition. A research which considered an input from discards on the basis of carbon and nitrogen (Cabral *et al.* 2002) may reflect such a viewpoint. There is a discussion that discarding is not a problem as long as landing is maximised. It is suggestive to point out that the bycatch and discard issue is a matter how to utilise a fishing ground and resources rationally and maximisation of allowable catch is the final goal. It must be carefully studied if there is a way of resource use to increase MSY under a condition where bycatch and discards occur.

5. Solutions to Bycatch and Discards

Occurances of bycatch are attributed to weak selectivity of fishing gear and multi-species characters of fishing grounds (Seidel 1975; Watson and McVea 1977), while, discards are attributable to mainly less profitability. Possibility of discards is high where the price difference between wanted species and others is large (Seidel 1975). Where fishing grounds are in rural areas far from markets, even utilisable species may be discarded. Some discards occure due to catch or landing regulations for resource management. Discards due to genuine non-edibility must be periferal. The insufficient space of fish holds on fishing vessels is mentioned as a reason (Slavin 1982), however, this is a synonimous of no consideration given to bycatch in vessel designing.

There have been two ways of approaches toward countermeasures against bycatch and discards as; (1) underwater exclusion of unwanted species by improvement in fishing technology, and (2) utilisation of bycatch. Utilisation includes those for other sectors such as aquaculture feed and materials for other industries in addition to human consumption (Allsopp 1982).

5.1. Improvement in fishing technology

For development in fishing technology toward reduction of unwanted catch, there are two directions; (1a) improvement of fishing gear design toward enhancement of size- and species-selectivity, and (1b) development of bycatch exclusion devices to be added to fishing gear.

The typical approach in the former direction is the conventional mesh-size regulation to exclude small individuals of fishes to be discarded otherwise. A variety of tests have been conducted to activate size-selectivity by opening meshes widely, e.g. using square-mesh panels. It is the latest achievement that discards can be reduced by around 40% through simple modification to trawl gear with square-mesh panels (Cooper and Hickey 1989; Robertson 1989; Revill *et al.* 2007). Starting researches on species-selectivity over the world in the 1990’s must be reflection of the bycatch and discard issue. Even peripheral modifications such as changing vertical opening and foot-gear arrangement for trawl nets (Valdemarsen 2001) and changing underwater height and giving spaces around a foot rope for gillnets result in altering the species selectivity. There are still extensive possibilities to exclude unwanted species and sizes by selectivity for most fishing gear.

Development of bycatch reduction technology is advanced in trawl, which has the oldest history of researches since the 1960–70’s (Seidel 1975; Watson and McVea 1977). A variety of devices referred to as TED

(Trawl Efficiency Device), BED (Bycatch Exclusion Device) and BRD (Bycatch Reduction Device) have been developed particularly for prawn trawling. This is attributable to that prawn trawling is conducted in multi-species fishing grounds, it distinctively targets prawns, while, it is difficult to exclude small bycatch finfishes with size-selectivity by mesh size regulation because of the similar sizes between prawns and bycatch finfishes (Watson and McVea 1977; Watson *et al.* 1986).

Most bycatch reduction devices for trawl nets are composed of both/either net-webbing/grids and open sections such as windows or large-meshes. The former function is an induced exclusion by mechanical size-selectivity and the latter, passive exclusion based on difference in behaviour amongst animals (Matsuoka and Kan 1991; Matsushita 2000). Most bycatch reduction devices combine both functions. The net webbing used by High *et al.* (High *et al.* 1969) and Seidel (Seidel 1975) and a metal grid used by Karlsen and Larsen (Karlsen 1989) were in the former category, while, the large-meshed sky-light designed by Rulifson *et al.* (Rulifin *et al.* 1992), the latter. The famous NMFS TED (Watson *et al.* 1986) had a metal grids referred to as a deflector and lateral windows. Soft BEDs such as Morison type (Kendall 1990; Clark *et al.* 1991; Andrew *et al.* 1993) have merits of easy handling.

Rulifin (Rulifin *et al.* 1992) set an achievement criteria in bycatch exclusion in prawn trawl, as bycatch reduction more than 50%, while, loss of wanted catch less than 5% in weight. This criteria is still hardly achieved constantly. Watson *et al.* (1986) reported that unwanted finfishes were excluded at approximately 50% with almost no loss of targeted prawns, however, it was a result in a fishing ground where the major bycatch finfish was grouper which is easy to exclude (Matsuoka and Kan 1991). Comparable results were not obtained with the device in other fishing grounds (Sujastani 1984). This is because a function of a bycatch exclusion device depends on fish sensory and behaviour, therefore, the required designs of exclusion devices differ according to bycatch species compositions, or from fishing ground to fishing ground. This is one of the difficulties in development of bycatch exclusion technology. The latest achievement is that the Nordmore grid could reduce finfish bycatches by 48–74%, while, loss of targeted lobster and shrimp, 4–15% (Fonseca 2005).

Another reason of relatively low exclusion ratios for exclusion devices is that the chances for organisms to encounter with their grids or meshes are limited. Where the probability to pass through a grid or mesh space when an individual animal of size L at once encounter is denoted as $f(L)$, the probability of remaining after encountering for n times is described as Eq. (5).

$$S(L) = \left(1 - f(L)\right)^n \tag{5}$$

$S(L)$ is the selectivity. The $S(L)$ curve becomes steeper with increasing n (Fig 1). In other words, small individuals which are statically excludable tend to remain when repetition of encountering is limited. Designing to let animals repeat encountering to grids or meshes is needed because they are usually short longitudinally. Suuronen (2005) also suggests that bycatch exclusion devices must be set at an appropriate position in net because the fish individuals pressed on the codend have no more chance to meet them.

Regarding selective harvest and exclusion of bycatch, questions have been raised to the survivability for the organisms excluded underwater. Code of Conduct for Responsible Fisheries repeatedly urges improvement of survivability for excluded escapees. Suuronen (1996, 1997), however, proved low survivability for Baltic herring *Clupea harengus* excluded from a trawl codend and suggested that the codend mesh size management must be reconsidered.

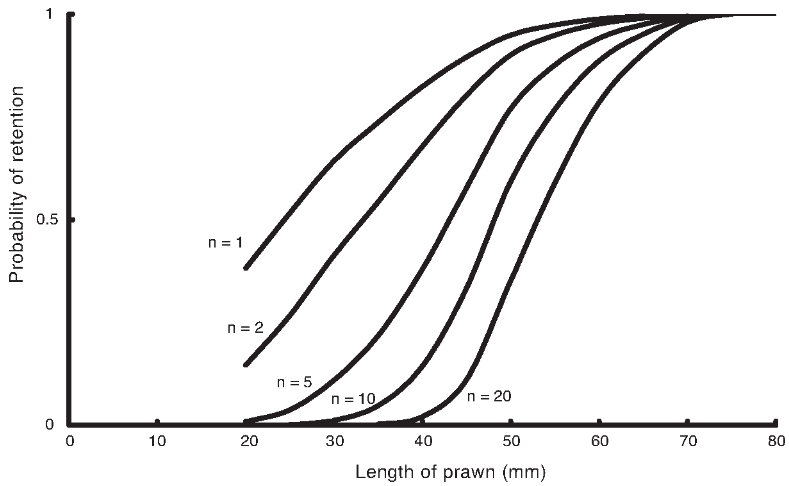

Fig. 1. Simulated selectivity at different numbers of encountering on net; An example of calculation of probabilities of retention of deepwater prawn, changing prawn size and number of encountering to a net webbing with fixed mesh size and hanging ratio.

Extensive works in this field have been conducted through an ICES research programme recently (Ingolfsson *et al.* 2007). Suuronen (2005) is the best summarisation of the researches on the survival issue.

There are trials of technical development towards friendly release of bycatch organisms, for example, release after selection in a shallow tank or under a shower, aiming at high survivability of released ones (Berghahn *et al.* 1992). There is, however, a criticism that the survival possibility for the released individuals are not very high, e.g. chances to return to the original environment may not be very high, in particular, in the case of deep water species, in addition to a question of mechanical damages after even friendly selection. High survivability by this approach is conjectured to be hardly guaranteed in many fishing sectors (Suuronen 2005). Segregation between friendly release and discarding is also questionable.

For further development of bycatch exclusion devices, the technology must give more consideration to merits for fishermen to compensate the possible loss of catches. Watson (Watson *et al.* 1986) discussed on positive side-effects to be given by bycatch exclusion from a trawl net as; (1) reduction of resistance to a net and consequent fuel consumption, (2) reduction of on-deck work, and (3) improvement of quality of catches. Reduction of fishing gear materials is also a possible merit in such a case as a semi-demersal trammel-net with a space with no net material at the bottom part (Matsuoka 1999). In the case of static fishing gear, e.g. improved gillnets or trammel-nets, loss of wanted catch could be compensated by use of an increased number of fishing gear, as long as the bycatch exclusion ratio is higher than the wanted catch loss ratio. This implies, however, a declined catch efficiency is compensated by increased fishing effort and an essential consideration is needed from the viewpoint of rational development of capture fisheries.

5.2. Promotion of landing

Landing of bycatch has been assumed a fundamental solution to the bycatch and discard issue (FAO 1982). This is based on the idea that there is no problem as long as catches are utilised. The officials and researchers from some Asian countries relied upon this logic and insisted that there is no discard problem in the region because of landing of small finfishes as trash-fish. It is truism that there are local utilisation practices in small-scale fisheries in many countries in Asia, such as catches are gradually sorted from those for human food to non-human consumptions depending on species, sizes and qualities through marketing and, consequently, catches are all utilised. There is, however, an essential problem that trash-fish usually includes juveniles of commercially important species. Careless promotion of landing may undermine the principle to avoid catching juveniles in the fisheries management. No discard is not necessarily a synonymous of rational utilisation.

Landing of bycatch is usually promoted with public investment. Promotion of landing of bycatch finfishes in prawn trawl is, for example, often conducted as official development assistance (ODA) projects. In an example of the author's observation of an ODA project, fishing companies became able to sell finfishes which were discarded before due to establishment of a marketing system to promote landing and newly born commercial value of those species. No additional investment was needed for fishing companies themselves and, consequently, the shift of the cost and income balance resulted in increased fishing effort and, then, the resource condition of wanted species declined.

5.3. Researches on sensory and behaviour

Active researches on the capture processes are conducted nowadays as the basis for development of selective fishing, and sensory and behaviour of aquatic organisms have been studied in fishing technology. Such works were oriented by, for example, Seidel (Seidel 1975) which indicated that difference in the swimming ability between prawns and finfishes is the ruling factor in separation in a TED and Watson (Watson 1989) and Wardle (Wardle 1989) which emphasised the difference in behaviour against fishing gear for prawn trawl, in particular, Watson (1989) pointed out the difference between optomotor reaction by finfishes and reflex response by prawns in a trawl net. The author considers guidance by utilising visual responses, including the optomotor reaction, is the key concept in designing bycatch exclusion devices, i.e. incontinuity in the net structure and material colour, including windows and large-mesh sky-light, etc. of TED, is the stimulation to induce actions to result in exclusion of unwanted animals. Passive exclusion relying upon behavioural differences is functional even when the size difference is small between wanted and unwanted species. There are, however, species hardly excluded by this mechanism (Matsuoka and Kan 1991; Matsushita 2000), such as ponyfish *Leiognathus* spp. Utilisation of difference in swimming layer must be the most effective way in development of species-selective gillnets. In addition to the visual sensory, there are many researches on hearing, taste, chemical, tactile and lateral line sensory. Contribution from their results for development of bycatch reduction technology has been still limited, however, the researches in this orientation are important also toward the exclusion of incidental catches of sea turtles and sharks, beyond the mechanical selectivity of fishing gear.

6. Encouragement of Simple Assessment on Bycatch and Discards

In order to restructure the research basis for the bycatch and discard issue, the Division of Capture Fisheries, Japan Society of Fisheries Sciences convened an international meeting in 2005, where standardisation of bycatch and discard monitoring was proposed particularly from a viewpoint of Asian

Table 3. Example of analysis of commonness between retention and discards found in a set-net fishing in Japan.

	Retained always		Discarded always		Common between ret. and dis.		
N of species	44		114		44		
5 major species and average weight per catch	Major species	(kg)	Major species	(kg)	Major species	(kg)	Ro
	Acanthopagrus schlegeli	6.7	*Strongylura anastomella*	9.4	*Sarda orientalis*	50.8	0.004
	Thunnus albacares	6.4	*Apogon notatus*	2.3	*Seriola dumerili*	21.9	0.002
	Lethrinus haematopterus	5.2	*Dasyatis akajei*	2.3	*Trachurus japonicus*	21.9	0.003
	Istiophorus platypterus	4.7	*Aetobatus narinari*	1.9	*Trichiurus lepturus*	8.7	0.794
	Scomber japonicus	3.9	*Myliobatis tobijei*	1.1	*Auxis thazard*	6.2	0.079
G. total		21.2		25.8		160.0	

*Table shows, e.g. that 44 species appeared in both retained and discarded catches throughout the sampling; a large amount of *Sarda orientalis* appeared in this category, however, the specific discard ratio (=specific discards/specific landing) is small; on the other hand *Trichiurus lepturus* is one of the major species in this category and the specific discard ratio is large; therefore, exclusinon of *Trichiurus lepturus* must be the research target. The list of the species discarded always is useful to consider the possibilities of utilisations.

fisheries. A simple analyse on the commonness between landed and discarded species was encouraged for the purpose of assessment of bycatch and discards in individual fishing sectors. Table 3 is an example which was found in a survey of set-net fishing in Japan, where hairtail *Trichiurus lepturus* is found in the category of five major species common between landing and discards and its specific discard ratio is large. The species in this category are all commercial species and mainly their juveniles are discarded. It is, therefore, easily found that exclusion of juvenile hairtail must be the key point in the countermeasure research in this sector. This analysis anticipates that the combination of exclusion of small individuals of the species which appear in landing and discards and promotion of landing of the species which appear always in discards is the realistic approaches toward solutions.

As encouraged by FAO as early as in the 1980's, conversion of discards to landing is comparable to finding new resources for utilisation. The author wishes to urge that researches on bycatch and discards will open a new horizon in capture fisheries and, monitoring of bycatch and discard practices is important for responsible capture fisheries toward solutions to the bycatch and discard problems and it is the synonymous of finding of new food resources for human being.

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