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Discards in the world's marine fisheries

An update

Cover illustration:
"Water" by Giuseppe Arcimboldo (1527–1593). Courtesy of the Kunsthistorisches Museum, Vienna.

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An update

by
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This study was prepared as part of the FAO Fishery Industries Division's Regular Programme 2.3.3. Fisheries Exploitation and Utilization.

The reference materials used in compiling the quantitative data form part of the discard database and are provided on the accompanying CD-ROM. A bibliography of the citations used in the text, the references contained in the discard database and sources of other information presented in the report are also provided.

Abstract

This study provides an update of the quantity of discards in the world's marine fisheries based on a fishery-by-fishery approach. The weighted discard rate is estimated at 8 percent (proportion of the catch discarded). Based on this discard rate, in the 1992–2001 period, yearly average discards are estimated to be 7.3 million tonnes. Because of the different method used in the current estimate, it is not directly comparable with the previous estimates of 27 million and 20 million tonnes.

Trawl fisheries for shrimp and demersal finfish account for over 50 percent of total estimated discards while representing approximately 22 percent of total landings recorded in the study. Tropical shrimp trawl fisheries have the highest discard rate and account for over 27 percent of total estimated discards. Demersal finfish trawls account for 36 percent of the estimated global discards. Most purse-seine, handline, jig, trap and pot fisheries have low discard rates. Small-scale fisheries generally have lower discard rates than industrial fisheries. The small-scale fisheries account for over 11 percent of the discard database landings and have a weighted discard rate of 3.7 percent.

Evidence is presented for a substantial reduction in discards in recent years. The major reasons for this are a reduction in unwanted bycatch and increased utilization of catches. Bycatch reduction is largely a result of the use of more selective fishing gears, introduction of bycatch and discard regulations, and improved enforcement of regulatory measures. Increased retention of bycatch for human or animal food results from improved processing technologies and expanding market opportunities for lower-value catch.

A number of policy issues are discussed. These include a "no-discards" approach to fisheries management; the need for balance between bycatch reduction and bycatch utilization initiatives; and concerns arising from incidental catches of marine mammals, birds and reptiles. The study advocates the development of more robust methods of estimating discards, allowance for discards in fishery management plans, development of bycatch management plans and promotion of best practices for bycatch reduction and mitigation of incidental catches. Global discard estimates could achieve greater precision through additional studies at national and regional levels.

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Acronyms and abbreviations

ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
ACFMAFMA	Advisory Committee on Fishery Management Australian Fisheries Management Authority
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
BOBP-IGO	Bay of Bengal Programme Inter-Governmental Organization
BRD	Bycatch reduction device
BSAI	Bering Sea Aleutian Islands
CBD	Convention on Biological Diversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCRF	Code of Conduct for Responsible Fisheries
CCSBT	Commission for the Conservation of Southern Bluefish Tuna
CECAF	Commission for the Eastern Central Atlantic Fisheries (West Africa)
CFP	Common Fisheries Policy (European Union)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on (the conservation of) Migratory Species (of Wild Animals) (Bonn Convention)
COFI	Committee on Fisheries
CPUE	Catch per unit effort
CRODT	Centre de Recherches Océanographiques de Dakar – Thiaroye
DFID	Department for International Development (United Kingdom of Great Britain and Northern Ireland)
DFO	Department of Fisheries and Oceans
DSPCM	Délégation à la Surveillance des Pêches et au Contrôle en Mer
EC	European Commission
EIA	Environmental Impact Assessment
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act (United States)
ETP	Eastern Tropical Pacific
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCMA	Fisheries Conservation and Management Act (Magnuson–Stevens Act)
FIGIS	Fisheries Global Information System (FAO)
FIS	Fish Information & Services
FMC	Fishery Management Council (United States)
FMP	Fishery management plan
GEF	Global Environment Facility
GOA	Gulf of Alaska
GRT	Gross registered tons
HMS	Highly migratory species

IATTC	Inter-American Tropical Tuna Commission
IBSFC	International Baltic Sea Fishery Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
ICES CM	ICES Council Meeting
ICES WG	ICES Working Group
IDCA	International Dolphin Conservation Act
IDPPE	Instituto de Desonvolvimento de Pesca Pequena Escala (Mozambique)
IDRC	International Development Research Centre
IFREMER	French Research Institute for Exploitation of the Sea
IIFFET	International Institute of Fisheries Economics and Trade
IMARPE	Instituto del Mar de Perú
INPFC	International North Pacific Fisheries Commission
IOTC	Indian Ocean Tuna Commission
IPHC	International Pacific Halibut Commission
IPOA	International Plan of Action (FAO)
ISSCFG	International Standard Statistical Classification of Fishing Gear
ITQ	Individual transferable quota
IUCN	World Conservation Union
IUU	Illegal, unreported and unregulated (fishing)
IWC	International Whaling Commission
LIFDC	Low income food deficient country
LME	Large marine ecosystem
LOS	Law of the Sea
MCS	Marine Conservation Society
MLS	Minimum landing size
MMPA	Marine Mammal Protection Act (United States)
MMS	Minimum mesh size
MPA(s)	Marine protected area(s)
MPEDA	Marine Products Export Development Authority (India)
MSA	Magnuson–Stevens Act (United States)
NAFO	Northwest Atlantic Fisheries Organization
NEAFC	Northeast Atlantic Fisheries Commission
NGO	Non-governmental organization
NMFS	National Marine Fisheries Service (United States)
NOAA	National Oceanic and Atmospheric Administration (United States)
NPFMC	North Pacific Fisheries Management Council
NRI	Natural Resources Institute
OECD	Organisation for Economic Co-operation and Development
PFMC	Pacific Fisheries Management Council
PWCC	Pacific Whiting Conservation Cooperative
RFB	Regional fisheries body
RF(M)O	Regional fisheries (management) organization
SEAFDEC	Southeast Asian Fisheries Development Centre
SEFSC	Southeast Fisheries Science Center (United States)
SERFC	Southeast River Forecast Center (United States)
SFA	Sustainable Fisheries Act (United States)
SGDBI	Study Group on Discard and By-catch Information (ICES)
SGFEN	Subgroup on Fishery and Environment
SOFIA	The State of World Fisheries and Aquaculture (FAO)

SPC	South Pacific Commission
SPREP	South Pacific Regional Environment Programme
SSC	Species Survival Commission
SSD	Seal saver device
STECF	Scientific, Technical and Economic Committee for Fisheries
TAC	Total allowable catch
TED	Turtle excluder device
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
UNGA	United Nations General Assembly
UNIA	United Nations Implementing Agreement
VNIRO	Russian Federal Research Institute of Fisheries and Oceanography
WTO	World Trade Organization
WWF	World Wide Fund for Nature

Foreword

A global assessment of fisheries bycatch and discards (FAO Fisheries Technical Paper No. 339) was published a decade ago with the hopes of stimulating further investigation of these serious problems. Since its publication, fishery scientists throughout the world, conservation and environmental organizations and members of the fishing industry have extensively referenced the report. However, these estimates no longer constitute a true reflection of current global discard levels and continued citation of the paper's estimates as such is inappropriate.

The estimates provided in the 1994 paper were largely based on data from the late 1980s and it was made clear that these estimates were of a provisional character. In 1996, a FAO Technical Consultation held in Tokyo noted that discards may have been overestimated for some FAO statistical areas in the report and there was strong evidence that discards were declining in many fisheries. FAO's 1998 publication *The State of World Fisheries and Aquaculture* attempted to update the much-cited 1994 discard estimate of 27 million tonnes and provided a revised estimate of 20 million tonnes. The senior author of the technical report also published several updates, noting a variety of factors that may have led to a decline in global discard levels during the late 1990s. This FAO update on global discards on a fishery-by-fishery basis also supports the affirmation that global discards have significantly declined in recent years.

The reasons cited for this decline have included: (i) greater utilization of bycatch species in Asia and elsewhere for both aquaculture and human consumption; (ii) adoption of more selective fishing technologies and methods; (iii) a decline in the intensity of fishing for some species having high bycatch rates; (iv) a variety of management actions that prohibit discarding in some countries, set bycatch quotas, impose time/area closures, and establish marine protected areas and no trawl zones; and (v) more progressive attitudes by fishery managers, user groups and society towards the need to solve discarding problems.

Indeed, with some exceptions, discards in most fisheries in China and Southeast Asia are now considered to be negligible and bycatch landings have increased significantly in many developing countries. Major fishing nations such as Norway, Iceland and Namibia prohibit discards and bycatch reduction devices are mandatory in many Australian, European and Northwest Atlantic Fisheries Organization (NAFO) area fisheries. Numerous national and international workshops have taken place to solve bycatch and discard problems.

Thus, it is disturbing to note that so many scientists revert to 15-year old data in order to document possible current discard levels. These old estimates are frequently cited by various advocacy groups to decry the state of the world's fisheries and the use of terms such as "dirty fishing" merely undermines the considerable efforts and investments of many responsible fishers, dedicated gear technologists and fishery managers to find solutions to long-recognized problems associated with certain fisheries and fishing gears.

We urge therefore that the 1994 global discard estimates are no longer cited to decry the state of the world's fisheries. There is no "one size fits all" solution. Bycatch and discard problems must be addressed fishery by fishery and we urge that scientists and advocacy groups alike focus on the successes of the past decade rather than on the continued citing of data not applicable to fisheries in this century.

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Executive summary

Discards represent a significant proportion of global marine catches and are generally considered to constitute waste, or suboptimal use of fishery resources. A number of United Nations resolutions have drawn attention to the need to monitor and reduce discards and unwanted bycatch, in order to assess the impact of discards on marine resources and promote technologies and other means of reducing them. The previous FAO estimate[1] of discards at a global level (referred to hereafter as "the Alverson assessment"), based on data prior to 1994, is considered to be outdated.

The present study re-estimated discards at a global level using information from a broad range of fisheries in all continents.

Selected policy and technical issues are highlighted and suggestions made for future actions. A road map for achieving further precision in the global estimate is described and associated initiatives are outlined.

METHOD

The Alverson assessment is based on the use of the FAO Fishstat database of national catches. This database provides catch (in practice, the live-weight equivalent of landings) information by country, FAO area and species (or species group). The Alverson assessment is essentially a function of landings by species. However, there is no a priori reason why the discarded quantities of a species should bear a relationship to the landings of target species.

The approach used in this study is based on the premise that discards are a function of the landings of a fishery, rather than a function of the landings of a particular species. A fishery is defined in terms of an area, a fishing gear and a target species.

A list or inventory of the world's fisheries was compiled in a discard database. Each database record contains quantitative data on: (i) the total landings of the fishery; and (ii) either the total quantity of the discards or the percentage of the total catch that is discarded. The total quantity of discards for a given fishery was generally extrapolated from the results of studies on a sample of the fishing activities.

The sources of the information on landings and discards are provided with respect to each fishery, so that the estimate can be readily verified, updated or changed, as new or more accurate information becomes available at national, regional or FAO level.

Discards (or discarded catch) were defined (FAO, 1996b) as being "that portion of the catch which is returned to the sea" for whatever reason. Post-harvest waste and discards of recreational fisheries are not included. Information on discards of turtles, seabirds and marine mammals is included in the database, but such incidental catches are a secondary target of the study. The study does not quantify either the unseen mortalities caused by fishing or the survival of discards.

The information contained in the database was compiled from three principal sources: (i) from scientific literature and from published national fisheries information; (ii) from reports and "grey" literature available within FAO or publicly available on the Internet; and (iii) from contacts with experts in national fisheries administrations, research institutions or regional fisheries organizations, many of whom provided detailed reports and databases.

[1] Alverson *et al.*, 1994. This publication is referred to hereafter as "the Alverson assessment".

The database contains four groups of fields:

- those specifying the fishing area, which include reference to the FAO fishing area codes and the country or Exclusive Economic Zone (EEZ) from which the catch is reported;
- those describing or designing the fishery, which include reference to the gear and the target species;
- those quantifying the landings by the fishery and the quantity or percentage of discards – the sources of the quantitative information are cited;
- other descriptive fields, which give the reasons for discards, relevant management measures in force, exploitation status of the fishery and other information of relevance to the analysis.

The fishery-by-fishery approach encountered several difficulties in data compilation:

- the sheer scale of the task of compiling a list of the world's fisheries and quantifying the landings of each one;
- the absence or inaccessibility of information on discards for many fisheries;
- the lack of published national fisheries catch statistics on a fishery-by-fishery basis;
- the failure of numerous publications to distinguish clearly between discards and bycatch; and
- the narrow focus of some studies on the discards of target or commercial species only.

To facilitate the discard estimates, certain assumptions were made, and use was made of fisheries information that had already been aggregated, specifically:

- in the absence of information to the contrary, artisanal fisheries were assumed to have a discard rate of 1 percent or less than 1 percent of the catch;
- in the absence of information to the contrary, "fishmeal fisheries" were assumed to have a discard rate of 1 percent or less than 1 percent of the catch;
- with some exceptions, Southeast Asian fisheries were considered to have a discard rate of 1 percent of the catch;
- tuna and other highly migratory species (HMS), and other fisheries for which statistical information has been collected by regional fisheries bodies (RFBs) were generally aggregated by ocean; and
- fisheries, in the opinion of the author considered to be substantially similar in terms of fishing grounds, target species, fishing area, socio-economic basis and management regime, were considered to have a similar discard rate.

RESULTS

Over 2 000 records of fisheries were compiled of which 1 275 contain quantitative information on either landings or discards. Of these records, 788 are quantitatively complete, i.e. they contain quantitative information on both landings and discards for a given fishery. Countries with such complete sets of information include Norway, Iceland, the South Pacific Island states, Thailand, Malaysia and Viet Nam. In the case of the Southeast Asian countries this "completeness" is based on assumptions made by national fisheries authorities regarding low discard rates, rather than on empirical information on discard quantities. There are 62 records that refer exclusively to numbers of marine animals caught incidentally (marine mammals, seabirds and turtles).

Based on the set of complete records, the sum of the recorded discards is 6.8 million tonnes with respect to total recorded landings of 78.4 million tonnes. The global weighted discard rate is 8 percent.

Applying the global weighted discard rate estimated in this study (8 percent) to a ten-year average of the FAO Fishstat[2] reported global nominal catch, total extrapolated discards are 7.3 million tonnes. Some caution is required in extrapolating from the total

[2] Fishstat Plus (version 2.3) of 24 July 2003. The nominal catch value excludes marine animals and plants.

global catch, as certain major fish producer countries are not adequately represented in the database. These include the Democratic Republic of Korea, the Republic of Korea (no discard information), the Russian Federation, New Zealand and the Philippines. The European Union (EU) member countries and India have only partially been covered. A number of small fish-producing countries are not included.

Shrimp and demersal finfish trawl fisheries account for over 50 percent of total estimated discards while representing approximately 22 percent of total recorded landings. Tropical shrimp trawl fisheries have the highest discard rate and alone account for over 27 percent of total estimated discards. Small-scale fisheries generally have lower discard rates than industrial fisheries. Purse-seine, handline, jig, trap and pot fisheries have low discard rates. In geographical terms the highest discards are in the Northeast Atlantic and Northwest Pacific, which jointly account for 40 percent of discards (FAO areas 27 and 61, respectively).

At the global level it was not possible to compile a time series on discards to enable an empirical assessment of global trends in discards to be established. Nevertheless, two trends are apparent. There has been a reduction in bycatch and in discards in many fisheries, particularly those in developed countries. There is increasing utilization of bycatch and a consequent reduction in discards in many fisheries, particularly in developing countries. Several time series of discard data for selected fisheries are provided in support of these conclusions. A decrease in effort and change of target species in some major trawl fisheries has also resulted in a reduction of discards. Changes in fisheries regulatory regimes, requiring more selective fishing and prohibiting or curtailing discards, have also contributed to discard reduction.

The Alverson assessment, published in 1994, estimated discards to be 27 million tonnes (range 17.9 and 39.5 million tonnes). A subsequent (1998) FAO estimate suggested a reduced estimate of 20 million tonnes and a further study by Alverson in 1998 indicated that the 1994 assessment was an overestimate. Because of differences in method, the estimates provided in this report are not directly comparable with the Alverson assessment and consequently the extent to which the estimates represent a reduction in discards is not known.

The main spreadsheet file of the discard database and a bibliography are provided on the accompanying CD-ROM. The spreadsheet file is supplemented by numerous country and fishery files as well as files generated from databases supplied by the regional fisheries organizations or derived from national fisheries statistics. These files and source materials, including electronic copies of reference materials, are archived within FAO, classified by continent, country or regional fisheries organization. A searchable bibliography was compiled using bibliographic software.

POLICY IMPLICATIONS

The "discard problem" embraces several issues or subproblems:

- the moral problem of responsible stewardship of marine resources;
- designing a management regime that limits or prevents discarding while meeting multiple social, economic and biological objectives;
- the practical problem of enforcing regulations designed to prevent or minimize discards, particularly as discards occur at sea where enforcement is most difficult;
- the technical problems of gear selectivity and utilization of species with a low market demand through transformation or adding value; and
- the economic problems posed by efforts to reduce bycatch, increase landing of bycatch or increase utilization of bycatch.

Moral issues

International instruments, including United Nations (UN) resolutions, the Kyoto Declaration and the Code of Conduct for Responsible Fisheries (CCRF) have

highlighted the need to reduce or minimize discards. These instruments reflect the idea, enshrined in many of the world's religious and secular beliefs, that wastage of natural resources is morally wrong.

A number of countries have instituted fisheries policies and management regimes based on the principle of "no discards". A "no-discard" policy implies a paradigm shift in approaches to fisheries management. It moves the focus of management measures from landings to catches and from fish production to fish mortality. In conformity with the precautionary approach, by regarding "no discards" as the norm, any discarding then requires adequate justification.

Issues related to the Code of Conduct for Responsible Fisheries

There are two principal approaches to addressing the "discard problem":

- reducing bycatch
- increasing utilization of bycatch

These two harvest strategies may be complementary and in any given fishery an appropriate balance between bycatch reduction and utilization is required. The biological and social principles upon which such a balance can be based require further analysis and development of decision frameworks. A more precise interpretation of "the ecosystem approach" in terms of the trade-off between promoting bycatch reduction and promoting bycatch utilization may be of value. In particular, the balance between highly selective fishing that targets one trophic level (or species) only, and less selective fishing that is likely to impact upon several trophic levels (or species groups), may require further attention to enable best scientific advice to be made available.

A third approach is to improve the survival of discards and animals returned to the sea. This is of particular importance with regard to species groups such as marine mammals, turtles, seabirds, lobsters and crabs.

Responsible fishing operations (in relation to discards and bycatch) can be based on the following principles:

- making efforts to avoid unwanted catches – in particular, catches of endangered species and unwanted catches and discards that may reduce biodiversity or disrupt ecosystem function or integrity;
- where catches of unwanted species, sizes or sexes are unavoidable, making efforts to find sui uses for such animals, and/or if there is a reasonable probability of survival, making efforts to return the unwanted catch to the sea;
- taking measures to increase the survival of unwanted catch destined to be returned to the sea;
- keeping records of discards, if required for management purposes.

The incidental catch and subsequent discard of charismatic, protected or endangered species, such as turtles, marine mammals and seabirds, are likely to have an increasing impact on fishing activities and trade in fish products. The absence of a neutral and internationally accredited mechanism for compilation of information on the incidental catches of many of these species and for examination and promotion of best practices in mitigation measures may impede rational discussion and development of solutions.

TECHNICAL IMPLICATIONS

Discard information has a high inherent level of variability requiring high levels of discard sampling to give accurate assessments. On-board observer reports are considered indispensable for accurate estimation of discards. Relationships between discard rates and other variables (e.g. landings, duration of trip, length of trawl tow, market prices) tend to be weak. Consequently, raising or extrapolating discard estimates derived from samples to the level of the fleet or fishery may have a high degree of error. Accuracy is dependent on the design of an appropriate sampling protocol.

Discards account for a significant mortality in fisheries. For numerous reasons discard estimates may not be included in stock assessments, TAC determination or quota management. In general, the "accounting toolkit" for discards is deficient.

National fisheries statistics are generally collected, compiled and presented on a species-by-species or species group basis. There are several advantages in also compiling national fisheries statistics on a fishery-by-fishery basis. In particular, this may focus attention on the definition of coherent management units, link trends in landings to fishery-specific management measures and facilitate inclusion of discard estimates if required.

The discard database includes information on fishery management measures associated with discards and bycatch. The measures include legal obligations (e.g. minimum landing sizes, quotas and transhipment prohibitions), economic incentives and technical improvements (e.g. bycatch reduction devices [BRDs]). A number of fisheries have specific bycatch plans or require environmental impact assessments that specifically address bycatch and discard issues.

FUTURE DIRECTIONS

The development of guidelines on best practices can be considered with regard to:

- discard sampling, e.g. from observers, logbooks, fishers' estimates;
- raising of discard estimates to the fleet or fishery level;
- use of discard estimates in stock assessments;
- use of discard estimates in total allowable catches (TACs) and quotas;
- development of bycatch management plans; and
- introduction and adoption of bycatch reduction and incidental catch mitigation technologies and practices.

A series of related studies can be considered to supplement this study, in particular, to compile:

- information on the interaction between fishing activities and charismatic species at fishery, ocean and global level, with a focus on effective mitigation measures;
- information on unobserved mortalities caused by fishing activities; and
- additional information on survival of discards.

This study is regarded as an evolving tool rather than a static report. Ideally, it requires a further "decentralized" phase at national or regional level to: (i) verify or update the information in the discard database; (ii) give a broader "ownership" base to the discard information, through dialogue and consultation with national fisheries administrations and regional fisheries organizations; and (iii) compile discard information from countries and fisheries where information is deficient.

The global fishery-by-fishery records of landings form the backbone of the discard database. This set of records is of potential use for a range of other analyses, in particular if fields such as "status of exploitation of the fishery" are complete. Efforts are under way to integrate the database into FAO's Fisheries Global Information System (FIGIS) both as a basis for compiling the global inventory of fisheries and as a discard database subset. Records in the database may be biased towards discards, since many of these records are derived from "discards literature".

1. Introduction

> *"It is impossible to estimate the quantity of small fish that is destroyed since it is impossible to estimate the amount that is shovelled overboard, dead or dying."*
>
> **(Holt, 1895)**

Discards are that portion of the total catch which is dumped or thrown overboard at sea. Discards are generally considered a waste of fish resources and inconsistent with responsible[1] fisheries. However, while technically a discard, the return of an egg-bearing lobster to the sea is clearly supportive of responsible fisheries.

WHY IS AN UPDATE OF GLOBAL DISCARDS NEEDED?

FAO is required to report periodically to the United Nations General Assembly (UNGA) on progress with regard to UN resolutions on fisheries. A number of these resolutions (see Section 4.2.1) make reference to monitoring bycatch and discards, including provisions on bycatch and discards in international fisheries instruments, and reviewing the impact of bycatch and discards on the sustainable use of living marine resources.

This update helps to quantify the scale of discards in different types of fishing operations and in different regions and provides an indication of the progress made in reducing discards and wastage in the world's capture fisheries. These trends are of interest for the design of national and multilateral initiatives to promote responsible fishing operations and utilization of the catch. Estimating discards also raises practical issues with regard to the interpretation, application and monitoring of the Code of Conduct for Responsible Fisheries (CCRF).

PREVIOUS ESTIMATE

In 1994 FAO published an estimate of global discards in marine fisheries (Alverson *et al.*)[2] indicating that 27 million tonnes, or approximately 27 percent of the global catch, were discarded annually. The initial estimate was a major achievement, providing the order of magnitude for the estimate of global discards and illustrating the difficulty in estimating global discards, as indicated by the wide range of the estimate (17.9–39.5 million tonnes). In particular, the Alverson assessment helped to reduce global discards by focusing attention on the potential magnitude of the "discard problem".

The 1994 estimate was based on data from the 1980s and early 1990s and cannot accurately reflect the changes that have occurred in world fisheries. However, the estimate continues to be cited in support of particular policies and actions. The Alverson assessment was also subject to criticism with respect to aspects of the estimation method, including the assumptions on which the assessment was based and the limited geographical coverage of the available discard information.

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[1] UN General Assembly Resolution 49/118 (UNGA, 1994). There are numerous references to discards in the Code of Conduct for Responsible Fisheries (CCRF).

[2] Alverson *et al*., 1994 (referred to hereafter as "the Alverson assessment"). While the primary author made subsequent revisions of the estimate, the 1994 estimate is that which is most frequently cited in the literature. A previous estimate was also made by Saila (1983).

CURRENT STUDY

The objectives of the current study were to develop an improved and more robust and transparent method for estimating discards at the global level, and to use the method to re-estimate discards in the world's marine capture fisheries.

The approach used in this study differs substantially from that used in the Alverson assessment, which was based on discard/catch ratios determined by species or species group. These ratios were then applied to FAO's Fishstat nominal catch statistics for the 1988–1990 period in order to derive the global estimate.

In contrast, the current study compiled an inventory of the world's fisheries and their respective catches. Information on the quantity of discards or the proportion of discards in the catch was obtained from available discard studies. As discard studies were not available for all fisheries, in some cases the ratio of discards to catch was assumed, based on information from similar fisheries. The total quantity of discards for the fishery was calculated by raising (extrapolating) the results of the discard studies to the total recorded landings for the fishery, as extracted from national fisheries statistics and other sources.

The fishery-by-fishery approach offers the possibility of verification and periodic updating of the discard estimates at the country or regional level in consultation with national fisheries authorities and regional fisheries organizations.

While it is unlikely that a definitive estimate of discards at the global level can be made, the re-estimate is seen as a contribution to an ongoing FAO process[3] to focus attention on the scale of discards, trends in discarding and on fisheries management issues and practices associated with discards.

[3] See UN resolutions, Section 4.2.1.

2. Method

2.1 SUMMARY OF THE APPROACH

The method is summarized in this subsection. Because there are significant differences between countries with regard to the interpretation of key terms, definitions are further discussed in Section 2.2. Reference is also made to Annex C, where details of the discard database file structure and a diagrammatic representation of the catch concepts are presented.

2.1.1 Key definitions

The key concepts and definitions are summarized below.

The definition of discards used in this study is adapted from FAO Fisheries Report No. 547 (FAO, 1996b).

> **Discards, or discarded catch is that portion of the total organic material of animal origin in the catch, which is thrown away, or dumped at sea for whatever reason. It does not include plant materials and post harvest waste such as offal. The discards may be dead, or alive.**

Discarding is considered to be an act of volition requiring a decision by fishers to reject or dump the fish. Discards include slipped fish, i.e. fish caught in a net and subsequently released into the sea without being brought on board the vessel. Discards do not include dead corals or empty shells. The release of fish by recreational fishers has not been considered as a discard for the purposes of this study.

Bycatch is the total catch of non-target animals. Discards are *not* a subset of bycatch since the target species is often discarded.

Discard rate is the proportion (percentage) of the total catch that is discarded.

Catch is used to refer to the "gross catch" as indicated in FAO's diagrammatic presentation of catch concepts (see Annex C, Figure 3, and Section 2.2.4). Catch includes all living biological material retained or captured by the fishing gear, including corals, jellyfish, tunicates, sponges and other non-commercial organisms, whether brought on board the vessel or not. Plant material is not considered part of the catch for the purposes of this study.

Landings refer to the portion of the total catch brought ashore or transhipped from the vessel. The landings information contained in the discard database is derived from a range of different sources. For a given set of "catch statistics" it may be difficult to determine whether the values are landed weights or the live-weight equivalent of the landings (= nominal catch as used in Fishstat).

Fishery is used as the principal unit of account for the discard database. A fishery is defined as a combination of a fishing area or zone *plus* a fishing gear *plus* a target species.

2.1.2 Sources of information

Information on discards and associated catches and landings by fishery was compiled from a broad range of sources. These included papers published in scientific journals, official publications of national fisheries administrations, "grey" or unpublished literature, reports of scientific working groups, catch and discard databases and correspondence and contacts with national and international fisheries experts. Over 3 000 references were compiled in a searchable bibliographic database archived in FAO.

2.1.3 The discard database

Records of over 2 000 fisheries were compiled in a discard database. Each record represents one fishery. The record identifies the fishery in terms of its location, fishing gear used and target species. The key quantitative fields provide the tonnage of the landings and discards for each fishery. Reference fields indicate the source of the landings and discard information and the year(s) to which they refer. A "discard rate" field indicates the percentage of the catch that is discarded (effectively discards as a percentage of discards plus landings). Other fields record additional qualitative information, such as the species composition of the discards and reason for discarding. The structure of the database is presented in Annex C.4.

2.1.4 Raising and key assumptions

The proportion of discards in the catch was obtained from discard studies. The studies were generally based on a sample of the vessels, fishing trips or fishing activities in the fishery. This proportion or discard rate was applied to the total landings of the fishery to raise or extrapolate the tonnage of discards to the level of the fishery. A linear relationship between discards and landings was assumed (see Section 2.4.1 for further discussion of the assumptions). In some cases, notably in small-scale and artisanal fisheries, the proportion of discards in the catch was assumed based on information from similar fisheries.

2.1.5 Verification

Information was checked by the use of multiple information sources for some records, further scrutiny of apparent anomalies (e.g. exceptionally high or low discard rates), by direct contacts with the authors of publications on discards, and by comparisons between extracts from Fishstat and the records. For selected countries the information was checked by requesting verification on the content of the discard database records from the national fisheries authorities or research institutes.

2.1.6 Differences between current and previous estimates

The main difference between the current method and the 1994 estimate is the use of the fishery-by-fishery approach, in contrast with the species or species group approach used in 1994. The information on which the current estimate is based has a substantially broader geographical range and is more representative of the world's fisheries. The evolution of discard estimates is detailed in Annex B.

2.2 OTHER DEFINITIONS AND TERMS USED

2.2.1 Other definitions of discards and bycatch

The term "discard" has distinctly different meanings in different jurisdictions, resulting in frequent confusion between "discard" and "bycatch". This confusion pervades the literature and has resulted in considerable difficulty in the course of the study.

The Nordic workshop (Nordic Council of Ministers, 2003) defined "discard" as:

> *"the proportion of the catch which is taken on board, or brought to the surface by the vessel and which is subsequently thrown back to sea, dead or dying, or likely to die".*

The definition includes "slipped catches" as discards and is essentially the same as that given above and used in this study.

In contrast, the United States of America Magnuson–Stevens Act (MSA), Section 3(2), (1996) defines bycatch as:

> *"fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards. Such term does not include fish released alive under a recreational catch and release fishery management program".*

This effectively means that bycatch[4] is equivalent to discards under the Act. This definition has been reinterpreted (NMFS, 1998) in the United States within the context of specific fishery management plans and publications, for example:

> *"Bycatch: discarded catch of any living marine resource plus retained incidental catch and unobserved mortality due to a direct encounter with fishing gear."*

The Inter-American Tropical Tuna Commission (IATTC) refers to "discards" as commercially important tuna species only (i.e. yellowfin, skipjack, bigeye, bluefin and albacore) that are dumped dead at sea, while "bycatch" is considered to be fish and other animals other than commercially important tunas that are dumped dead at sea.

A recent European Commission (EC) paper (European Commission, 2002a) defines discards as **commercial** species retained by a fishing gear that have been brought on board a fishing vessel and are thrown back into the sea, effectively ignoring non-commercial species.

Other definitions of bycatch

In Australia's bycatch policy, the term "bycatch" refers to all non-targeted catch including by-product, discards and the biomass that does not reach the deck of the fishing vessel but is affected by interaction with the fishing gear.

Bycatch is sometimes defined as "discarded catch plus incidental catch" where incidental catch is considered to be retained non-target species. However, if target species (e.g. juveniles) are discarded this may cause some confusion, as target species are not usually considered to be "bycatch".

Three further terms are used in this study to describe discards, or discard practices.

- *Regulatory discards*. Catch that is required by regulation to be discarded (from the Sustainable Fisheries Act [SFA], United States).
- *Discretionary discards*. Catch that is discarded because of undesirable species, size, sex or quality, or for other non-regulatory reasons (NMFS, 1998).
- *Highgrading*. Discarding of lower value commercial catch to maximize the value of quota. Highgraded discards are part of "discretionary discards" and are common in fisheries managed through individual vessel quotas.

2.2.2 Discard rates

The term "discard rate" used throughout this report refers to the **weighted** discard rate. The weighted discard rate is derived from the set of **complete** records for the type of fishery and is the summed discards as a percentage of summed landings plus summed discards.

$$\text{Weighted discard rate (\%)} = \frac{\text{Summed discards (tonnes)} \times 100}{\text{Summed discards + summed landings (tonnes)}}$$

The term "average discard rate" is the average of the individual discard rates for a set of fisheries. Average discard rates are provided together with their respective standard deviations for several of the major types of fishery.

[4] Concerns with the terminology used to identify bycatch or discards were addressed at a bycatch workshop in the United States in 1992. The terminology was subsequently updated by Alverson *et al.* (1994). Also see McCaughran, 1992.

2.2.3 Fishery and métier

The basic thesis on which the re-estimate is based is that discards are specific to a fishery. The fishery is used as the principal unit of account for the discard database. A fishery is defined as a combination of a fishing *area* or zone *plus* a fishing *gear plus* a target *species*. The term "fishery" is considered to be equivalent to the French term "métier".[5]

A range of analyses can be used to identify fisheries (Pelletier and Ferraris, 2000; Rochet *et al*., 1994; Laurec, Biseau and Charuau, 1991). Because of the lack of such empirical analyses for many countries and areas, the fisheries listed in the discard database were generally identified on the basis of descriptions of the fisheries sector prepared by the national fisheries administrations, e.g. in national fisheries development or management plans, in national fisheries statistics, or in research reports. Essentially, most of the fisheries listed in the discard database were identified by the competent national fisheries authorities.

Despite the fact that the fishery is an important focus of fishery management, many fisheries administrations do not necessarily compile catch or landings information by fishery. Consequently a substantial number of database entries refer to aggregate or generic fisheries, e.g. "the inshore small-scale, multigear, multispecies fishery".

Industrial fisheries

Industrial fisheries are large-scale fisheries that use large mechanized fishing vessels as distinct from small-scale and artisanal fisheries. Note that in the EU, the term "industrial fishery" may be used to refer to fisheries for small pelagics harvested for the manufacture of fishmeal.

Small-scale fisheries

This generic term is used in the study to characterize a highly diverse group of fisheries. The definition is essentially country specific, i.e. the country considers the fishery to be "small-scale". The terms "artisanal fisheries" and "small-scale fisheries" are considered equivalent for the purposes of this study and embrace other categories (e.g. subsistence, traditional, indigenous) as used in national fisheries statistics, or in the fisheries terminology of different countries. It is recognized that the term "small-scale" refers to "scale" rather than the nature of the fishing operation itself, e.g. the family nature of artisanal fisheries.

2.2.4 Other terms used

Landings

Landings values in the discard database are reported as given in the source of reference, except in rare cases such as when lobster or shrimp catches are reported as tail weight. In such cases the reported landings are converted to live-weight equivalent.

It is not always clear whether the mass of landings or catches reported in national fisheries statistics or other sources used is the "gross catch", the "landings" or the "nominal catch" as per FAO definitions (see Annex C, Figure 3, which gives a comprehensive graphical illustration of the different catch concepts). Fishstat provides statistical information on catches as "nominal catches" by species and country. The *nominal catch* is the live-weight equivalent of the landings.

No attempt has been made to adjust for additional catches or landings arising from illegal or unreported fishing activities, or for possible inaccuracies in national fisheries

[5] For a discussion of different definitions and approaches to defining fisheries see ICES, 2003. The ICES study group proposed a narrower definition of the term "métier": a "homogenous subdivision of a fishery by vessel type (e.g. by vessel size)". ICES also uses the term "fishery units" and has distinguished such units in terms of fishing depth.

statistical information as no adequate information is available at a global level. The principal reasons for this are the lack of any standardized reporting of such catches at global, regional or national level and the inability to resolve conflict with official reports of national fisheries catches.

Target catch
This term refers to catch of a species, a particular size or sex, or an assemblage of species that is primarily sought in a fishery, such as shrimp in a shrimp fishery or mature female fish in a roe fishery. The definition of targeted catch within a fishery is not static, as in a multispecies fishery, the mix of species targeted and caught may change over time.

Incidental catch
This term is used in the context of rare incidents or events such as catches of marine mammals, turtles or seabirds. Incidental catch is generally expressed in numerical terms rather than in terms of weight. Incidental catch is usually discarded and is considered as a discard for the purposes of this report.

Slipped catch
This term is applied to catches (usually purse-seine catches) that are released in the water without being taken on board the vessel. Slipped catches are considered to be discards. Quantities of slipped fish are difficult to estimate.

Trash fish
This term is not generally used in the study but refers to non-commercial or very low-value fish, usually caught by a trawl fishery. Trash fish is usually discarded unless collected at sea, or landed for aquaculture feed or fishmeal manufacture.

Debris
This term is used in the restricted sense of non-organic materials caught during fishing operations. Examples include rocks, sand, mud and plastic bottles. Organic materials such as dead shells, dead coral and plant materials (seaweed) are also considered debris.

Endangered and charismatic species
Endangered species[6] are those threatened with local or global extinction. Charismatic species,[7] sometimes referred to as "icon species", are species that for cultural or religious reasons society accords an existence value substantially in excess of market value (e.g. dolphins, seals, albatrosses).

2.3 THE DISCARD DATABASE

2.3.1 Structure of the discard database

An inventory of the world's fisheries was compiled[8] and a search conducted for quantitative information on landings and discards from each fishery. The information was stored in the form of a master spreadsheet and with numerous supporting

[6] The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) does not define the term "endangered species". The World Conservation Union (IUCN) also uses the terms "threatened" and "vulnerable" in categorizing endangered species.

[7] The term "charismatic discards" was used by Hall (1996).

[8] No comprehensive inventory or list of the world's fisheries has previously been compiled. A global inventory of fisheries is gradually being developed under the FAO Fisheries Global Information System (FIGIS, http://www.fao.org/fi/figis).

spreadsheets. The master spreadsheet is referred to as the "discard database" and contains 33 fields. The field structure is detailed in Annex C.4, Table 33. The fields can be divided into six categories.

- *Area*. Fields contain information on area, including the FAO statistical area code, national or regional fishery statistical areas and the name of the country.
- *Fishery*. Fields describe the fishery, including the name of the fishery, the type of gear and the target species.
- *Landings*. Fields contain information on the landings of the fishery including the quantity of landings in tonnes, year of reference and source of information.
- *Discards – quantitative*. Fields contain information on discards in the fishery: quantities in tonnes; the basis for estimation of the discards (e.g. observer reports, research survey); the reference to the source of the information; and the year or period to which the discard information refers.
- *Discards – descriptive*. Fields contain information on the reason for the discards, the measures or policies relating to discards and information on the status of exploitation of the fishery.
- *Flags*. Fields used either to distinguish particular records (e.g. those referring to incidental catches of marine mammals, or to small-scale fisheries).

The supporting spreadsheets were used to transform the landings and discard information provided in the source material to the formats and units required in the discard database. For example, some studies present discards as numbers of fish of different sizes, requiring a transformation from numbers discarded to weights discarded. The format and content of the subsidiary worksheets vary in relation to the different source materials.

2.3.2 The records in the discard database

There are over 2 000 records in the discard database of which 1 275 contain quantitative information on either landings or discards. The remaining records list fisheries for which quantitative information was not recorded.

Of these 1 275 records, 788 are quantitatively complete, i.e. they contain quantitative information on both landings and discards for a given fishery, 1 274 records contain information on catches, while 839 contain information on discard quantities. Some records are considered to be "duplicates", i.e. there is more than one record for the same fishery, either for different time periods, or providing information from different authors or sources. Sixty-two records refer exclusively to numbers of marine animals caught incidentally (marine mammals, seabirds, turtles). Excluding duplicates and incidental catch records, 956 records contain catch information, while 755 records contain discard information. Some records are used for summary or checking purposes.

2.3.3 Scope of the database

The primary focus of the study is on commercial and subsistence marine capture fisheries for finfish and shellfish. Records of incidental catch of marine mammals, turtles, seabirds and protected species are included because of the growing impact of the catches of these species on fishing activities. All such incidental catches are considered to be discarded.

The study does not cover freshwater and recreational fisheries. The importance of catches and discards in some recreational fisheries is recognized, but few countries[9] maintain adequate records. Freshwater species, species that migrate between freshwaters and marine habitats, reptiles, amphibians and aquatic plants have been excluded from Fishstat values and other values used.

[9] See Alverson, 1998. Exhibit 22 gives aggregate discard rates for United States Atlantic recreational fisheries of 60 percent (Northeast) and 52 percent (Southeast).

Post-harvest waste, such as offal, guts, frames and waste from surimi processing, is not considered a discard. Roe fisheries (e.g. herring, or United States rock sole) may have substantial wastage of males, which are not considered as discards since much of the sorting takes place onshore.

Shark finning

In theory, the practice of shark finning may not be considered different from filleting and gutting. The shark carcass would then be considered as "offal" or waste of a processing operation rather than as a discard. However, in this study, finned sharks are considered to be discards because most of the edible portion is discarded and because of the widespread condemnation[10] of and legislation[11] on what is considered a wasteful practice.

No allowance has been made for the quantities of fish killed through interactions with fishing gear that does not result in their capture. These unobserved mortalities may be caused by the impact of trawl gear on the bottom, escapement or drop-out from nets, ghost fishing by lost nets and similar gear inefficiencies (e.g. there are high scallop mortalities associated with scallop dredges).

Both fishers and observers tend to focus on commercial species and recognized animals. There is a tendency to group tunicates, sponges, echinoderms, hermit crabs, worms and corals with jellyfish[12] and perceive such biomass as debris, rather than as organic material. These non-commercial animals are frequently ignored and not recorded as discards during studies. This biomass tends to be omitted from estimates of discards. Many of these animals also pose practical problems of measurement of the biomass concerned (e.g. jellyfish), but may constitute a significant proportion of the total biomass harvested by trawls (Prena et *al.,* 1999). The literature contains relatively few estimates of invertebrate discards and discards of unusual species such as sea snakes. Because of a lack of information the estimates have made no allowance for such unperceived or unrecorded discards.

2.3.4 References and bibliographic archive

To facilitate checking and updating of the discard database each discard database record contains two bibliographic reference fields indicating: (i) the source of the catch or landings information; and (ii) the source of the discard rate or discard tonnage estimate. These bibliographic references and those used in the text of the report have been compiled in a bibliographic database using a commercial bibliographic software. Electronic versions of many of the reference materials are organized by continent, country and several generic categories in an electronic archive held in FAO Fisheries Department, Fishery Industries Division (FIIT).

2.4 ASSUMPTIONS AND ISSUES RELATED TO THE METHOD

2.4.1 Assumptions and aggregations

Certain assumptions and aggregations were necessary to prepare the discard estimates.

Correlation between total landings and discards

It is assumed that for a given fishery, during a given period, there is a linear relationship between landings and discards at the aggregate level. In other words, the discard rate of a sample has been applied to the total landings of the fishery to derive the total quantity of discards. This relationship does not necessarily hold true at the level of

[10] See International Plan of Action on Sharks, par. 22.

[11] For example, see NOAA, 2002 and Council Regulation (EC), 2003.

[12] Up to 30 percent of the catch is comprised of jellyfish in the United States South Atlantic shrimp trawl fishery (Lassen, SEFSC Web site).

individual vessel trips or fishing operations,[13] or in relation to the landings of target species. Furthermore, the linear nature of the relationship is open to question (Trenkel and Rochet, 2001). For further discussion see Section 2.4.3 on "raising".

Representative sample

Discard rates for a particular fishery are generally based on a sample of discards by particular vessels. The sample discard rates are assumed to be representative of the entire fishery for the purposes of raising (extrapolating) the discards to the fleet or fishery level. While this assumption is essential in order to estimate the quantity of discards from a given fishery, the assumption is open to a range of criticisms (see Annex C, Section 2.6 for further discussion of discard sampling). As the quantity of the landings for which discard estimates have been made (the sample) accounts for 94 percent of the ten-year average of Fishstat nominal catch, it is assumed that the weighted discard rate is a representative discard rate for the global marine catch.

Countries and fisheries with low or negligible discard rates

Based on expert opinion from in-country sources, the fisheries in several countries were assigned a discard rate of 1 or <1 percent (see Annex C.5, Table 35). These countries include the Pacific Island states, the small island countries of the Caribbean and several South Asian and Southeast Asian countries. There are some notable exceptions to the latter category, e.g. the Arafura Sea shrimp fishery (Indonesia) and some Chinese fisheries and trawl fisheries in the Philippines.

In the absence of information to the contrary, fisheries in the following categories were also assumed to have discard rates ranging from <1 to 5 percent: (i) artisanal and subsistence fisheries, in particular those based on coral reef resources and small pelagic species and those based on collection by hand or by divers; (ii) fisheries prosecuted for fishmeal; and (iii) fisheries using factory trawlers where minimum size regulations are not applied.

Comparable fisheries

Fisheries considered to be similar were assumed to have a comparable discard rate, i.e. a known discard rate from one fishery was applied to a fishery considered to be similar. Each assumption is essentially a case-by-case subjective judgement by the author based on personal knowledge of the fisheries, on contacts with experts on the fisheries in question, or on apparent close similarities between fisheries in terms of area, gear, target species, markets and regulations as deduced from the literature on these fisheries. Examples include artisanal reef fisheries, tuna pole and line fisheries for a given ocean, and the set of Celtic Sea demersal fisheries.[14]

Generic fisheries

In the absence of more detailed information, fish catches/landings were aggregated into generic fisheries, e.g. "south coast artisanal multigear multispecies fishery" or "all industrial trawl fisheries". It is acknowledged that such groups may contain several different fisheries with different discard rates. With the help of local experts, future discard estimates may achieve a greater level of disaggregation and precision.

Fisheries for tuna and highly migratory species (HMS)

Tuna fisheries, fisheries for HMS and other highly dispersed fisheries for which statistical information has been collected by relevant regional organizations (e.g. by

[13] For further discussion see Trujillo and Pereda, 1997; Reeves, 1990; and Rochet , Péronnet and Trenkel, 2002.

[14] An example of an essentially similar methodology applied at an enhanced level of detail is given by Melnychuck *et al.*, 2001.

the International Commission for the Conservation of Atlantic Tunas [ICCAT], the Indian Ocean Tuna Commission [IOTC], the Inter–American Tropical Tuna Commission [IATTC], the South Pacific Commission [SPC] and the Commission for the Conservation of Antarctic Marine Living Resources [CCAMLR]) were generally aggregated by ocean or major fishing grounds rather than by flag state (e.g. Western Central Pacific tuna purse-seine fishery). The statistical information collected by the regional fisheries organizations was used as the basis for these discard calculations. This means that vessels from several flag states may be grouped into one fishery and database record. In order to avoid double counting of such catches, tuna and HMS catches were subtracted wherever possible from catches recorded by country in the discard database.

2.4.2 Availability and quality of information

A complete discard database record requires two pieces of information: (i) the total catch or landings by a fishery; and (ii) either the discard rate or the total quantity discarded by that fishery.

Absence of discard information

There is a general absence of quantitative information on discards or discard rates and relatively few countries have made comprehensive assessments of discards. Essentially, many of the difficulties encountered by Alverson in preparation of the 1994 assessment still exist.

Catch/landings information by fishery

At the country level, aggregate statistical information on fish catches is generally published by species, fleet or area, but more rarely by fishery. Few lists of fisheries exist in the published literature, much less the associated quantitative information on catches or landings. Nevertheless, such information is often available in the unpublished internal reports of national fisheries administrations. In many jurisdictions fisheries tend to have an amorphous or fluid definition. This is partly because several different gears may be used, several species may be targeted on a single fishing trip or by a particular vessel, and because the fishery changes over time. Consequently the attribution of catches to a particular fishery may be difficult.

At the global level, FAO nominal catch statistics (Fishstat) are available by area and species (or species group), but not by fleet, fishing gear or fishery. The FAO database of fishing vessels contains information on the numbers of decked and undecked vessels by size class and by type of vessel (e.g. trawler, longliner). The Fishstat (nominal catch) database and the vessel database are independent of each other. Thus, the Fishstat catch information cannot currently be linked to a type of vessel or fishery.

Quality and scope of discard information

Studies on discards rarely refer to the total catch of the fishery studied. Even in peer-reviewed publications, the terms "bycatch" and "discards" are at times used in an apparently equivalent or interchangeable manner, often rendering the information unusable without clarification from the authors. In many of the references cited it is not clear whether the catch values quoted refer to landings, gross catch or nominal catches.

Many discard studies have a narrow focus on the discards of one or few target commercial species, which may be reported in numbers, without the information necessary to convert the discard numbers to weights. Studies frequently ignore non-commercial finfish species and a significant discarded biomass of invertebrates such as tunicates, corals, coelenterates (jellyfish), sponges, echinoderms and other commonly discarded invertebrates.

Information in the published literature is generally incomplete. For example, the average weight of shark fins and the total weight of shark fins landed may be given,[15] but the average weight of the shark is not provided, nor the estimated weight of shark as a percentage of the total catch. Numbers of fish are often given, but there are no means of converting the numbers to weight. The lack of characterization of the fleet or the difficulty in clearly identifying the fleet to which the discard information refers, creates substantial problems in identifying the corresponding catch/landings by fishery in the fishery statistics of the country or regional fisheries organization, and in the subsequent raising of observed discards to the fleet or fishery level.

Time series

Ideally, an analysis of trends in discarding practices should be based on adequate time series. Selected time series information is presented in Annex A.6 in support of the conclusions of this report. However, there is a general lack of globally representative time series on discards. Existing time series are often short as the observer programmes or the discard studies are often funded as a relatively short-term project rather than as an integral part of the normative fisheries information collection process. Interpretation of time series is further complicated by the need for supplementary information (e.g. changes in regulations, market conditions, catch per unit effort or size of year classes) needed to determine the reasons for changes in discard rates or in the absolute levels of discards.

2.4.3 Variability, sampling and raising

Some of the issues raised above are partly a result of the inherent characteristics of discard information, namely: (i) the high level of variability in discards; and (ii) the inability to correlate discards with other variables.

Variability

Discards reflect the response of the fisher to the changing circumstances of the fishery. The quantity of discards depends on an individual fisher's decision on where and how to fish, on the results of the fishing activity and on the behaviour and payment of the crew. Discards will tend to vary[16] in relation to catch composition, seasons, fishing areas, rigging of the fishing gear, market prices, port of landing, duration of the fishing trip, quota regulations, minimum landing size regulations and many other factors. Interannual variation may be linked to the presence of strong year classes of smaller less-marketable fish. Efforts to correlate the volume, composition and temporal or spatial variability of discards with such parameters have poor or mixed results. Fishers' discard behaviour (see Annex D) is characterized more effectively by game theory than by stable correlations with single, or even multiple parameters. Despite the high variability inherent in individual discarding actions (e.g. by vessel, trip, trawl and season), aggregate (summed) discard volumes tend to provide a relatively accurate estimate of discards.

Sampling

A comprehensive sampling or discard recording programme is required to obtain an accurate estimate of discards. Such a programme can be carried out by on-board observers, on board by fishers, through interviews with fishers or through comparison of landings with a known profile of the total catch. Observer programmes have consistently been shown to provide the most accurate results, although this is not

[15] Xiao-jie and Zhan-quing,1999. In this case the purpose was to identify the numbers, rather than the weight of shark.

[16] Variability within a fishery (métier) may be greater than between fisheries (Rochet, Péronnet and Trenkel, 2002).

necessarily so if discarding is illegal. However, observer programmes may be costly and may not be appropriate for all types or sizes of vessels. The problems encountered in the design and uses of discard sampling programmes are further addressed in Annex C.2.

Raising

Raising or extrapolating discard estimates obtained from sampling to the level of the fishery or fleet presents a further set of problems. There are two basic options available: to raise as a function of effort or to raise as a function of total recorded catch of the fishery. Effort information is rarely available and catch information often means recorded landings. Raising discard estimates as a function of single target species landings data may result in substantial error (Matsuoka, 1997) as discards will tend to have a weaker correlation with the landings of a single species than with total landings. Target species landings are likely to be a function of the distribution and availability of the target species and may not be correlated (van Beek, 1998) with the temporal and spatial distribution and the size range of the discarded species. Complex models may also be used for raising, e.g. including information on catch composition, minimum landing sizes, year classes, seasons or market prices. The raising of discard estimates is further discussed in Annex C.3.

In this study, total quantities of discards were used if available as such in the cited literature, i.e. if the author had extrapolated from the fleet sampled to the total fishery. In these cases, the sample was more commonly raised by landings, and less frequently raised by effort. In cases where both raising methods were adopted, the mean estimate of discards was used, unless the author stated a preference. Where the raised discards quantity was not provided, discards were raised in linear[17] proportion to landings, as the only available raising factor.

2.4.4 Analysis

Analysis and interpretation of the discard database encountered several difficulties that may result in inconsistencies and potential sources of errors.

Temporal inconsistency

Every effort has been made to use discard and landings information from the 1994 to 2003 period. For a given database record the information on which a discard rate is estimated and the information on landings for that particular fishery may refer to different years. Landings quantities and discard quantities from different years were summed to provide the respective global totals.

National check-sum gaps

The sum of the catches for fisheries where information is available is frequently less than the total recorded national catch. Assignment of a discard rate to the balance of the catch is problematic and was not attempted (also see Confidence limits on p. 14).

TABLE 1
Generic example of check-sum gap and temporal inconsistency issues

Country X	Catch/landings	Discards	Discard rate *(%)*
Fishery 1 – 2000 data	100	10	10
Fishery 2 – 1998 data	200	50	25
Fishery 3 – 2001 data	300	150	50
Subtotal fisheries 1–3 (mixed years)	600	210	26
FAO Fishstat national total	1 000		Not estimated
Balance	400	Not estimated	Not estimated

[17] Trenkel and Rochet, 2001. The authors reject the linear relationship between catch and discards for the French Celtic Sea fishery.

Estuarine and freshwater species
Freshwater species have been excluded from the FAO Fishstat quantities used in the study. Catches of freshwater species in marine and estuarine waters are not readily distinguishable in many catch statistics and may make a significant contribution to catches and discards in countries with large coastal wetlands and estuaries (e.g. Bangladesh, Brazil).

Distant water fishing nations
In the discard database, catches of distant water fishing nations were generally assigned to the coastal state where the fishing takes place. Alternatively, distant water catches were assigned to the flag state. The assignment is dependent on the information available with regard to the fishery or fleet. For example, with respect to a coastal state that has issued fishing licences to a distant water fleet, the name given to the fishery indicates the distant water nature of the fishery, e.g. country: Senegal; name of fishery: EU deepwater shrimp trawl.

Double counting
Double counting may arise as a result of including several records that relate to the same fishery. This occurs when several different studies quantify the discards in a particular fishery, possibly using different approaches, or for different time periods. In general, the most recent value or the value that is (subjectively) judged to be the most accurate has been chosen. Every effort has been made to avoid double counting in calculating total global discards and the corresponding total landings by using a single record for each fishery. Records in which double accounting arises are flagged in the database. All records containing a discard rate (e.g. a time series) are used to estimate mean discard rates for different fisheries.

Database bias
The results of literature searches or Internet searches using a keyword such as "discards" will tend to generate more information on fisheries in which discards are a concern than on fisheries for which discards are not considered problematic. Thus the records and fisheries contained in the discard database may be biased in favour of fisheries with high discards. The inclusion of records of artisanal fisheries with a low assumed discard rate and the use of the fishery-by-fishery methodology may counterbalance this potential bias. Large numbers of relatively minor fisheries are included, whereas the database information is incomplete for some major fisheries. The database is also biased in favour of fisheries for which documentation exists in English, French, Portuguese and Spanish since most literature searches were made in these languages. Internet information and "grey" literature published in other languages, in particular in Arabic, Russian, Japanese, Korean and Chinese, were not comprehensively accessed.

It is not possible to quantify these potential biases.

Confidence limits
Some of the references for individual records provide confidence limits for discard rates or discarded quantities. However, these individual record confidence limits cannot be summed or aggregated across records.

As the sum of the landings in the discard database is equivalent to 94 percent of the ten-year average Fishstat nominal catch, this "sample" represents a substantial proportion of the population of the world's fisheries. As such, measures of sampling error of the weighted mean result in small upper and lower limits. The range of values for the global estimate is provided (see Annex A.1). The range does not reflect the internal variance of individual records.

Indications of the level variance in the discard estimates are provided for the major types of fisheries (e.g. shrimp trawl, finfish trawl) as standard deviations from the mean discard rate for each of these groups of fisheries (Annex A.2).

Narrow confidence limits are required for stock assessments in some jurisdictions, for example by the EC. The observer coverage required to achieve similar confidence limits for discards may incur substantial costs.

Survival of discards

This study does not address the survival of discards, which has been studied in many fisheries. Among the factors influencing the survival of discards are the depth of fishing, duration of trawls, soak time for lines and nets, and the physiology of the species discarded. In comparison with fish escaping from trawls, those fish escaping from traps tend to have a high survival rate as do releases of live lobster and crab.

Impact of discards

An associated FAO study (Poseidon Aquatic Resource Management Ltd, 2003) has examined aspects of the economic and ecological impacts of discards. These impacts are difficult to distinguish and isolate from the impacts of bycatch and fishing activities. The ecological and economic issues are briefly discussed in Sections 4.5 and 4.6.3 respectively.

Interpretation

The global discard estimate provided in the results section may be misinterpreted, no matter how carefully predicated by caveats. As previously indicated, the records in the database may be biased in favour of a high estimate of discards. The database remains incomplete and discard information on several important fish-producing countries has not as yet been compiled, or is only partially compiled. These countries include the Democratic Republic of Korea, the Republic of Korea and the Russian Federation. The omission of some important fisheries may in itself be a source of bias. Assumptions regarding discard rates applied to certain fisheries will require further verification. Discard estimates may be politically sensitive and imprecise discard estimates can lead to political and other difficulties.[18] As such, these results must be treated with due caution and interpreted in the appropriate context.

2.4.5 Future updating of the discard estimate

Discard practices may change rapidly as a result of changes in fish stocks, in regulations, in markets, or in any of the multiple factors influencing the behaviour of fishers. The estimates should therefore be repeated at intervals in order to monitor trends in discarding practices and the implementation of the relevant parts of the CCRF.

FAO plans to update the discard estimates periodically from national sources and through regional fisheries organizations. The country-by-country architecture of the discard database and the references associated with each record enable updating, verification, substitution or addition of records by competent experts from each FAO statistical area.

[18] For example, the Pacific Fisheries Management Council (PFMC) in the United States has been forced to reassess bycatch and discard rate assumptions under a ruling by the federal magistrate in *Natural Resources Defense Council*, 2001.

3. Results

3.1 OVERVIEW OF RESULTS

3.1.1 Estimated discards

Based on the set of *complete* records in the discard database, the sum of the recorded discards is 6.8 million tonnes for total recorded landings of 78.4 million tonnes (Table 2). The global weighted discard rate is 8 percent.

Global quantity of discards

Applying the weighted average discard rate (8 percent) to a ten-year average of the FAO Fishstat[19] reported global nominal catches gives a total discards estimate of 7.3 million tonnes (Table 2). If this extrapolated quantity of global discards is added to the nominal catch, the total global marine catch (= gross catch) is approximately 91 million tonnes, excluding the unknown quantities harvested by illegal and/or unrecorded fishing.

Comparison with previous estimates

Because of the different methods of calculation, the estimate of 7.3 million tonnes provided in this study is not directly comparable with the 1994 global discard estimate of 27 million tonnes. Nevertheless, the estimate is less than 50 percent of the lower end of the 1994 range (17.9 million tonnes). Even allowing for some overestimation in the Alverson assessment and some underestimation in the present study, the current estimate strongly suggests a reduction in discards and discard rates at the global level. The evolution of the different global estimates of discards is discussed in detail in Annex B. The 1994 estimate is based on data from the 1980 to 1992 period while, with some exceptions, the current study has used data from the 1992 to 2003 period.

Reduction in global discards

Time series at the global level are not available to provide comprehensive empirical evidence of reductions. However, there is compelling evidence for a substantial reduction in discards based on an examination of trends in many major fisheries. A summary of the considerations leading to such a conclusion is given in Sections 3.1.2 and 3.1.3. Supplementary tables (see Annex A.6, Table 27) provide supporting information on discard reduction in selected fisheries, many of which make major contributions to the global discard total. The reduction can be attributed to two major factors:

- a reduction in bycatch resulting from the use of more selective fishing gears, the introduction of bycatch and discard regulations, improved enforcement of regulatory measures and reduction of effort in some major trawl fisheries; and

TABLE 2
Estimate of the annual global quantity of discards (tonnes)

Summed landings for which discard information was available[1]	78 448 399
FAO average marine nominal catch for 1992–2001 period (from Fishstat)	83 805 355
Weighted discard rate	8.0%
Total estimated discards (from discard database)	6 824 186
Extrapolated global annual discards for 1992–2001 period	7 290 170

[1] Equivalent to 94 percent of a ten-year (1992–2001) average of Fishstat nominal catch.

[19] Fishstat Plus (version 2.3) of 24 July 2003. The nominal catch value excludes marine animals and plants.

- increased retention of bycatch for direct utilization as a result of improved technologies and expanding market opportunities, or for conversion to fishmeal, silage or similar products, and changes in target species to include species previously discarded.

Discards by FAO area

Figure 1 and Table 4 (pp. 20–21) present the sum of the recorded discards by FAO statistical area. The table includes a column derived from FAO Fishstat showing a ten-year (1992–2001) average reported nominal catch (excluding marine plants, marine animals and marine mammals) for each FAO statistical area. The Northeast Atlantic (Area 27) and Northwest Pacific (Area 61) jointly account for 40 percent of estimated discards, attributable to high discards in many EU fisheries and in some Japanese fisheries. Details of discards and discarding practices by FAO area and by fishery are presented in subsequent sections and supplemented by additional tables in Annex A.

Some differences are apparent between the Fishstat nominal catch data and aggregated country landings, as derived from national statistics and other sources during this study. However, it is *not* valid to compare the two data sets directly, since the landings reported in the discard database are a sample reflecting the availability of discard information. The differences between the data sets are also a result of the different time periods used, different sources of data and the summing of different years in the case of the discard database. A region-by-region commentary is provided in Section 3.2.

Discards by country

Discards and discard rates by country are tabled in Annex A.4, Table 24. Discards in low income food deficit countries (LIFDCs) are highlighted, with a view to indicating where future efforts at discard reduction may be directed.

Discards by fishery

Tables 3, 5 and 6 provide an overview of discards by major type of fishery. Shrimp and demersal finfish trawl fisheries account for over 50 percent of total estimated discards while representing approximately 22 percent of total landings. Tropical shrimp trawl fisheries have the highest discard rate and alone account for more than 27 percent of total estimated discards. Small-scale fisheries account for at least[20] 8.5 million tonnes (11 percent) of the discard database landings and in aggregate have an estimated discard rate of 3.7 percent.

The discards by fishery are discussed in detail in Section 3.3. Fisheries with the highest discards and discard rates are tabulated in Annex A.

Approximately 50 percent of discards are accounted for by the 80 percent of records with the lowest discard rates (Table 6). Conversely, if records are taken as proxies for fisheries, then 20 percent of the fisheries account for 50 percent of the discards. The total (cumulative) landings for fisheries with discard rates below 1 and 5 percent are 40.9 million tonnes and 57.6 million tonnes respectively.

Because of lack of information on the state of the individual fisheries (e.g. under-/overexploited), it has not been possible to examine discard rates in relation to the level of exploitation. The use of the term "overexploited" often refers to a particular target fish stock, rather than to a fishery, which may target a number of species.

[20] There are considerable difficulties in disaggregating catches between industrial and small-scale fisheries. The percentage cited above (11 percent) does *not* indicate the proportion of the global catch harvested in small-scale fisheries.

TABLE 3
Summary of discards by major types of fishery (tonnes)

Fishery	Landings	Discards[1]	Weighted average discard rate (%)	Range of discard rates (%)
Shrimp trawl	1 126 267	1 865 064	62.3	0–96
Demersal finfish trawl	16 050 978	1 704 107	9.6	0.5–83
Tuna and HMS longline	1 403 591	560 481	28.5	0–40
Midwater (pelagic) trawl	4 133 203	147 126	3.4	0–56
Tuna purse seine	2 673 378	144 152	5.1	0.4–10
Multigear and multispecies	6 023 146	85 436	1.4	n.a.
Mobile trap/pot	240 551	72 472	23.2	0–61
Dredge	165 660	65 373	28.3	9–60
Small pelagics purse seine	3 882 885	48 852	1.2	0–27
Demersal longline	581 560	47 257	7.5	0.5–57
Gillnet (surface/bottom/trammel)[2]	3 350 299	29 004	0.5	0–66
Handline	155 211	3 149	2.0	0–7
Tuna pole and line	818 505	3 121	0.4	0–1
Hand collection	1 134 432	1 671	0.1	0–1
Squid jig	960 432	1 601	0.1	0–1

[1] The sum of the discards presented in this table is less than the global estimate, as a number of discard database records could not be assigned to particular fisheries.
[2] Low estimates in some fisheries (e.g. gillnet) are partly a result of the inclusion of high Chinese catches with low or negligible discard rates.
Source: discard database.

TABLE 5
Fisheries and fishing areas with very low to negligible discard rates

Net fisheries
Midwater trawl for small pelagics
Beach-seine fisheries (developing countries)
Purse seines for small pelagics
Saury stick-held dipnet (Japan)
Line fisheries
Handline fisheries
Trolling for large pelagics
Tuna pole and line
Squid jig fisheries
Trap and other fisheries
Fixed fish trap fisheries
Pot fisheries (excepting discards of berried female/undersized crabs and lobsters)
Diver and collection fisheries
Small-scale and artisanal fisheries in general
Areas
Southeast and East Asian fisheries in general
South Pacific Islands coastal fisheries (multigear/multispecies)
Caribbean Islands coastal fisheries (multigear/multispecies)
Fisheries in countries with a "no-discards" policy

TABLE 6
Breakdown of discard rates by quintile of total quantity of discards

Cumulative percentage of total discards	20%	40%	60%	80%	100%
Percentage of records	72%	8%	6%	7%	7%
Range of discard rates	0–13.8%	14–27.1%	27.3–40%	41.2–61.3%	61.6–96%
Cumulative discards (tonnes)	1 364 251	2 569 061	4 016 954	5 452 227	6 824 186
Cumulative landings (tonnes)	65 863 626	73 527 837	76 773 955	78 062 224	78 432 299

Note: the breakdown was derived from sorting records by (i) discard rate as a primary sort key; and (ii) by quantity of landings as a secondary key.
Source: discard database.

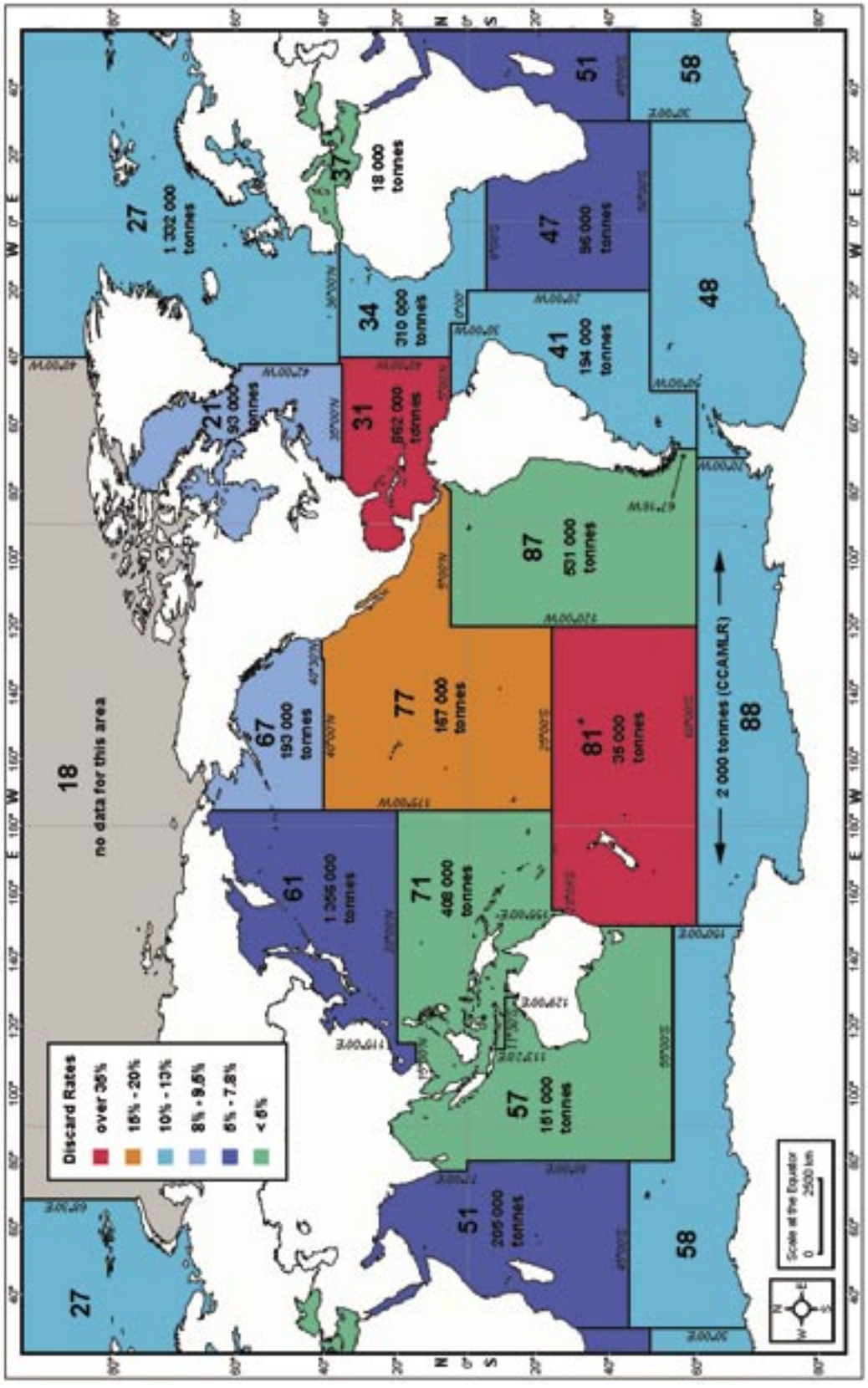

FIGURE 1
Recorded discards by FAO statistical area
*Note: the high discard rate in FAO Area 81 is a data artefact (see area discussion)

TABLE 4
Summary of recorded discards by FAO statistical area (tonnes)

FAO statistical area/other grouping/ item	Data source: discard database				Data source: FAO Fishstat		Indicative coverage[2] (%)
	FAO statistical area(s)	Discards	Associated landings[1]	Discard rate (%)	FAO statistical area(s)	1992–2001 mean nominal catch	
Arctic Sea	18	0	0	–	18	n.a.	
Atlantic, Northwest	21	92 926	909 142	9.3	21	2 123 792	43
Atlantic, Northeast	27	1 332 212	8 921 013	13.0	27	10 799 785	83
Atlantic, Western Central	31	831 808	1 372 480	37.7	31	1 687 236	81
Atlantic, Eastern Central	34	309 718	2 631 660	10.5	34	3 118 038	84
Mediterranean and Black Sea	37	17 954	352 228	4.9	37	1 449 955	24
Atlantic, Southwest	41	193 668	1 413 682	12.0	41	2 301 953	61
Atlantic, Southeast	47	95 896	1 626 692	5.6	47	1 560 103	104
Indian Ocean, Western	51	205 428	2 931 174	6.5	51	3 026 425	97
Indian Ocean, Eastern	57	151 190	4 205 810	3.5	57	3 938 277	107
Pacific, Northwest	61	1 355 822	22 052 304	5.8	61	21 896 194	101
Pacific, Northeast	67	192 829	2 078 367	8.5	67	2 898 518	72
Pacific, Western Central	71	407 826	9 366 816	4.2	71[3]	7 136 017	131
Pacific, Eastern Central	77	167 351	700 623	19.3	77	1 107 429	63
Pacific, Southwest	81[4]	35 475	38 760	47.8	81	748 093	5
Pacific, Southeast	87	530 582	14 675 997	3.5	87	14 648 906	100
Multiple area[5] (Central America)	31, 77	27 335	12 557	68.5	–	–	–
Multiple area	67, 77	150 161	287 937	34.3	–	–	–
Multiple area	71, 77	2 138	13 362	13.8	–	–	–
Subtotal without Antarctic and tunas		6 102 399	73 604 939	7.7		**78 440 723**	94
Tunas, bonitos, billfish							
Atlantic and Mediterranean	ICCAT (21, 27, 31, 34, 41, 47,48)	156 930	823 962	16.0	21, 27, 31, 34, 37, 41, 47, 48	684 080	120
Indian Ocean	IOTC (51, 57)	139 465	1 409 589	9.0	51, 57	1 214 669	116
Pacific, E. Central	IATTC (67, 77, 87)	56 508	672 968	7.7	77	401 753	–
Pacific, SW and W. Central	SPC (71, 81)	162 068	1 919 706	7.8	71, 81	1 916 653	–
Pacific, NE, NW, SE					61, 67, 87	1 013 337	–
Subtotal tuna		514 972	4 826 225	9.6		**5 230 492**	92
Antarctic							
Atlantic, Antarctic		n.a.	n.a.	–	48	124 846	0
Indian Ocean, Antarctic		n.a.	n.a.	–	58	8 883	0
Pacific, Antarctic		n.a.	n.a.	–	88	411	0
Subtotal Antarctic	CCAMLR (48, 58, 88)	2 079	14 336	12.7		**134 140**	11
Global shark fin (derived from)	Global	206 815	17 235	92.3		–	–
Total for sample		**6 824 186**	**78 448 399**	**8.0**	**All FAO areas**	**83 805 355[6]**	**94**

[1] Catches/landings as recorded by the study from national statistics and other sources (see Methods section).
[2] The column "Indicative coverage" gives "study landings as a percentage of the Fishstat average nominal catch (1992–2001)". It is provided only as an *indication of relative coverage* by the study. The 94 percent value *does not mean* that 94 percent of global landings have been accounted for in the study, but merely illustrates that a high proportion of the world's fisheries have been considered. This column is primarily intended to indicate relatively low adequate coverage in certain FAO statistical areas (e.g. Areas 81and 21).
[3] It is not valid to compare the two data sets directly. The large difference between the discard database and Fishstat values shown for Area 71 is largely attributable to Viet Nam (a 2.2 million tonne difference between the historical average and recent reported catches). Note that Fishstat assigns over 90 percent of the Chinese nominal catch to Area 61 and assigns 100 percent of Viet Nam's nominal catch to Area 71.
[4] The high discard rate in Area 81 is a data artefact resulting from the relatively low number of database records for that area.
[5] The study was unable to separate recorded catches for some countries by FAO statistical area. These catches are recorded as "multiple area".
[6] Sum of areas, not average of global values by area. Quantities exclude aquatic plants and animals and fish considered to be freshwater species.
Source: Discard database and Fishstat Plus version 2.3 (2003).

3.1.2 Bycatch reduction

Several major fisheries and numerous smaller fisheries, which previously made significant contributions to the global volume of discards, have introduced more selective fishing gears, reduced fishing effort or applied other measures that have reduced unwanted bycatch. Examples of major fisheries in which bycatch has been significantly reduced include:

- United States Northwest Pacific groundfish fisheries, in particular those under the management of the North Pacific Fisheries Management Council (NPFMC). A variety of measures are used including area and seasonal closures, bycatch quotas and total allowable quotas (TACs), and economic measures (see Annex A.6.1);
- United States Gulf of Mexico and Atlantic shrimp trawl fisheries where bycatch reduction devices and turtle excluder devices (TEDs) are obligatory in certain areas;
- Argentina's hake and other trawl fisheries operating in areas where juvenile hake are caught;
- numerous Canadian and Northwest Atlantic Fisheries Organization (NAFO) fisheries as a result of a range of management measures, changes in target species and reduced trawl effort;
- the Arafura Sea shrimp trawl fishery where BRDs have been introduced (although enforcement of BRD regulations is reported to be problematic);
- the Gulf of Carpentaria northern prawn fishery and other Australian trawl fisheries;
- EU *Nephrops* fisheries in which square mesh panels are obligatory;
- EU flatfish fisheries where the minimum landing size (MLS) has been decreased for some species; and
- fisheries in countries with "no-discard" policies (e.g. Norway and Iceland).

Many factors have contributed to bycatch reduction. United Nations resolutions on bycatch and discards (see Section 4.2.1) and promotion of the CCRF have increased public and international awareness of discards as morally unacceptable waste. Scientific concerns over the unaccounted mortalities of juvenile fish, and fishers' concerns[21] over the impact of unsustainable fishing practices on ever-scarcer fish resources have resulted in a broad range of bycatch and discard reduction initiatives. Economic factors such as the costs of sorting catches, crew shortages, efforts to comply with ecolabelling requirements, and the introduction of quotas on bycatch species have all contributed to reductions in unwanted bycatch. Improvements in fisheries management in general, changes in fisheries regulations and improved enforcement of regulations have also played an important role in bycatch reduction. In several countries, the common concerns of government and industry have enabled the formulation of joint bycatch reduction strategies and implementation of mutually agreed measures. National efforts to reduce bycatch and discards have been complemented by important contributions from non-governmental organizations (NGOs) and the media in raising public awareness and concern over wastage in fisheries. Changes in target species and a decrease in the level of trawl effort in several important fisheries have also played a role in discard reduction.

However, some fisheries have contributed to increases in discards, notably the expanding deepwater fisheries and fisheries where severe quota restrictions have resulted in highgrading. Overfishing in many fisheries also contributes to increases in discards, particularly where an increasing proportion of the target species is comprised of juveniles or fish below the MLS. Nevertheless, overfishing may also result in discard reduction when fishing effort or catches decline, or when prices for previously discarded fish increase. Anecdotal evidence suggests that despite the introduction of square

[21] For example, see Wray, 1995. The fishing industry made substantial contributions to this initiative.

mesh panels and other bycatch reduction measures in the EU, stricter enforcement of progressively reducing quotas is resulting in greater discards in some fisheries.

3.1.3 Increased bycatch retention and utilization

Many species and types of fish that were previously considered to be bycatch are now included in a broader range of target species. It is not clear to what extent increases in global marine captures may be a result of increased landings of previously discarded species. Lack of time series again precludes empirical assessment at the global level, but evidence strongly suggests increased utilization of bycatch in many fisheries, particularly in:

- South Asian and Southeast Asian fisheries, which (with some exceptions) have very low or negligible discard rates. The increased utilization is partly a result of increased demand for aquaculture feed and innovations in product development;
- African industrial trawl fisheries, which are marketing increasing quantities of previously discarded demersal finfish, particularly on African[22] urban markets; and
- increased at-sea processing by factory vessels producing surimi[23] and related products. However, these operations may result in increased disposal of offal and processing waste, which are not considered discards.

Several related reasons for increased bycatch utilization can be identified:

- population and income increases leading to greater demand and price increases for fish products, particularly in developing countries;
- use of low-value bycatch for aquaculture and animal feed, particularly in South and Southeast Asia;
- development and transfer of technologies to use small-sized fish of a variety of species to produce value-added products, such as surimi;
- development of consumer markets for unfamiliar or previously discarded species, e.g. deepwater shark, and reduced availability and increased prices of preferred species;
- reductions in quotas or target species catches (possibly caused by overfishing), which frees hold space for increased retention of non-quota species or lower valued bycatch;
- shorter fishing trips to improve fish quality, but which may also create "spare" hold capacity that can be used for bycatch;
- increased at-sea collection of bycatch, particularly in tropical shrimp trawl fisheries in Africa and in Central and South America;
- changes in management regimes that encourage, facilitate or even oblige landings or at-sea collection of bycatch;
- other changes in regulations, e.g. a reduction in the MLS to ensure compatibility with trawl mesh sizes and the ability to transfer target or bycatch quotas between vessels or fishers; and
- economic incentives to maximize returns from the catch.

In theory, a reduction in discards should be reflected in the statistical information on trends in the composition of landings.[24] However, because of natural fluctuations in catch composition, aggregation of catch information at species level (i.e. a large proportion of the catch is recorded as "not elsewhere included"), the trends in retention in previously discarded species cannot readily be detected at global level by analysis of species composition in the Fishstat database. Fishery-by- fishery analysis may provide a clearer indication of such trends.

[22] For example, Senegal now exports more demersal fish to Africa than to Europe.
[23] For example, Argentina, Chile, Northeast and Northwest Pacific.
[24] If it is assumed that discards are more likely to comprise animals at a lower trophic level, then the evidence for "fishing down aquatic food webs" can be considered corroborating.

Further efforts to promote bycatch utilization[25] are likely to reduce discards further in LIFDCs, particularly in Africa, Central America and in the fisheries along the north and east coast of Latin America.

The following sections are presented as illustrative of general trends but disguise the wide variety of discarding practices, the reasons for discarding and the ongoing changes in the fisheries concerned.

3.2 DISCARDS IN SELECTED REGIONS AND COUNTRIES

This section provides a brief commentary on discards in selected regions and countries. The groupings do not precisely correspond to FAO statistical areas since the marine waters of some countries may extend to more than one FAO statistical area. The commentary concentrates on major fisheries, points of interest and trends. Only selected sources are cited.

3.2.1 Northeast Atlantic (Area 27)

Two groups of countries can be distinguished in Area 27. Norway, Iceland and the Faeroe Islands pursue a "no-discards" policy; all other countries permit discards, while promoting selective fishing and increased utilization of the catch. The no-discards policy is further discussed in Section 4.3.1.

Northern waters

Norway has a weighted discard rate of 3.9 percent, or about 100 000 tonnes of discards from landings of approximately 2.5 million tonnes (Valdemarsson and Nakken, 2002). The fisheries in the far northern International Council for the Exploration of the Sea (ICES) areas have relatively low discard rates, partly because of the influence of Norwegian policy exercised through international fishing agreements and because of the relatively low diversity in catch composition. The large proportion of pelagic species in the total catch and the high manufacturing capacity for fishmeal in Norway, Denmark and Iceland also contribute to a low aggregate discard rate.

Baltic Sea

A relatively small number of commercial species in the Baltic (cod, herring, sprat, salmon) and a well-developed processing industry combine to ensure relatively low levels of discards in Baltic fisheries. Cod trawl discards are reported[26] to be less than 7 percent, while a discard rate of 5 percent in salmon and cod gillnet fisheries is primarily a result of seal damage to the catch. The largest fisheries (by quantity) are the herring and sprat "fishmeal" fisheries that have low or negligible discards. The aggregate discard rate for the Baltic is estimated (ICES, 2000a) to be 1.4 percent.

North Sea

Pelagic species and species targeted for fishmeal production jointly account for over 70 percent of North Sea landings. These fisheries have low discard rates. Nevertheless, total annual North Sea discards have been estimated to be between 500 000 tonnes (comprising 120 000 tonnes of roundfish, 200 000 tonnes of flatfish and 180 000 tonnes of benthic invertebrates) and 880 000 tonnes (Camphuysen *et al.*,1995; Tasker *et al.*, 2000). Since 1981 there has been a tendency for the discard rate to increase (European Commission, 2002), partly as a result of overfishing and high catches of juveniles, although recent declines in catch and effort mean that the total quantity of discards may have decreased in recent years. High interannual variation in the total quantity of

[25] For an analysis of the utilization of bycatch and discards see Clucas, 1997.

[26] See also Box 6 which gives an example of the difficulties in harmonizing gear (BACOMA trawl) and MLS regulations in the International Baltic Sea Fishery Commission (IBSFC) area.

North Sea discards is closely related to the magnitude of the year classes of whiting, haddock and cod.

The Netherlands and Belgian beam trawl fisheries and the *Nephrops* and *Crangon* trawl fisheries account for a substantial proportion of discards. The Netherlands beam trawl fishery targeting sole in the North Sea has been estimated to discard in the order of 270 000 tonnes of fish, invertebrates and debris annually.[27] North Sea haddock discards represent 20–50 percent of the total catch of the species (50 000–100 000 tonnes per year). Annual whiting discards are in the order of 50 000 tonnes. The flatfish beam trawl fisheries have discard rates in the order of 70 percent while the shrimp (*Crangon*) and *Nephrops* beam trawl fisheries have discard rates as high as 83 percent. A reduction of the MLS for plaice in the North Sea has resulted in retention of increased quantities of juvenile plaice in recent years. Closures of some inshore areas to trawls (in ICES IVb, c) and the mandatory use of square mesh panels in the *Nephrops* trawls have contributed to a significant reduction in discards of juvenile plaice and whiting and haddock respectively.

EU Atlantic fisheries

There is greater species diversity in waters under the jurisdiction of EU members than the more northerly European waters. The dominance of demersal trawl gear and high discards by the important shrimp, *Nephrops*, and flatfish trawl fisheries are major factors that contribute to high aggregate discard rates in EU Atlantic fisheries. Overfishing of demersal stocks is also a primary contributing factor to the high level of discards in many of these fisheries. MLS and quota regulations, weak market conditions for smaller-sized fish and a diminishing proportion of larger-sized fish in some fisheries contribute to regulatory discards and highgrading in EU waters. A lack of definition of manageable fishery units and the wide geographical range of many important stocks throughout the waters of several member states mitigate against the formulation of bycatch and discard management plans.

Discards are rarely estimated on a systematic and continual basis in most EU fisheries and as EC fisheries legislation[28] does not require mandatory recording of discards, most of the studies are based on limited[29] seagoing observer coverage. Numerous EC studies on discards have tended to focus on those of commercial target species. However, discard estimates are generally not included in stock assessments.[30] This is a result of several factors,[31] including the low level of observer coverage, which may not meet the requirements of a statistically significant sampling protocol, and the concern that inclusion of the lower quality of discard data would simply detract from the (higher) quality of the catch and other data used in stock assessments.

High discard rates were identified in a broad range of EU fisheries, including deepsea fisheries; the Algarve *Nephrops* and deepwater shrimp trawl fishery (70 percent); the Algarve demersal finfish trawl fishery targeting hake, seabream and other species

[27] van Beek, 1998. The data are from 1976 to 1990, but substantiated by more recent additional information.

[28] EC Regulation 1639/2001 specifies a triennial collection of discard data for some stocks, which may not be useful in stock assessment. If discard data are used for recruitment indices then an estimation of discarding levels is required annually.

[29] The EC observer programme under Regulation 1639/2001 for the year 2002 planned to field only 34 observers, including Icelandic participation in the programme (ICES, 2002).

[30] While the exclusion of discard estimates from stock assessments may not significantly affect the assessment per se, its inclusion may influence recruitment projections and management advice. Many United States fishery stock assessments include discard estimates. The IBSFC/ICES assessments include discard estimates as does the stock assessment for North Sea haddock and northern hake. Breen and Cook (2002) conclude that the exclusion of discard estimates would lead to significant biases in all aspects of stock assessment.

[31] "... the levels of sampling effort currently being applied in European fisheries are not providing adequate discarding information for stock assessments as currently carried out" (ICES, 2002).

(62 percent); the Irish razor shell dredge (60 percent); and the French Bay of Biscay hake trawl (56 percent). *Nephrops* trawlers have a consistently high level of discards.

A substantial quantity of additional discard information is available from a range of EC studies[32] and as a result of the work of the ICES Study Group on Discard and By-catch Information (SGDBI), which has coordinated, compiled and analysed discard information on several EU fisheries.[33] Because much of this information refers exclusively to discards of target species, rather than to total discards, additional complementary information is required prior to inclusion in the discard database.

Western waters

Increasing pressure on stocks in the area known as the "Western waters" (West of Ireland and Scotland) by Irish, French, Spanish and United Kingdom fleets has reduced average sizes of some species with a consequent increase in discards. In 1999, whiting discards (in the order of 25 000 tonnes, particularly from the *Nephrops* fisheries) represented 60 percent by weight of the catch and more than 80 percent of the catch by number. Approximately 30 percent of Irish hake catches (ICES Areas VI and VII) are discarded, partly because of trawl damage to the fish and about 25 percent of the discards are of marketable size. Large quantities of pelagic species (horse mackerel, mackerel and blue whiting) are discarded by Spanish demersal trawlers because of weak market demand and quota restrictions.

Quota restrictions increasingly influence highgrading and other discarding decisions in both demersal and pelagic fisheries, in particular when the catch composition consistently differs from the quota mix available to fishers, in some cases as a result of weaknesses in quota trading systems.

Deepwater trawl fisheries off the west coast of Ireland (Rockall Trough, Hatton Bank) targeting roundnose grenadier, blue ling and orange roughy have high discards of shark and grenadier. Discard rates vary between 31 and 90 percent depending on the fleet (French, Irish and Spanish fleets participate), target species and depth range.

Inshore bivalve dredge fisheries for scallop and razor recorded discard rates of 25 and 60 percent respectively, while Irish Sea *Nephrops* fisheries have similarly high discard rates to the North Sea fisheries.

Celtic Sea and French Atlantic fisheries

Almost 33 percent of the catch of the French trawler fleet operating in the Celtic Sea is discarded (Rochet, Péronnet and Trenkel, 2002), a total of 30 000 tonnes (data from 1997). Total discards by the French fleet fishing in ICES Areas VII and VIII are estimated (Melnychuk *et al*., 2001) to be approximately 150 000 tonnes or 18.7 percent of the total estimated catch (including discards) of over 820 000 tonnes.

Iberian fisheries

Spanish multispecies baca trawls discard 45 percent of the catch (Lart *et al*., 2002b) while the Spanish gillnet fisheries, hake longline and small pelagics purse-seine fisheries have discard rates in the 13–15 percent range. The Algarve[34] trawl fisheries discard over 35 000 tonnes, while the seine and encircling net fisheries discard approximately 40 000 tonnes. Particularly high discard rates are reported from the small Tagus estuary beam

[32] See ICES, 2000b for an inventory of studies on discards in the ICES area. Some studies address the economic aspects of discards.

[33] The SGDBI reports are available on the ICES Web site (www.ices.dk). See ICES, 2002 for a listing of the discard data tables by country, ICES area and major species. Additional information is required to make fishery-by-fishery estimates. Data referring to non-target species have not been compiled for several studies.

[34] See reports of the DISCALG and DISCARDS I projects, e.g. DISCALG 97/0087 *Análise das rejeições da pesca - sul de Portugal.*

trawl targeting sole and *Crangon* (90 percent) and the Algarve *Nephrops* and deepwater shrimp fishery (43–70 percent).

3.2.2 Mediterranean and Black Sea (Area 37)

Most of the information on discards in the Mediterranean is a result of a range of EC studies that focused on deepwater trawl fisheries (mainly targeting shrimp) and pelagic gillnet fisheries, which have an incidental catch of marine mammals and turtles. The discard database accounts for only 24 percent of the 1.5 million tonne nominal catch from the Mediterranean and Black Sea, reflecting a shortage of information on discards for Area 37. The trawl fisheries discard 20–70 percent of the catch, depending on depth. Average discard rates for these trawl fisheries are 45–50 percent. Most of the artisanal fisheries discard less than 15 percent of the catch, although little empirical information is available. The Mediterranean has relatively few trawl grounds, which contributes to a relatively low level of discards and a weighted discard rate of 4.9 percent. In many fisheries there are negligible discards, for example in Syrian trawl and artisanal fisheries and in many of the North African artisanal fisheries.

Other than for Turkey, no discard information from Black Sea countries was obtained. The anchovy purse-seine fishery has negligible discards since most fish is used for fishmeal. Midwater trawlers targeting sprat slip anchovy and other species (discard rate 5.1 percent). The sea snail dredge fishery has a discard rate of 11.5 percent while coastal encircling nets have a discard rate of 7.4 percent. Little information on discards in North African countries is recorded in the discard database,[35] although significant discards may occur in the shrimp trawl fishery of the Gulf of Gabes.

As there are no quota regimes (except for ICCAT species) in the Mediterranean, highgrading is negligible. There is also a market for small sizes of many species. The high number and dispersion of landing points makes MLS difficult to enforce and smaller unmarketable fish may be used either for autoconsumption or bait. Management measures such as the designation of no-trawl zones (e.g. Sea of Marmara, seagrass beds and areas of archaeological interest) help reduce discards in the Mediterranean.

3.2.3 North America – Atlantic (Areas 21, 31)

United States

Three important aspects of discards and bycatch management are illustrated in United States fisheries.[36] (The first two issues are addressed in subsequent sections.) These aspects are:

- the growing impact of the incidental catch of charismatic species in fisheries management and in trade;
- the emerging influence of civil society with regard to bycatch and incidental catch issues; and
- the importance of fishery management plans (FMPs).

Fishery management plans

Most federal fisheries operate under FMPs. These are funded management programmes agreed with stakeholders through regional fishery management councils. As the various fisheries (multispecies groundfish, halibut, salmon and crab/other crustacean) each take bycatch species targeted by other fisheries, the economic interests of the various stakeholders are crosslinked (Queirolo *et al.,* 1995). The Fishery Management Councils (FMCs), which are charged with preparing management plans, provide a forum to

[35] No search of Arabic publications was made and contacts with the relevant fisheries administrations were not fruitful.

[36] Substantial additional progress on bycatch management has recently been made in the United States while this report was going to press. For details see http://www.nmfs.noaa.gov/bycatch.htm/.

address numerous bycatch and discard issues within the context of the plans. Most of the information included in the discard database originated from federal sources and refers mainly to federal fisheries. Discards in fisheries under state jurisdiction are not well represented.

Several major North American fisheries have a high level of discards. Major sources of discards include the trawl and dredge fisheries of the Gulf of Maine and the northeastern United States. These include the silver hake trawl (discard rate 41.7 percent) and Atlantic scallop with important discards of yellowtail flounder. In contrast to flatfish trawl fisheries in European waters, fisheries for American plaice and witch flounder have comparatively low discard rates (8.7 and 18.8 percent respectively). Reductions in discards have occurred as a result of decreased trawl fishing effort and changes in target species in the area.

In more southerly Atlantic waters, the South Atlantic shrimp trawl fishery discards over 70 000 tonnes (discard rate 83.3 percent) while the Gulf of Mexico reef fish fishery has a rate of 44 percent. Discards in clam fisheries are not recorded in the discard database.

The Gulf of Mexico shrimp trawl fishery shows the highest discards of any single fishery in the database, discarding an estimated 480 000 tonnes of *Sciaenidae*, snappers, emperors and many other species. Numerous changes have occurred that have reduced bycatch in the fishery (NMFS/NOAA, 1998). TEDs have been obligatory for offshore vessels since before 1992 and for inshore vessels since 1995. BRDs have been used since 1998 and have been made obligatory west of 83°30' in 2003. Because of the impact of the fishery on turtles and juvenile red snapper, major studies have been carried out. Informed local sources can add significant precision to the discard estimate and trends for this important fishery.

Mexico

The Gulf of Mexico shrimp fisheries generate 19 000 tonnes of discards (discard rate 46.2 percent) and Pacific shrimp fisheries approximately 114 000 tonnes (discard rate 76.7 percent) (Bojorquez, 1998).

Canada[37]

The major discards occur in the scallop dredge fishery (23 000 tonnes, 20 percent discard rate), groundfish trawl (over 11 000 tonnes) and the lobster and crab pot fisheries (over 25 000 tonnes). Minor discards (9 percent) occur in the swordfish longline fishery. BRDs are used in many NAFO fisheries and NAFO has initiated work on a discard database. Substantial changes in the Canadian Atlantic fisheries and related regulatory framework are likely to have resulted in significant reductions in discards in recent years. As in United States waters the changes include a reduction in trawl effort and changes in target species from finfish to crustaceans.

3.2.4 North America – Pacific (Areas 67, 77)

Canada

The British Columbia Pacific hake demersal trawl generates discards of arrowtooth flounder, dogfish and ratfish in the order of 9 000 tonnes (discard rate 8.9 percent). The shrimp beam trawl fishery has a considerably higher discard rate (29.1 percent) than the shrimp otter trawl fishery (7.8 percent). Discards in herring and salmon fisheries have not been recorded in the discard database.

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[37] Information on Canadian Atlantic fisheries is largely derived from the pre-1996 period (Duthie, 1997b) and to a lesser extent from more recent NAFO sources. Current studies (R. Forrest, pers. comm.) will provide more accurate and up-to- date estimates.

United States

The multispecies groundfish trawl fishery of the Pacific states (Washington, Oregon, California) produces major discards of over 130 000 tonnes with a discard rate of 44 percent (Northwest Fisheries Science Center, 2003). The nearshore shrimp fishery discards approximately 20 000 tonnes and has a similar discard rate. California's gillnet fisheries have substantial incidental catches of common mure, pinnipeds and cetaceans. The vast majority of dolphins caught in the tuna purse-seine fishery are released alive.

The United States Northwest Pacific (Alaska) fisheries, which previously accounted for a substantial proportion of global discards, have experienced a significant decline in discards. Discards in the combined Bering Sea Aleutian Islands/Gulf of Alaska (BSAI/GOA) groundfish fisheries declined from 307 000 tonnes (14 percent) in 1995[38] to less than 140 000 tonnes[39] (7.3 percent)[40] in 2002. Many fish previously discarded are now the raw material for surimi. In the mid-1990s offal discharges made up almost 60 percent of "total" catch, representing a major energy shunt or transfer in the ecosystem. In 1995, the crab pot fisheries discarded over 40 000 tonnes (44.1 percent).[41] These discards are mainly regulatory, in response to species quota, minimum size and other regulations. As already noted, many of the United States non-federal fisheries (i.e. under state jurisdiction) are not represented in the discard database (or in the United States Bycatch Matrix) and important scallop, salmon and herring fisheries in Area 67 contribute additional discards that are not recorded in the database.

In these Northwest Pacific fisheries, bycatch limits, area closures and other prohibited-species bycatch mitigation measures serve to limit discards and total fleet capacity, and trawl effort has declined. However, some of these measures have also created barriers to harvesting groundfish total-allowable-catch amounts, and have generated allocative controversy among harvesters of species taken as bycatch in the groundfish fisheries. Consequently, comprehensive information on bycatch and discards is required to prepare management plans for these fisheries, which means that these fisheries must have a high level of observer coverage (in some cases 100 percent). In the BSAI/GOA fishery administrators maintain complete records of bycatch and discards. These records are updated weekly on the Alaska NMFS Web site to ensure transparency and assist operators in planning their fisheries activities. Fisheries are closed when bycatch limits are reached. The management of bycatch and discards in this important fishery is further discussed in Annex A.6.1.

3.2.5 Central and South America (Areas 31, 41, 77, 87)

Central America

The shrimp trawl fisheries in Central America generally have high discard rates. TEDs are used in most shrimp fisheries in order to comply with United States import requirements. Government and private sector initiatives to utilize the bycatch have met with mixed results and could be the subject of a comparative analysis to help determine effective utilization strategies. Artisanal fisheries and pot fisheries have low to negligible discard rates.

Caribbean

With the exception of Cuba the shrimp trawl fisheries (e.g. in Haiti and Trinidad and Tobago) all have high discard rates (70–90 percent in the case of Trinidad and Tobago). In

[38] From the United States Bycatch Matrix in *Managing the Nation's Bycatch* (NMFS/NOAA, 1998a).

[39] NMFS/Alaska Fisheries Weekly Production and Observer Reports to 31 December 2002 indicate total discards of 138 000 tonnes for 2002 (excluding weights of protected species discards).

[40] The discard rate refers to 2001 (Fish Information & Services, 2003). Protected species (crab, salmon) numbers were converted to weights using average weights obtained from the National Marine Fisheries Service (NMFS) to give total discards of 148 000 tonnes in 2001.

[41] 1995 data calculated from the United States Bycatch Matrix (NMFS/NOAA, 1998a).

Cuba the entire catch is landed, either for human consumption or reduction to fishmeal. The fisheries of the small island states are considered to have zero discard rates.

Northeast South America
The Guianas shelf supports important shrimp trawl fisheries, which have high discard rates, despite long-standing attention to the bycatch issue (Allsopp, 1982). Artisanal and industrial shrimp trawler fleets that fish from Venezuela to northern Brazil targeting penaeid shrimps and seabob (*Xiphopenaeus kroyeri*) have an average discard rate in excess of 70 percent. The high discards may be partly attributable to the distance of the fishing grounds from markets and poor demand for the discarded species. These fisheries have an aggregate discard of approximately 220 000 tonnes.

Area 41 (Brazil, Uruguay, Argentina and the Falkland Islands [Malvinas])
Trawl fisheries off central and southern Brazil have discard rates in the 22–33 percent range. Uruguayan trawl fisheries for hake and *Corvina* have even lower discard rates (9–18 percent). Argentina's hake trawl fisheries are a major contributor to global discards, discarding almost 150 000 tonnes (discard rate 24 percent) in the mid-1990s (Dato, Villarino and Cañete, 2000). The shrimp beam trawl fishery (discard rate 50 percent) discards substantial quantities of juvenile hake, and the Patagonian scallop dredge fishery and other clam fisheries are also considered to have high discards. In contrast, the important squid (jig and trawl) and pelagic fisheries for southern blue whiting have low discards.

Chile and Peru
Chile harvests an average (1992–2001) of 5 million tonnes of small pelagics, over 330 000 of hake and other demersal finfish and approximately 100 000 tonnes of invertebrates. Fisheries for small pelagics have a low discard rate and account for under 40 000 tonnes of discards while the hake fisheries account for approximately 42 000 tonnes of discards for catches of over 300 000 tonnes (12.5 percent discard rate in the trawl fisheries). Peru shows a similar pattern of discards, although a higher discard rate in the small pelagic fisheries (average nominal catch of 8 million tonnes, 1992–2001) generates discards of 260 000 tonnes. The shrimp trawl fishery (discard rate 81 percent) and the hake fishery also have substantial discards (74 000 and 15 000 tonnes respectively).

3.2.6 Africa and the Red Sea (Areas 34, 47, 51)
The artisanal fisheries are considered to have low or negligible discards unless information to the contrary is available. The substantial post-harvest losses incurred in African artisanal fisheries are not included in the discard database.

A high level of observer coverage in the licensed distant water fleets and on national flag vessels provides a considerable volume of information on discards in industrial fisheries. A number of countries have 100 percent observer coverage for certain fleets and Namibia places two observers on certain vessels. The primary focus of these observers, many of whom have only rudimentary scientific training, is usually on establishing the quantity and composition of the retained catch. Information on discards is not always collected, or collected in a systematic manner. Even when available, the information is not necessarily compiled and analysed. Despite the considerable effort and costs associated with the observer programmes, observer reports do not tend to be fully exploited, partly because of staff and funding shortages in the research institutes, or because these reports are retained by the enforcement agency and not accessed by the researchers.

Area 34 (Morocco to Angola)
Discard rates vary widely. The Moroccan cephalopod trawl fishery discards up to 45 percent of the total catch. The discard rate for the foreign deepwater shrimp fleet

in Mauritania is over 80 percent and 63 percent for a similar fishery in Senegal. An increasing quantity of finfish bycatch of Senegal's shallow-water trawl fisheries is being directed to African urban markets, reducing discards to approximately 34 percent. The industrial shrimp trawl fishery in Guinea-Bissau discards 87 percent of the catch, while in neighbouring Guinea the rate is 33 percent, reflecting the relative importance of local purchasing power and processing capacity with respect to bycatch. Trawlers in Sierra Leone are obliged to land bycatch for local consumption, which reduces discards. Trawl fisheries in Ghana, Nigeria and Cameroon have low discard rates since there is extensive collection at sea. Because of high demand for fish products and high coastal populations in many areas, discards in the artisanal fisheries are negligible.

Area 47 (Angola to South Africa)
Demersal finfish and shrimp trawl fisheries in Angola are understood to generate significant discards. Pending legislation will require increased landings of bycatch. Namibia has a "no-discards" policy that prohibits discarding of marketable fish, i.e. discards of non-marketable species may be permissible. The hake and monkfish trawl fisheries have discards in the 5 to 15 percent range. South Africa prohibits discarding in the hake and sole fisheries and has a progressive bycatch management approach. Bycatch quotas in the horse mackerel fishery have resulted in pilchard and anchovy discards in the order of 30 000 tonnes in the past and the hake trawl fishery has a similar quantity of discards. The south coast trawl fisheries targeting hake, sole and monkfish have discard rates ranging from 4.1 to 19.2 percent. The highest discard rate (70 percent) is recorded from the KwaZulu–Natal shallow-water prawn trawl fishery.

Area 51 (East Africa and the Red Sea)
Madagascar's industrial shrimp trawl fisheries discard over 30 000 tonnes (72 percent discard rate). Approximately 23 percent of Mozambique's shrimp trawl bycatch is landed with over 23 000 tonnes discarded (60 percent discard rate). In the United Republic of Tanzania's shrimp fishery, fishing is permitted only during daylight hours. A discard ban is poorly enforced and about 78 percent of the catch is discarded. A similar daylight regime has been introduced in Kenya. It is complemented by an inshore closed area and most previously discarded species are now sea-frozen and landed for human consumption. No discard information is available for Somalia, although trawlers fishing close inshore are known to impact on the hard corals. Discards in the East African artisanal fisheries are negligible. Fisheries in the Comoros, Mauritius and Seychelles have low to negligible discards.

Discards in most Red Sea artisanal fisheries are also negligible. In Djibouti, even fish heavily damaged by sharks are retained for sale. Discards in the trawl fisheries are relatively small as the lower value fish (lizard fish and threadfin bream) find ready markets in Egypt. Eritrea, which operates a 100 percent observer coverage, calculates the royalties for the foreign trawl fleet on the value of the total estimated catch, whether discarded or not. The Egyptian finfish trawlers discard an estimated 20 percent of their total catch in Eritrean waters.

3.2.7 South and Southeast Asia (Areas 51, 57, 71)

With the exception of the shrimp trawl fisheries, discards in the northern part of Area 51 (Yemen to Pakistan) are low. Aggregate discards from the shrimp fisheries (Saudi Arabia, Kuwait, the Islamic Republic of Iran, Bahrain and Pakistan) total approximately 100 000 tonnes.

National authorities[42] and experts indicate that discards in many countries in South Asia and Southeast Asia are low or negligible. These countries include Sri Lanka,

[42] Pers. comm. with fisheries authorities, 2003.

India, Myanmar, Thailand, Malaysia, Cambodia and Viet Nam. A recent workshop[43] on discards and bycatch identified three factors, which differentiate the fisheries of the region from most temperate fisheries:

- dominated by small-scale fisheries with most fishing operations lasting less than a week;
- multispecies nature of the fisheries with fishers depending on many different species; and
- inherent flexibility of the markets based on a long tradition of consuming a wide variety of fish and fish products.

The workshop considered that discards for many countries and fisheries in the region were low or negligible and suggested that rather than endeavouring to obtain accurate discard estimates at high cost, efforts should concentrate on measures to avoid catches of juveniles and less marketable species.

Trawl fisheries tend to dominate in the shallow seas of the Southeast Asia region. In many areas, the fisheries are overexploited and almost all of the catch is landed and used. The lower value portion of landings that are deemed fit for human consumption is used for dried fish, surimi, fish balls, fish sauce and a range of traditional and new fish products. The remainder is used for animal and fish feed. With some notable exceptions, the fisheries in the region have been assigned a discard rate of 1 percent.

India

Shrimp freezer trawlers operating offshore from Visakapatnam on the eastern coast of India had relatively high discards in the early 1990s. However, this fleet has almost disappeared and current discards are low or negligible. Discards are considered to be negligible in traditional fisheries and very low in motorized fisheries. The reasons for the decline in discards are similar to many other countries in South and Southeast Asia:

- overfishing, particularly in inshore and coastal waters;
- rising demand as a result of population increase, rising urban incomes and export of better quality fish;
- poverty leading to consumption of lower value food fish;
- product development, e.g. production of surimi[44] and fish sauce; and
- increased production of fishmeal and animal and fish feed.

Bangladesh and Myanmar

Discard rates in the order of 80 percent lead to discards of over 50 000 tonnes in Bangladesh's industrial shrimp and finfish trawl fisheries while estuarine pushnets collecting penaeid larvae discard 90 percent of the catch. Myanmar's trawl fisheries discard approximately 20 000 tonnes. Increasing quantities of fish are being exported overland from Myanmar to feed the growing demand in southeastern China. Any move towards intensive shrimp aquaculture in Myanmar is likely to reduce discards further.

Indonesia

With the notable exception of the Arafura Sea shrimp trawl fishery most Southeast Asian fisheries have been accorded a discard rate of 1 percent. While some discarding undoubtedly takes place, the volumes are so low as to be considered insignificant

[43] International Workshop on the Estimation of Discards and Measures to Reduce Bycatch in the Indian Ocean and Western Pacific, Samut Prakan, Thailand, 2003. Global Environment Facility (GEF)/FAO/ Southeast Asian Fisheries Development Centre (SEAFDEC) (unpublished internal FAO report). The workshop was held under the auspices of the GEF shrimp bycatch project (FAO, 2003a).

[44] Improvement in technology is enabling surimi production from shrimp bycatch (IMPEDA [India Commerce Authority]), pers. comm.

by most experts from the region. The Arafura Sea shrimp trawl fishery discards over 80 percent of the total catch, in the order of 230 000 tonnes per year (National Committee for Reducing the Impact of Tropical Shrimp Trawling in the Arafura Sea, 2001). Despite the introduction of BRDs total discards remain high; a consequence of weak enforcement of regulations and lack of local markets for the bycatch, since the fishery is prosecuted at considerable distance from major population centres. Approximately 76 percent of Indonesia's nominal catch originates from Area 71.

Gulf of Thailand countries and Viet Nam

An arbitrary discard rate of 1 percent was assigned to the fisheries of Thailand, Malaysia and Cambodia, which are considered to generate combined discards of under 50 000 tonnes. Similarly, the fisheries of Viet Nam are considered to have insignificant discards. Recent (internal) estimates of the country's marine catch are substantially in excess of Fishstat values. Fishstat assigns all Vietnamese catches to Area 71 although the Area 71/Area 61 boundary bisects Viet Nam.

Philippines and the South China Sea

Philippine inshore shrimp and finfish trawl fisheries have high discard rates. Industrial and "baby" trawl fisheries in Sorsogon and San Miguel bays have discard rates ranging from 19 to 85 percent. In the case of the San Miguel Bay fisheries, 91 percent of the discards are jellyfish. Trawl fisheries in Brunei Darussalam discard 74 percent of the catch, reflecting the greater purchasing power of the population and the lack of markets for lower valued species.

3.2.8 East Asia and the Northwest Pacific (Area 61)

China

Discards are low or negligible in almost all Chinese fisheries.[45] Essentially there are no bycatch species since all species are target species. Some discarding is known to occur in trawl fisheries which are prosecuted at considerable distance from the port of landing, e.g. Chinese trawlers operating in the South China Sea. However, discard rates are considered to be relatively low and no quantitative information was located during the study. Closed seasons are in force to reduce catches of juveniles in certain fisheries. No information has been obtained on discards in Taiwan Province of China. Fishstat data indicate that 98 percent of Chinese nominal catches originate from Area 61. The low to negligible discard rate in Chinese fisheries, which produce approximately 12 million tonnes, or over 14 percent of the global nominal catch (average 1992–2001), tends to skew the global discard rate downwards.

Japan

Landings of over 6 million tonnes generate discards of more than 0.9 million tonnes, an average discard rate of 14.2 percent. Fisheries with high discards include a diverse group of small coastal trawlers, the boat-seine fishery (including *gochi-ami*), and tuna longline fisheries. Estimates prepared for the 1996 workshop (Matsuoka, 1997) were transferred unchanged to the discard database. Although it is acknowledged that some changes have occurred in these fisheries since the estimates were made, changes in the fishery-by-fishery breakdown of Japanese catch statistics preclude direct transposition to the most recent Japanese catch statistics.[46]

No information has been located on discards in the Democratic Republic of Korea and the Republic of Korea. Because of the severe food deficits in the former country discards are assumed to be negligible.

[45] Ministry of Agriculture, pers. comm. (November 2003).
[46] The best available information is that in FAO Fisheries Report No. 547. Matsuoka, pers. comm., 2003.

Russian Far East

Characterization of fisheries in the Russian Far East has been based on a combination of sources and in particular the information relating to quota allocation and use provided by the Russian Federal Research Institute of Fisheries and Oceanography (VNIRO) and that reported in Russian trade publications.[47] Information on discards in the fisheries of the Russian Far East has proved particularly difficult to obtain and no estimates are included in the discard database. VNIRO[48] has not collected discard information since the disintegration of the Soviet Union. Regulations on discards are reported to be poorly enforced. The newer generation of processor trawlers makes full use of catches, but filleting machinery on older smaller trawlers in the Alaska pollock fishery is not fully adapted to handle smaller Alaska pollock and discards may be over 45 percent in some parts of the fishery (Norinov, 2003). Catches of Alaska pollock have declined progressively from over 2 million tonnes in the mid-1990s to under 1 million tonnes in 2002. The other important components of the catch include Pacific herring, flounder, Pacific cod, squid and crab. Current discards in the Russian Far East fisheries may be similar to those in the Eastern Bering Sea in the mid-1990s, which would mean that approximately 200 000 tonnes might be discarded.

3.2.9 Oceania and Australia (Areas 57, 71, 77, 81)

Pacific Islands

Discard levels are considered to be insignificant in this region. The South Pacific islands' coastal commercial, subsistence and artisanal fisheries were allocated[49] a discard rate of 0.5 percent. Discarded species include puffer fish, porcupine fish, "ciguatera" fish[50] and sea snakes. The pole and line fleets may discard small quantities of baitfish, rainbow runner and similar non-tuna species. A shrimp trawl fishery in the Gulf of Papua (Papua New Guinea) has substantial discards.

Australia

Most of the larger "offshore" fisheries are managed by the Australian Commonwealth, while most of the coastal and inshore fisheries fall under the jurisdiction of the Australian states or territories. Progressive Commonwealth bycatch management policy and programmes make the Australian fisheries of particular interest (Australian Fisheries Management Authority, 2000). The overarching objective of the policy is to ensure that bycatch species and populations are maintained and that fisheries are ecologically sustainable through bycatch reduction, improved protection of vulnerable/threatened species and minimizing adverse impacts of fishing on the marine environment.

Bycatch action plans[51] have been completed for the following fisheries managed by the Australian Fisheries Management Authority:

- Australia's tuna and billfish fisheries
- Bass Strait central zone scallop fishery
- Great Australian Bight trawl fishery
- Northern prawn fishery
- Southeast non-trawl fishery
- Southeast trawl fishery
- Southern shark fishery
- Southern squid jig fishery
- Sub-Antarctic fisheries (Macquarie Island fishery and Heard Island and McDonald Islands fishery)
- Torres Strait prawn fishery

[47] See Russian Fisheries Report, 2003; Vaisman, 2002; and documents relating to the Convention on the Conservation and Management of Pollock Resources of the Central Bering Sea.

[48] Director of VNIRO, pers. comm. (2003).

[49] Based on authors' experience; Adams (SPC), Gillett (Fiji) and Wright (South Pacific Regional Environment Programme [SPREP]), pers. comm.

[50] Fishing in areas known for "ciguatera" is usually either prohibited or avoided in the South Pacific, the Caribbean and parts of the Indian Ocean.

[51] See http://www.afma.gov.au/.

These action plans are of particular interest in relation to TEDs, BRDs and mitigation measures for seabirds in longline fisheries and are further discussed in Section 4.4.1. Environmental impact assessments are also required in Australia for fisheries from which products are exported.

Three northern shrimp fisheries, northern prawn (Gulf of Carpentaria), Torres Strait and Queensland trawl fisheries jointly discard approximately 80 000 tonnes. The southeast trawl fisheries targeting redfish, tiger flathead, orange roughy and blue grenadier discard approximately 17 000 tonnes with discard rates of 45 and 10 percent for the east and west fisheries respectively. The New South Wales (NSW) oceanic prawn has a high discard rate (88.7 percent) generating approximately 16 000 tonnes of discards. Experiments have demonstrated that the use of BRDs results in a reduction of up to 90 percent in unwanted bycatch in the NSW prawn fisheries and that square mesh panels can be selective for larger prawns (Broadhurst, 2003). BRDs are now mandatory in inshore/estuarine prawn fisheries. Progressive implementation of bycatch action plans is likely to reduce the discards and discard rates presented above. Several smaller fisheries also have high discard rates, e.g. NSW beach seine (58 percent) and the NSW ocean haul (38 percent).

Discards in New Zealand fisheries have not been recorded in the discard database.

3.2.10 Antarctic and the CCAMLR area (Areas 48, 58, 88)

The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) implements an ecosystem-based approach to manage both commercial fisheries and other living marine resources. While this approach imposes obligations on members to record bycatch, the records cannot readily be converted to discard rates by fishery (CCAMLR, 2002a). A major focus of CCAMLR work is the mitigation of incidental catch and, through observer programmes, the close monitoring of seabird and marine mammal mortalities (see Section 4.2.3).

Krill fishery

Fisheries operators reportedly avoid areas where there is likely to be a contaminating catch of fish[52] and large krill aggregations tend to be monospecific (Nicol and Endo, 1997; Sobrino Yraola, Giráldez Navas and Millán Merello, 1987). Vessels also move to avoid concentrations of salps (pelagic tunicates). Discard information is being collected by CCAMLR.

Toothfish fishery

The toothfish longline fishery generates the vast majority of the 2 000 tonnes of discards (discard rate 20 percent). A Chilean experimental pot fishery for toothfish discards approximately 60 percent of the catch. The discards mainly comprise crab (*P. spinosissima*). Discards in the trawl fishery are understood to be low while mitigation measures are in place to reduce bycatch mortalities of rajids and *Macrourus* sp. that comprise approximately 20 percent of the longline catch. A German trawl survey (Kock *et al*., 2002)[53] around Elephant Island demonstrated that changes in trawl rigging resulted in a sixfold reduction in bycatch of benthos without affecting the catch rate of the commercial species.

3.3 DISCARDS IN SELECTED FISHERIES

The fisheries have been grouped and analysed by gear type and target species. There is very great diversity within a group and considerable caution must be exercised

[52] Research cruises of the FV *Niitaka Maru* found fish bycatch in 41 out of 103 trawl catches. Predominant species were *Lepidonotothen larseni, Pleuragramma antarcticum* and *Champsocephalus gunnari* . There was a negative correlation between bycatch of fish and the krill catch per unit effort (CPUE).

[53] Cited in CCAMLR, 2002a.

in generalizing discard rates by fishery. For example, in some tropical shrimp trawl fisheries the use of TEDs and BRDs is strictly enforced, while in others fishing is only permitted during daylight hours, and many fisheries that target shrimp also target other finfish or cephalopods. This diversity is shown by presenting both average discard rates and the respective standard deviations for the subsets of discard database records, for which the discard rate is available.[54] The weighted (pooled) discard rate better reflects the quantitative importance of discards in such types of fisheries at a global level. Thus both average and weighted discard rates are presented for many fisheries.

3.3.1 Shrimp trawl fisheries

The discard database indicates that shrimp trawl fisheries, and tropical shrimp fisheries in particular, are the single greatest source of discards, accounting for 27.3 percent (1.86 million tonnes) of estimated total discards (see Table 8). The aggregate or weighted discard rate for all shrimp trawl fisheries is 62.3 percent.[55] These fisheries[56] have consistently high discard rates deriving from a range of factors.

- Shrimp is often less than 20 percent of the demersal biomass on many shrimp fishing grounds.
- The relatively small mesh size required to capture shrimp inevitably results in large quantities of bycatch.
- Vessels are designed for shrimp retention and have limited freezing and hold capacity for bycatch.
- Transhipment at sea is often discouraged by vessel owners or prohibited by authorities because of concerns about theft, or illegal/unrecorded transhipment.
- The shrimp grounds are often at a considerable distance from the markets for bycatch, rendering its retention and transport to market uneconomical.
- Bycatch species are often of small size and their relatively low value makes bycatch retention uneconomical.
- Enforcement of regulations on minimum landings of bycatch and on discard reduction may be deficient.

The global average (1992–2001) annual nominal catch of shrimp is 2.5 million tonnes (excluding *Nephrops* and other "langoustine"), of which the penaeid shrimp catch is over 1 million tonnes, the vast majority being harvested by trawlers. However, increases in the global nominal catch of shrimp in recent years to approximately 3 million tonnes means that the total quantity of discards may have increased by 10 to15 percent.

TABLE 7
Frequency distribution of discard rates in shrimp trawl fisheries

Range of discard rates (%)	Number of records: tropical industrial shrimp fisheries	Number of records: all shrimp fisheries
< 20	9	20
20–40	6	13
40–60	10	21
60–80	23	28
> 80	10	15
Total number of records	58	97

Note: includes five records of semi-industrial shrimp trawl fisheries. Tropical shrimp refers to penaeid shrimp.
Source: discard database.

[54] The corresponding information on catch and discard quantities is not available for all such records.
[55] This calculation excludes Chinese fisheries.
[56] For a review of bycatch in shrimp fisheries see Andrew and Pepperell, 1992; FAO, 2001a.

TABLE 8
Discard rates and discards in shrimp trawl fisheries

Shrimp trawl fisheries	Discard rate for set of all records[1] with a discard rate			Discard rate and discards for set of complete records (records with landings, discards, discard rate)					
	Average discard rate *(%)*	No. records	Standard deviation	Average discard rate *(%)*	No. records	Standard deviation	Landings (tonnes)[2]	Discards (tonnes)	Weighted discard rate[3] *(%)*
Column	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9 [8/(8+7)]**
Coldwater shrimp, various (South America, North Sea)	44.0	7	0.34	44.0		0.34	77 060	123 125	61.5
Crangon (Belgium)	83.3	1							
Deepwater shrimp, various[4]	67.7	4	0.35	43.8	2	0.28	4 403	1 697	27.8
Deepwater shrimp, Mediterranean	39.2	3	0.09						
Nephrops	50.1	7	0.13	45.2	5	0.37	14 722	10 954	42.7
Nephrops and deepwater shrimp, Mediterranean	56.5	4	0.16	70.0	2	0.12	11 086	70 000	86.3
Nephrops and deepwater shrimp, not Mediterranean	31.0	4	0.13						
Pandalus	11.6	9	0.17	11.6	9	0.17	235 966	13 512	5.4
Aggregate coldwater and deepwater					**18**		**343 237**	**219 287**	**39.0**
Tropical shrimp[5]	55.8	58	0.27	58.2	52	0.25	783 030	1 645 777	67.8
All shrimp trawl fisheries		**97**			**77**		**1 126 267**	**1 865 064**	**62.3**

[1] Records used to compile this table exclude China as catches/landings attributable to targeted shrimp trawling could not be clearly identified.
[2] Landings include landings of bycatch.
[3] The weighted discard rate (column 9) is considered to be the most accurate and representative at a global level
[4] Includes deepwater non-penaeid trawl fisheries in tropical areas, e.g. Aristaeidae, Solenoceridae.
[5] Almost exclusively penaeid shrimp fisheries.
Source: discard database.

Tropical shallow water shrimp fisheries

These fisheries[57] account for 70 percent of total estimated discards from shrimp trawl fisheries. Almost all of these fisheries target penaeid shrimps. They have an average discard rate of 55.8 percent, but the standard deviation of 0.27 (see Table 8) indicates a relatively wide range of discard rates. The weighted discard rate of 67.8 percent is substantially higher than the average, reflecting discards of 1.6 million tonnes for landings of 0.78 million tonnes recorded in the discard database.

Three countries, China, India and Thailand, all with low or negligible discard rates, account for over half of the penaeid shrimp catch. Most shrimp trawl fisheries in South and Southeast Asia have insignificant discards with the notable exception of the Arafura Sea shrimp fishery. This fishery, shrimp fisheries in the Gulf of Mexico, Atlantic United States, Ecuador and on the Guianas shelf account for a large proportion of discards from tropical shrimp fisheries (see Annex A.2.1, Table 15). Several smaller shrimp fisheries have discard rates in excess of 80 percent. These include the Kuwait, French Guiana, Panama and Suriname fisheries. This study suggests a much lower level of discards in present-day tropical shrimp fisheries than previously estimated (Teutscher, 1999), which is one of the major contributing factors to a lower global discard estimate.

An extensive mix of species are discarded, including jellyfish, lizard fish, threadfin bream and juveniles of many commercial whitefish species such as croakers, snappers and emperors, which may be the target species of other fisheries.

Artisanal shrimp fisheries

Most records of artisanal penaeid shrimp fisheries indicated a negligible discard rate. However, there are many exceptions, particularly when trawl, pushnets or similar gears are used, e.g. San Miguel Bay baby trawl (25 percent discard rate), the Brazilian north coast and the Trinidad and Tobago artisanal shrimp fisheries. Many small-scale shrimp trawlers are motorized and some freeze the product on board. It is becoming increasingly difficult to distinguish between small-scale and industrial shrimp fishing vessels.

Coldwater shrimp and prawn

The coldwater shrimp trawl fisheries exhibit an even greater variety than the tropical shrimp in terms of fishing gears, fishing depths and substrates. In aggregate these fisheries have a weighted discard rate of 39 percent and contribute approximately 220 000 tonnes to the global discard estimate (see Table 8). The highest recorded discards occur in Peru's fishery (74 000 tonnes with a discard rate of 81 percent).

Many of the deepwater shrimp fisheries are located on the slopes of the continental shelves (100–600 m depth) in both tropical and temperate regions. In the Mediterranean and North Atlantic many of these trawlers also target *Nephrops*. Most of the discard database records are from the Mediterranean and North Atlantic and indicate a high level of discards (20–94 percent). The deepwater shrimp fisheries contribute over 70 000 tonnes to the global discard estimate. The main discards[58] include small sharks (dogfish), rays, hake and blue whiting.

The fisheries for Pandalidae (*Pandalus, Heterocarpus* sp.) concentrated in the North Atlantic (Canada, Norway, Iceland) account for approximately 13 000 tonnes of discards. The mandatory use of Nordmore grids and other BRDs in most of these fisheries results in a relatively low discard rate (weighted discard rate of 5.4 percent). There are no records in the discard database for the North Pacific fisheries.

[57] The average (1992–2001) world catch of penaeids is 1.1 million tonnes (Fishstat Plus, version 2.3). However, an additional catch of 0.5 million tonnes of "other" shrimps is reported, at least some of which is penaeid shrimp. Global catches of both tropical and coldwater shrimps have tended to increase in recent years.

[58] 170 taxa were represented in the discards of the Straits of Sicily fishery (Castriota, Campagnuolo and Andaloro, 2001).

The weighted discard rate for discard database records of *Nephrops* trawl fisheries[59] is 43 percent for a total discard estimate of approximately 11 000 tonnes. In the North Atlantic (North Sea and Irish Sea), discards from *Nephrops* fisheries comprise whiting, haddock, starry ray and broken/undersized *Nephrops* and flatfish. The high discards of juvenile whiting and haddock have been of particular concern to fishery managers. Obligatory use of square mesh panels for these fisheries in the waters of EU member states has resulted in substantial decreases in discards. Continued progress with gear selectivity and improved compliance with regulations are likely to reduce discards further.

The Belgian *Crangon* beam trawl fishery has a discard rate of 83 percent. There are no records in the discard database that refer to fisheries for the important sergestid shrimps (21 percent of the global nominal catch), which have both a tropical and coldwater distribution.

Turtle excluder devices (TEDs)

The use of TEDs appears to have little impact on the level of discards. Penaeid shrimp fisheries in which use of TEDs is mandatory account for over 700 000 tonnes of discards with a weighted discard rate of 75 percent (range 0–79 percent).

Bycatch reduction devices (BRDs)

BRDs are used in a wide range of shrimp fisheries with apparent discard reductions in *Pandalus* fisheries (0.2–29 percent discards), less impact in other coldwater fisheries for *Nephrops* and other species (44–50 percent discards) and even less impact in tropical fisheries (67–89 percent discards). The low impact in some tropical fisheries may be a result of poor enforcement of BRD regulations, since experimental results clearly indicate significant reductions in unwanted bycatch. Shrimp fisheries in which BRDs are mandatory accounted for almost 0.4 million tonnes of discards (weighted discard rate of 62.8 percent). Although the discard database contains few details of catch and discards in *Pandalus* fisheries, the extensive and compulsory use[60] of Nordmore grids and similar BRDs has reduced bycatch to less than 5 percent in many *Pandalus* fisheries. Additional work is necessary to interpret and include additional information, particularly from the ICES and NAFO areas, from Australia and from the Gulf of Mexico.

There is clear evidence of bycatch reduction through the use of BRDs, in particular in Australian and United States penaeid trawl fisheries. However, the use of BRDs is not widespread in developing countries.[61] Reduction in discards is more likely to arise from increased utilization of bycatch, rather than reduction of bycatch. Many shrimp trawl fisheries in developing countries are marginally profitable and any reduction in shrimp catch through the use of BRDs may result in significant economic losses.

Trends

There are major differences between the reasons for discard reductions in the tropical and temperate water shrimp fisheries. The tropical fisheries are located in the waters of developing countries with a high demand for lower value bycatch fish, either for human consumption or animal feed. In social and economic terms the total commercial biomass extracted may be more important than shrimp biomass, i.e. the unstated fishery management objective is to maximize the catch, irrespective of the species composition.

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[59] *Nephrops* vessels may land substantial quantities (>50 percent of landings) of bycatch species. Some EU *Nephrops* fisheries may be uneconomical without the bycatch revenue, such that the definition of the target species may be questionable.

[60] For example, in Norway, Svalbard, Barents Sea, Greenland and Canadian shrimp fisheries.

[61] An important GEF/United Nations Environment Programme (UNEP)-funded project, "Reducing the impact of tropical shrimp trawling fisheries on living marine resources through the adoption of environmentally friendly techniques and practices", is addressing this issue. Kenya has recently made BRDs mandatory in its penaeid shrimp trawl fishery.

TABLE 9
Discard rates and discards in non-shrimp trawl fisheries

Non-shrimp trawl fisheries[1]	Discard rate for set of all records with a discard rate			Discard rate and discards for set of complete records(records with landings, discards, discard rate)					
	Average discard rate *(%)*	No. records	Standard deviation	Average discard rate *(%)*	No. records	Standard deviation	Landings (tonnes)[4]	Discards (tonnes)	Weighted discard rate[2] *(%)*
Column	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9 [8/(8+7)]**
Demersal finfish[3]	20.80	102	0.17	18.60	63	0.16	3 182 715	775 396	19.60
Flatfish[4]	39.30	24	0.22	36.10	19	0.21	355 048	401 268	53.1
Other trawl fisheries		8	n.a.		7		900 628	258 570	n.a.
Midwater[5]	8.60	45	0.13	10.00	34	0.15	4 165 807	152 959	3.50
Demersal multispecies[6]	11.30	19	0.21	6.90	16	0.18	12 149 328	131 682	1.10
Deepwater[7]	33.80	9	0.29	32.50	6	0.37	56 899	37 276	39.60
Cephalopod	24.80	6	0.16	18.50	4	0.16	117 404	34 612	22.80
Fishmeal[8]	0.80	8	0.01	0.80	8	0.01	1 244 300	9 296	0.70
Total	**19.1**	**221**		**16.9**	**157**	**0.20**	**22 172 129**	**1 801 059**	**7.5**
Hake trawlers (ice and freezer)[9]				20.4	14	0.17	1 008 201	144 423	12.5
Factory trawlers				28.8	16	0.19	845 863	90 328	9.6
Beam trawl				34.6	5	0.35	173 290	399 068	69.7

[1] The fisheries are sorted on the basis of the primary target species. Additional details are provided in Annex A.
[2] The weighted discard rate is considered to be the most accurate and representative at a global level.
[3] Demersal finfish are fisheries primarily targeting roundfish for human consumption.
[4] Flatfish fisheries include beam trawl fisheries.
[5] Midwater trawl fisheries include some fisheries that harvest for both fishmeal and human consumption and include a large proportion of the Alaska pollock fishery.
[6] Demersal multispecies means that both finfish and shellfish are targeted. The reason for the low discard rate is because of the inclusion of Chinese and Southeast Asian trawl fisheries in this group.
[7] Deepwater fisheries include those targeting orange roughy, *Coryphaenoides* and *Molva* species.
[8] Fishmeal fisheries are those specifically targeting small pelagics for fishmeal.
[9] The hake, factory trawler and beam trawl values are presented separately. The reported landings and discards from these fisheries are already weighted in the total in the preceding line.

Source: discard database.

In contrast, the total biomass harvested in the temperate water shrimp fisheries is likely to be reducing as a result of the introduction of square mesh panels, BRDs and other measures. Overfishing of whitefish and the higher price of shrimp encourages fishers increasingly to target shrimp, while the intricate predator-prey relationships between crustacea and finfish further complicate management of many interrelated fisheries (e.g. NAFO area, Barents Sea and North Sea).

3.3.2 Non-shrimp trawl fisheries

The analysis distinguishes between a number of non-shrimp trawl fisheries, each of which is discussed in more detail below and summarized in Table 9. These fisheries, operating in 49 countries, include:

- demersal finfish trawl, primarily targeting roundfish;
- flatfish (e.g. plaice, sole, flounder) trawl fisheries, including several beam trawl fisheries;
- hake trawl (both ice and freezer vessels combined);
- beam trawl, including those targeting flatfish;
- deepwater trawl fisheries, including those for orange roughy and grenadier;
- cephalopod fisheries targeting squid, octopus and cuttlefish;
- fishmeal fisheries;
- midwater trawl fisheries, some of which may harvest for fishmeal;
- factory trawlers, including the "catcher processors" in GOA/ BSAI; and
- an important group of trawl fisheries termed "demersal multispecies" which target several phyla including finfish, cephalopods and crustacea, i.e. these fisheries cannot be readily included in any of the preceding groups.

Details of the discards in these fisheries are provided below and in the supplementary tables in Annex A, Tables 16–19. The fisheries are considered both in relation to the gear used and the target species.

Trawl fisheries with the highest discards include the North Sea beam trawl fisheries; Japan's small trawl fishery; the Washington/Oregon/California groundfish fishery;[62] and industrial trawl fisheries in Morocco and Argentina. Substantial discards also occur in South Africa and Angola. The midwater trawl fisheries for small pelagics have the lowest discard rates and are also discussed in Section 3.3.4.

Bottom otter trawl

Bottom otter trawl for finfish is one of the most common fishing gears. Fish landed for direct human consumption has been estimated to be between 13.9 and 17.9 million tonnes (Chopin, in press), or in the order of 20 percent of global marine fishery production (excluding plants). Nineteen trawl fisheries involving 13 countries generate 80 percent of the estimated global bottom trawl landings.

The landings of an equivalent discard database set of fisheries total 15.9 million tonnes with discards of 1.3 million tonnes or 19 percent of the estimated total discards reported in the discard database. The weighted discard rate of these otter trawl fisheries is 7.6 percent.

Among the main finfish fisheries contributing to these discards are the hake fisheries in Argentina, the cephalopod and finfish trawl fisheries in Morocco, the French trawl fisheries in the Bay of Biscay and Celtic Sea, and Japanese fisheries for Alaska pollock. Fisheries with high discard rates include the offshore finfish trawl in Bangladesh, the Algarve finfish trawl (Portugal), several Spanish and Greek Mediterranean fisheries, and several United States fisheries (GOA Alaska pollock bottom trawl, silver hake).

Important demersal multispecies (i.e. targeting other phyla in addition to finfish) otter trawl fisheries include the Japanese "small trawl" fishery, India's east coast trawl

[62] While the fishery is predominantly a trawl fishery, pots, lines and other gears are also deployed.

and the Chinese, Myanmar and Thai trawl fisheries which in aggregate contribute over 350 000 tonnes of discards.

Beam and pair trawl

Beam trawl finfish fisheries in the EU show discard rates ranging from 14 to 69 percent. The finfish beam trawl fisheries account for 330 000 tonnes of discards and have a weighted discard rate of 68.7 percent. These discards are primarily from the plaice and sole fisheries in the North Sea. Shrimp beam trawl discard rates range from 8 percent (*Pandalus*, Canada) to 83 percent (Belgium). Pair trawl fisheries (from Spain, Viet Nam, China and Brazil) for which discard records are available are considered too diverse to be grouped. Discard rates range from 1 to 45 percent.

Flatfish trawl

Flatfish trawl fisheries have a significantly higher discard rate (weighted rate 51.3 percent) than all other non-shrimp trawl fisheries, contributing 0.4 million tonnes to the global total. Discards in EU fisheries include cod, haddock, whiting, plaice, saithe, dab, dogfish, shrimp and *Nephrops.* Substantial quantities of invertebrates (*Echinocardium*, starfish and crabs) are also discarded. Arrowtooth flounder is a major component of the discards in the GOA/BSAI fisheries for yellowfin sole, flathead sole and other flatfish. The reasons for the high discard rates in these fisheries are not clear, although the flat muddy and sandy inshore habitats of many flatfish species may serve as important nursery grounds with concentrations of juvenile fish of non-commercial sizes.

Factory trawlers

Factory trawlers are considered to be those with a fishmeal plant on board and/or those producing surimi. Lack of information on the technical characteristics of vessels active in a given fishery precludes clear identification of factory trawlers and, by extension, of factory trawl fisheries. Consequently, discard information on this category of fishery remains tentative. Recorded discards are 90 000 tonnes for a weighted discard rate of 9.6 percent based largely on records of "catcher processor" vessels in the GOA/BSAI groundfish fisheries. Argentine surimi vessels, targeting southern blue whiting and grenadier, are understood to have low or negligible discards. It is likely that substantial quantities of fish that were hitherto discarded are now processed by such vessels and that there are increased discharges of offal, either in liquid or solid form.

Hake trawl

Hake is a major target of the demersal finfish trawl fisheries. Trawl fisheries in more than 25 countries harvest the vast majority of the global hake landings of 1.9 million tonnes (Merlucciidae). Argentina dominates the landings (over 0.5 million tonnes) followed by Chile/Peru (0.36 million tonnes), the Namibia/South Africa fishery and a range of United States fisheries.

In the discard database, hake fisheries account for almost 150 000 tonnes of discards for landings of approximately 1 million tonnes and a weighted discard rate of 12.5 percent. The combined Argentine ice and freezer trawl hake fisheries have discards of 30 000 tonnes and a weighted discard rate of 13.9 percent (range: 9.9 percent for freezer trawlers to 19.8 percent for offshore ice trawlers) followed by Chile with over 26 000 tonnes of discards. Discards include small hake and horse mackerel (all fisheries), kingklip and rattails (Africa), arrowtooth flounder, dogfish and ratfish (North Pacific). Minimum size regulations, quotas and bycatch quotas (Chile) are among the reasons for discarding. Namibia pursues a "no-discard" policy' although "non-commercial species" may be discarded.

Fishmeal demersal trawl fisheries
The discard database records are exclusively from the North Sea/Kattegat/Skaggerak fisheries for sand eel and Norway pout. Landings of over 1 million tonnes have discards under 10 000 tonnes with a weighted discard rate of less than 1 percent.

Deepsea (deepwater) finfish fisheries
Several different types of gear, including trawls, longlines and gillnets are used in these fisheries and growing concern has been expressed over the status of these deepsea or deepwater fisheries (FAO, 2003b). Many of the fishing grounds are located on continental slopes and high seas plateaus or on seamounts outside coastal state jurisdiction. With the exception of small-scale dropline fisheries, discards are considered high in many deep sea fisheries.

The discard database records are from fisheries in the Northeast Atlantic (Gordon, 1999) and Chile and give a weighted discard rate of 39.6 percent (range 31–90 percent) and total discards of 37 000 tonnes. These fisheries target grenadier (*Coryphaenoides*), ling, seki shark and orange roughy. Discards have been particularly high in the French fishery for roundnose grenadier. Discarded teleosts include grenadiers, whiptails, rabbitfish and oreos. The discards also include a range of chondrichthyans (sharks such as birdbeak dogfish [*Deania*], batoids and chimaeroids), some of which also constitute part of the retained or target catch (e.g. seki shark in the Hatton Bank/Rockall Trough fisheries). There is evidence that survival of discards from these fisheries is low (Conference Steering Committee, 2003).

The discard database does not contain records of other important deepsea fisheries, e.g. off Namibia and New Zealand and exploratory fisheries such as those for deepwater crab (Hawaii area) and lobster (off Brazil). The Patagonian toothfish fishery is discussed in Section 3.2.10.

Midwater (pelagic) trawl for demersal species
With catches of over 1.2 million tonnes, the Alaska pollock fishery entirely dominates this category. The discard rate here is less than 1 percent and discards are comprised almost entirely of undersized or damaged pollock (see Annex A.6.1 for details). In contrast, other midwater[63] trawl fisheries have discard rates ranging from 1 percent for Atlantic redfish in Canada to 54 percent for hake in France. Discards in these fisheries include horse mackerel, mackerel, pilchard and black bream.

Midwater (pelagic) trawl for small pelagics
The recorded landings of over 2 million tonnes have discards of under 100 000 tonnes and a weighted discard rate of 4.2 percent. The major fisheries in Iceland (blue whiting, capelin), Norway (blue whiting, capelin) and Namibia (horse mackerel) all have discard rates of less than 2 percent, as do the fisheries for southern blue whiting (Argentina and the Falkland Islands [Malvinas]). Fisheries in the more southerly waters of Area 27 appear to have a greater species mix and higher discards. An estimated 35 000 tonnes is discarded in the combined Netherlands and Irish mackerel and horse mackerel fisheries (Area 27) with discard rates in the order of 11 percent. A substantial proportion of the Netherlands and Irish catch is taken off West Africa where discard rates are in the 2–6 percent range. Russian (and former Soviet bloc) midwater trawlers operating in the North Atlantic generally have negligible discards as potential discards are converted to fishmeal on board. The highest discard rates of up to 38 percent are recorded from the French pelagic trawl fisheries in the Bay of Biscay.

[63] Note that bottom trawls may fish the entire water column in some areas, e.g. shallow parts of the Baltic.

Discarded species include horse mackerel (EU countries), sardine, pilchard, mackerel and sprat. Dolphins (1.4 dolphins/100 tow-hours in French and Irish tuna fisheries) and sunfish are caught incidentally. Small-sized fish of the target species may be discarded as a result of highgrading in the quota-managed European fisheries or because processing equipment cannot handle smaller sizes.

Cephalopod trawl

Discard rates in the cephalopod trawl fisheries range from 3 percent in the fisheries for pelagic species (*Loligo, Ilex*) in the Falkland Islands (Malvinas) to 45 percent in the fisheries for octopus (Morocco, Mauritania, Japan). Guinea's cuttlefish-directed trawl fishery has a discard rate of 24 percent. These fisheries produce approximately 35 000 tonnes of discards and have a weighted discard rate of 22.8 percent.

3.3.3 Tuna and HMS fisheries

Discards in the tuna and HMS fisheries were assessed by ocean since information on catches and fishing activities is collected by five regional fisheries management organizations (RFMOs) and regional fisheries bodies (RFBs)[64] by fishing gear and country. The catch databases maintained by the RFMOs generally include catch information by country and gear, but do not necessarily discriminate catches by fishery. While in some cases the catch for a discrete fishery can be inferred (e.g. Maldives pole and line), in many cases it is not clear whether the reported tuna catch originates from a targeted tuna fishery or is a bycatch of another fishery (e.g. gillnets in the Indian Ocean). Every attempt has been made to avoid double accounting[65] for tuna catches also recorded as part of national fisheries statistics.

Two relatively comprehensive studies have been made of discards in the SPC area. In the case of the Atlantic HMS fisheries little quantitative information on discards was located. Table 10 summarizes discards and discard rates. Tuna catches in troll and gillnet fisheries cannot readily be separated from catches of other large pelagics.

Longline

There are significant differences between distant water longline fleets that target different species, even for those fleets with the same flag. Smaller longliners will tend to have shorter trips and retain more sharks and other non-target species. The long-range (mostly Asian) vessels are likely to discard greater quantities of bycatch (Nishida and Shiba, 2002). Discard rates for the long-range vessels range from 30 to 40 percent. The SPC discard rate of 40 percent is applied in the absence of other information and a rate of 15 percent is applied to the smaller, locally based longline vessels. Principal discards include *Prionace glauca* (blue shark), which is probably the most commonly discarded species, *Carcharinus* sp. and other sharks, damaged fish, albatross, petrels and other seabirds. Landings of sharks, frigate tuna, Kawakawa, Indo–Pacific king mackerel, and narrow-barred Spanish mackerel are not recorded in the IOTC database and it is assumed that industrial longliners discard the catch of most of these species. Discard rates in swordfish longline fisheries vary between 10 percent (Canada and Seychelles) to 19 percent in the Atlantic United States. Hook drop-off is not considered to be a discard.

[64] Commission for the Conservation of Southern Bluefish Tuna (CCSBT), IATTC, ICCAT, IOTC and SPC.

[65] It has not been possible to separate tuna catches from other artisanal catches in some countries. Consequently, if a discard rate is applied to a catch/fishery described as a "national artisanal multispecies/multigear fishery", then some double counting may have occurred. There is no double accounting with respect to the tuna catches from the small-scale fisheries of the island countries of the South Pacific.

TABLE 10
Discards and discard rates in fisheries for tuna and HMS

Fishery	Longline	Purse seine	Pole and line	Midwater trawl	Traps
Number of records	37	12	11	4	2
Average discard rate	22.0%	4.85%	0.1%	–	–
Standard deviation	0.16	0.02	0.003	–	–
Total tonnage of records	1 403 591	2 673 378	818 505	60 050	4 693
Total discards of records	560 481	144 152	3 121	26 532	0
Weighted discard rate	22.0%	5.1%	0.4%	30.0%	<1%

Source: discard database.

Purse seine

Discard rates vary from 1.5 percent in small (<400 GRT) Mexican seiners to 6.9 percent in the IATTC area. Other discard rates are Atlantic, 4.1 percent; Indian Ocean, 5 percent; and SPC area, 5.9 percent. Total recorded discards are approximately 145 000 tonnes. Discards include undersized target species, non-commercial tunas, shark, rainbow runner, dolphinfish, triggerfish, billfish and mantas. Large quantities of jellyfish are discarded in the bluefish and bonito fisheries in Turkish waters. Incidental catches of dolphins are discussed in Section 4.2.3.

Pole and line fisheries

These fisheries are essentially two fisheries – one for bait (usually anchovy) and the main fishery usually directed at skipjack and yellowfin tuna. The major pole and line fisheries are in the Western Pacific, Maldives, Japan, West Africa and Brazil. Discards of approximately 3 000 tonnes give a weighted discard rate of 0.4 percent for catches of over 0.8 million tonnes. Discards in baitfish fisheries have not been assessed.

Traps

Large anchored tuna traps are used on the coasts of Atlantic Morocco and Canada and in Mediterranean countries including Italy, Libyan Arab Jamahiriya and Tunisia. Tuna traps are quite selective and have a low or negligible discard rate, partly because of the large mesh size used in the traps. Canadian fishers are obliged to release bluefin tuna alive from traps licensed to catch herring and mackerel. Cetaceans may sometimes become entangled in trap mooring lines.

Other tuna fisheries

Trolling, handlines and coastal gillnets targeting tuna are also considered to have a low or negligible discard rate. Tuna gillnets are extensively deployed on the Indian subcontinent where discards are generally negligible (e.g. the Sri Lanka offshore gillnet fishery). Available records for harpoon fisheries (Nova Scotia swordfish) indicate zero discards.

Sharks

A study of elasmobranch fisheries cautioned against extrapolating the catch rates from one fishery to another because of the wide variation in the distribution of elasmobranchs (Bonfil, 1994). It is likely that weights of discarded sharks and other species can be derived from available[66] longline observer data and a more accurate estimation of discards can be made at the level of the RFBs. In the absence of recent comprehensive data on shark catch as a percentage of total longline catch, older[67]estimates have been

[66] See Cramer, 1999; Walsh, Kleiber and McCracken, 2002. Models comparing logbook and observer reports from the Hawaii longline fleet may also assist in providing more accurate estimates of global shark catches/discards by longline fleets.

[67] Based on Bonfil, 1994.

TABLE 11
Discards and discard rates in industrial fisheries for small pelagics

Fishery	Midwater/pelagic trawl	Seine/purse seine
Number of records	19	52
Average discard rate	5.7%	2.0%
Standard deviation	0.7	0.03
Total tonnage of records	2 763 040	21 664 338
Total discards of records	101 285	351 111
Weighted discard rate	3.5%	1.6%

Note: industrial and semi-industrial only. By industrial is meant industrial scale. Industrial does not mean fishing for fishmeal.
Source: discard database.

TABLE 12
Other industrial fisheries for small pelagics

Gear type	Range of discard rates
Danish seine and other unspecified seines	Negligible –7%
Trawl gears (unspecified)	Negligible – 4.7%
Gill nets	Negligible – 7.4%
Troll	Negligible

used to determine a longline discard rate in the Indian Ocean of 21.7 percent of the total catch. It is assumed that fish subject to predation are discarded (Nishida and Shiba, 2002).

At the global level, assuming that carcasses of all finned[68] sharks are discarded, over 200 000 tonnes of shark are discarded annually as a result of finning (discard rate of 96 percent). Discards of sharks in high seas fisheries alone are estimated to be 204 000 tonnes annually (Bonfil, 1994).

3.3.4 Small pelagics fisheries

The fisheries for small pelagics generally have low discard rates because the schools tend to be monospecific and the fish tend to be of a similar size. Tables 11 and 12 give details by gear type, based on the information in the discard database.

Purse seine

Purse seines and other seines catch the vast majority of global small pelagics. These seine fisheries contribute over 350 000 tonnes to the global discard estimate and have a weighted discard rate of 1.6 percent. Purse-seine fisheries in Peru, Norway, Chile and Iceland are the main contributors of discards. Because of the volume of catches, even with a low discard rate of 2.5 percent the Peruvian anchoveta fishery discards approximately 250 000 tonnes. Many small pelagic purse-seine fisheries are considered to have a zero discard rate, including United States menhaden, Black Sea anchovy and Malaysian and Vietnamese anchovy. Among the fisheries with the highest discard rates are those in Portugal, Spain and France targeting sardine, mackerel and anchovy. Discards in these fisheries are primarily of other non-target small pelagics including horse mackerel, *Scomber japonicus*, *Boops*, *Belone* sp., jellyfish, juveniles of other species[69] and small quantities of sharks.

[68] International trade in shark fins totals approximately 5 000 tonnes (recorded quantities as per FAO Fishstat commodity statistics). Real quantities are considered to be closer to 9 000 tonnes (re-exports excluded). Fins constitute approximately 2.5 percent of the live weight of the shark (5 percent of dressed carcass weight). Trade information and fin yield information from IUCN Species Survival Commission (SSC), Shark Specialist Group. Fin yield is derived from United States studies on *Prionace glauca*.

[69] Recent Norwegian experimental work with surface trawls has shown that significant catches of salmon smolts are caught in the mackerel fishery, possibly accounting for a significant percentage of the total recruits available.

Midwater trawl

These fisheries have already been discussed in Section 3.3.2. With the exception of the South African midwater trawl fishery for small pelagics (43.9 percent discard rate), all other high discard rates are from EU fisheries (seven records ranging from 10 to 47 percent). The quota regulations are a major cause of high discards in all these fisheries.

Slipping of unwanted fish is common in industrial fisheries for small pelagics. The quantity of such discards is particularly difficult to assess.[70] Norway has made use of crewless video-equipped submersibles to monitor slipping and discards in some of these fisheries.

Among the "other" industrial small pelagics fisheries, those with the highest discard rates are the Norwegian herring seine fishery (7 percent), the eastern Black Sea coastal encircling gillnet (7.4 percent), and Ireland's herring trawl (4.7 percent).

Artisanal

Lift nets, pushnets, beach seines, surround nets, gillnets trolling and a wide variety of other gears deployed in the artisanal fisheries for small pelagics are all considered to have low or negligible discard rates. Senegal produces over 250 000 tonnes of small pelagics with a fleet of outboard powered purse seiners. Numerous other artisanal purse seine fisheries exist producing a large, but unknown quantity of small pelagics (e.g. Bali Straits sardine fishery, Thai coastal fisheries). Mesh size regulations in these fisheries may contribute to discards since smaller fish can become gilled in the nets. Discard rate for such groups of fisheries are not available.

3.3.5 Gillnet fisheries

Surface and bottom gillnet fisheries (including trammel nets) account for under 30 000 tonnes of discards from reported landings of over 3 million tonnes (a weighted discard rate of 0.5 percent). The high level of catch is largely attributable to the Chinese small drift gillnet fishery (2.3 million tonnes). Source references do not always distinguish between surface and bottom gillnets and available gillnet catch statistics may combine both. The gillnet fisheries are highly diverse and would benefit from further disaggregation. They range from deepwater gillnets for hake and monkfish (Area 27, western waters) to surface nets for large pelagics, trammel nets for shrimp and crab and tangle nets for lobster. Some gillnet fisheries may target roe fish such as lumpfish and herring. Dropout from gillnets is not considered a discard. Among the highest discard rates are California's drift swordfish gillnet fishery and the sink gillnet fisheries in the northeastern United States, Canada's Greenland halibut fishery (1994 data) and Norway's lumpfish fishery.

Discards include dogfish, skate, sculpin (Canada), cod, haddock, plaice, saithe and dab (Europe). Coastal gillnet fisheries in France have low discard rates for marketable finfish, while offshore gillnet fisheries with soak times of up to six days may discard 100 percent of gadoid species because of the poor phytosanitary condition of otherwise marketable finfish (Morizur, Pouvreau and Guénolé, 1996). A number of countries prohibit monofilament gillnets but enforcement of such regulations is highly variable.

3.3.6 Non-tuna line and jig fisheries

In aggregate the non-tuna line fisheries have a weighted discard rate of 7.5 percent and discards of 47 000 tonnes. The bottom longline fisheries have a similar weighted discard rate of 7.5 percent, while the handline fisheries show a discard rate of 2 percent.

[70] "I don't see small mackerel landed any more." Fisheries inspector, Ireland, 2003, on the subject of highgrading.

The BSAI catcher processors targeting Pacific cod contribute over 24 000 tonnes of discards, while the GOA shoreside fleet targeting rockfish shows the highest discard rate (57.4 percent). In addition to the generally high discard rates in the GOA/BSAI line fisheries, toothfish longline (discard rates above 20 percent), artisanal shark fisheries (Peru and elsewhere) and longline fisheries in Norway and Spain (hake) have discard rates in excess of 10 percent.

Discarded species include arrowtooth flounder (GOA/BSAI fisheries), starry ray, dab and redfish (Iceland, the Faeroe Islands), hake, shark and kingklip (South Africa), and macrourids and rajids in the CCAMLR area. In many of these fisheries in Europe and the United States some discarding is attributable to highgrading and species-specific per vessel quotas.

Jig fisheries

Jig fisheries tend to be highly selective with a weighted discard rate of 0.1 percent for the squid fisheries and 3.5 percent for finfish fisheries (cod, Pacific cod and mackerel).

Additional details on these fisheries are provided in Annex A.2.2, Table 20.

3.3.7 Multigear and multispecies fisheries

Over 100 fisheries in the discard database were classified either as multigear, as multispecies or as both multigear and multispecies. In many cases this unhelpful designation reflects an aggregation of several fisheries and can be largely attributed to the manner in which statistical information is compiled at national level. Further work could disaggregate each of such "multi" fisheries into a set of differentiated fisheries. Nevertheless, in many fisheries, individual vessels deploy different gears during the same fishing trip and in some cases, e.g. many Asian trawl fisheries, "there is no target species because all species are the target".[71]

Most of the fisheries in this group are small-scale fisheries. The artisanal fisheries of the Pacific Islands and Caribbean comprise 43 of the records in this group of fisheries and have an assumed discard rate of 0 percent. The highest discard rate is reported from the multigear shrimp fishery in northern Brazil (50 percent) and the Uruguayan artisanal multigear fishery (15 percent). The weighted discard rate is 1.4 percent, representing discards of 85 000 tonnes from landings of over 6 million tonnes.

3.3.8 Fisheries using other gears

Dredge

Discard rates in dredge fisheries, which are mainly directed at scallops, clams and whelks range from 9 to 60 percent with a weighted average of 28.3 percent and a contribution of over 65 000 tonnes (ten records) to the total discard estimate.

Pushnet

Pushnets exhibit a wide range of discard rates from 90 percent for those collecting penaeid post larvae (Bangladesh) to 0–1 percent for those operating in the Gulf of Thailand and South China Sea, many of which are operated from larger motorized vessels.

Bagnets

Bagnets (five records from Asia and Africa) have a discard rate of less than 1 percent and make a negligible contribution to the total discard estimate.

Other fixed nets

Chinese landings of over 2.6 million tonnes from "stationary" nets dominate the category and have an assumed discard rate of 0.5 percent. Total fixed net discards

[71] Bureau of Fisheries, Ministry of Agriculture, Beijing, pers. comm. (2003).

are estimated to be approximately 24 000 tonnes. With the exception of the Guyana Chinese "seine" (a type of staked fyke net) with a discard rate of 25 percent, all these fisheries (six records) have discard rates below 1 percent.

Traps

Three main types of trap fisheries are distinguished: fixed traps (12 records), small-scale pots and industrial pots. The tuna trap fisheries (Mediterranean and Canada) and the small-scale fixed and arrowhead traps of Asia incur negligible discards. Octopus pots (West Africa, Japan) also have negligible discards. Lobster and crab pots often have high regulatory discards, as fishers are obliged to discard females and undersized specimens in many jurisdictions. In contrast to the negative connotation of many discarding practices, discards with a high survival rate are highly desirable for stock conservation. High discards in several major crustacean pot fisheries, e.g. BSAI crab fishery (over 40 percent) and Canadian lobster fisheries (23 percent) account for high discard rates of 12.4 percent (average 12 records) and 27.7 percent (weighted discard rate). Finfish pot fisheries (14 records) indicate a maximum discard rate of 5.2 percent with the exception of an experimental fishery for toothfish in the CCAMLR area, which has high discards of crabs and other species (61 percent). Finfish pot fisheries account for under 1 500 tonnes of the total discard estimate.

Other gears

Harpoons, used for swordfish in Canada and the United States, are highly selective and unlikely to incur discards. The saury stick-held dip net (Japan), dip nets in Viet Nam and scoop nets in peninsular Malaysia have low to negligible discards.

3.3.9 Artisanal and small-scale fisheries

The terms "artisanal" and "small-scale" fisheries are considered equivalent for the purposes of this study and embrace other categories (e.g. subsistence, traditional, indigenous) used in the national fisheries statistics or fishery terminology of different countries.

While most of these fisheries have been assumed to have a low or negligible discard rate, it is clear that some discarding takes place. Puffer fish, "ciguatera" fish and other poisonous species are discarded. Fish gilled in seine nets may be discarded. Hooked fish damaged by shark attack may also be discarded, although fish heads are often retained. Small quantities of living marine resources are often discarded in beach-seining operations. Many artisanal fisheries are highly selective,[72] e.g. trammel nets targeting shrimp may discard quantities of crabs that become entangled and broken. Artisanal trawlers in Southeast Asia discard benthos such as sponges and tunicates and "baby trawls" in the Philippines have relatively high discard rates. Estuarine stake nets tend to have significant discards. "Jellyfish" of several phyla are frequently discarded.

Nevertheless, little information exists in the available literature quantifying these discards, since discarding is generally not considered to be a priority concern in small-scale and artisanal fisheries. More frequently post-harvest losses are the primary concern. Numerous national experts consider that discards in their national artisanal fisheries are negligible (see Annex C.5, Table 35). Efforts have been made to identify the artisanal[73] or small-scale component of national landings and, in the absence

[72] Bundy and Pauly, 2001. This research indicates that a set of highly selective artisanal non-trawl gears exploit a greater range of species and niches than the less-selective trawlers. The set of artisanal gears are judged to have a more detrimental effect on the ecosystem. This suggests that studies may be required prior to advocating substitution of trawls with more selective gears.

[73] That is, the definition of "artisanal/small-scale" adopted by national fisheries authorities for the purposes of national fisheries statistics has been used in each case.

of information to the contrary, these fisheries have been assumed to have a low or negligible discard rate.

Partly as a result of problems arising from the definition of fisheries at the national level, it is difficult to separate clearly artisanal (small-scale) fisheries from industrial fisheries. Consequently, a comparison between the discard rates of these sectors is difficult. However, is quite clear that the vast majority of discards originate in the industrial sector.

Discard database records indicate that catches of at least 8.5 million tonnes can clearly be attributed[74] to small-scale fisheries. In aggregate these fisheries show a discard rate of 3.7 percent.

Beach seine

The average discard rate (32 percent) is high because beach seines in developed countries (e.g. Australia, Portugal) have high discards. However, the highest landings from beach seines take place in developing countries where the activity has a high social importance and discards are often negligible since even low value fish is used for autoconsumption and crew compensation. The weighted discard rate is 4.4 percent, whereas Table 5 lists beach-seine fisheries in developing countries among the fisheries with a negligible discard rate.

Diver

Diver fisheries (12 records) for abalone, clam, topshell and mother of pearl, lobster, octopus and rare shells all have a zero or negligible discard rate (<1 percent). Damage or mortalities caused by divers to corals or other species has not been estimated although it is reported to be substantial in some areas (e.g. cyanide fishing for live reef fish, "excavating" giant clams or harvesting ornamental corals). Discards of sea urchins may be substantial if gonad condition is poor.

Hand collection

Hand collection, also referred to as hand gathering or gleaning, is a common artisanal and commercial fishing activity. Many collection activities, e.g. for cockles and clams, take place during low-water spring tides. Substantial damage may occur to reefs from walking on corals or overturning rocks. Damage and mortalities may also occur from raking or dragging baskets and sacks and from collection vehicle movement (e.g. tractors). Such damage is not considered a discard. Substantial collection fisheries exist in Chile, Japan and Thailand. Discards in all cases (16 records) are negligible (<0.5 percent) and these fisheries contribute no more than 1 000 tonnes to the total discard estimate.

3.3.10 Discarded species

It is difficult to determine the most important discards by species or species group since the composition of the discards is often inadequately recorded. Most studies focus on the discards of commercial species and it is often unclear whether non-commercial species are recorded, e.g. there are few references to discards of jellyfish. A particular study may provide a list of discarded species without specifying the quantities discarded, or generic designations such as "juveniles of commercial species", "non-commercial species" or "invertebrates" may be used in the literature. The quantity of discarded invertebrates may be significantly under-reported. Significant discards

[74] Hand line and diver fisheries are clearly small-scale. However, it is unclear in many cases whether the fishery is small-scale or industrial. This means that the 8.5 million tonnes referred to above is a minimum, particularly as the study has been unable to separate catches from many Asian fisheries (e.g. China, Viet Nam) into small-scale and industrial.

of sponges, coelenterates[75] including corals, Ctenophora, echinoderms, tunicates and crabs occur, particularly in trawl and dredge fisheries. Often only the weight of the discarded commercial species is reported. Percentages by weight of the different species are rarely provided or, if provided, it may not be possible to relate the percentages to the total or retained catch. Consequently, little quantitative information on discards by species is contained in the discard database. A synthesis of selected information is provided in Annex A.5, Table 25.

For the purposed of discard estimation a division of the catch into three groups may be useful: species always retained; species always discarded; and species partially/sometimes discarded. If estimates of the overall catch composition are available, observers may then concentrate on the partially discarded species. Further analysis of the composition and quantity of discarded species may suggest a more effective targeting of market and product research to facilitate greater utilization of these species, and assist in studies on biodiversity and on the impact of fishing on marine ecosystems.

3.3.11 Regulatory measures and discard rates

Analysis of the discard database records by type of regulatory measure, summarized in Table 13, is not particularly useful because of the variety in the fisheries, the influence of other regulatory measures and the weak enforcement of some measures. The "no-discards" regime will be examined in more detail in Section 4.3.1.

Minimum landing size (MLS)

Many fisheries apply several regulations that directly influence discard rates. MLS regulations, which clearly promote discarding, are often associated with other regulations (e.g. closed areas, closed seasons or quotas) and the impact of a particular regulation is difficult to assess. In some cases the MLS is set below the marketable size. For example, reducing the MLS for whiting in the North Sea would have little effect on discard practices because there is no market for the small whiting. However, a reduced MLS for hake may have an effect in Spain where there is a ready market for small hake. Although there are MLS regulations in many Southeast Asian countries, the generally low discard rates reflect the weak application of these regulations. Sales of unsorted fish, such as "African mix" in West Africa, bycatch purchased at sea by collection vessels, often circumvent the MLS regulations.

Turtle excluder devices (TEDs) and Bycatch reduction devices (BRDs)

Shrimp fisheries using TEDs do not appear to have an appreciably lower discard level (aggregate discard level 62.3 percent) than those that do not use them. Discard rates in fisheries using BRDs range from <6 percent in the NAFO area (as low as 0.2 percent) to 88.7 percent in Australia and Indonesia (Arafura Sea). Time series showing discard rates before and after the introduction of TEDs and/or BRDs are necessary to provide a more accurate assessment[76] of the impact of these devices. The broad range of discard rates is also partly attributable to varying levels of enforcement of the TED/BRD regulations.

[75] High catches and discards of jellyfish are recorded in many fisheries, e.g. South Atlantic shrimp trawl (United States), purse seines for bluefish in the Bosporus, the Kimberly coast prawn trawl.

[76] See studies from Australia and the Gulf of Mexico, e.g. Kennelly, 2000.

TABLE 13
Weighted average discard rates for fisheries using different discard-related management measures

Measure	Discard rate *(%)*
Turtle excluder device (TED)	62.3
Minimum landing size (MLS)	50.9
Bycatch reduction device (BRD)	43.9
Obligatory bycatch landings	32.2
Obligatory release of certain species	19.8
Bycatch quotas	19.8
Observers	18.4
Area closures	10.5
Time closures	9.9
Bycatch plan	7.6
Multiple measures	3.8
Discard ban	3.6

4. Issues

4.1 WHAT IS "THE DISCARD PROBLEM"?

The expression "the discard problem" embraces several issues or subproblems, which go to the foundations of fisheries management philosophy and practice. Several subsidiary problems and issues can be identified (Hall, 1994).

- *Policy and ethical issues*. Discards are seen as a waste of natural resources, contrary to responsible stewardship and sustainable utilization of marine resources.
- *Fisheries management issues*: the difficulty in designing and implementing a management regime that meets multiple social, economic and biological objectives, while limiting or preventing discarding, or avoiding the catch likely to be discarded.
- *Ecological issues* related to the impact of discards on marine ecology.
- *Technical and economic issues*: the technical problems of gear selectivity and utilization of species with a low market demand through transformation, or adding value; the economic problems posed by efforts to reduce bycatch, increase landings of bycatch or increase its utilization.

4.2 POLICY ISSUES

4.2.1 International instruments and guidance

The international community has recognized both ethical concerns and policy regarding discards, related biodiversity and endangered species in several international instruments and statements, including United Nations resolutions,[77] multilateral agreements and plans of action (see Box 1).

The initial UN resolution (49/118) invited international organizations to:

- include provisions with regard to bycatch and discards in international instruments, including the United Nations Agreement relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks and the Code of Conduct for Responsible Fisheries;
- review the impact of fisheries bycatch and discards on the sustainable use of living marine resources; and
- recognize the need for greater monitoring and assessment of bycatch and discards and for continued improvement in bycatch reduction techniques.

Subsequent resolutions 50/25 and 51/36 of 1996 called for states and regional fisheries organizations to: adopt policies, apply measures, collect and exchange data and develop fishing techniques to reduce bycatches and fish discards; place "discards" on the United Nations General Assembly (UNGA) Law of the Sea (LOS) agenda; provide assistance to developing countries to collect and exchange data and develop techniques to reduce bycatches and fish discards; and requested the Secretary-General to submit biennial reports to UNGA relating to the implementation of the resolutions.

Resolution 52/29 of 1997 recalled that the Agreement relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks provides in its general principles that states shall minimize discards and reaffirmed the previous UN resolutions.

[77] The resolutions are A/RES/49/118 (1994); A/RES/50/25 (1996); A/RES/51/36 (1996); A/RES/52/29 (1997); A/RES/53/33 (1998); A/RES/55/8 (2000); and A/RES/57/142 (2002).

BOX 1
Selected multilateral initiatives

Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea (UNCLOS) relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (United Nations Implementing Agreement [UNIA])	… minimize ... discards, ..., catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species, in particular endangered species ...
The Rome Consensus on World Fisheries adopted by the FAO Ministerial Conference on Fisheries, Rome, 14–15 March 1995	... reduce bycatches, fish discards …
CCRF has numerous references[1] to discards	... collect information on discards ...; ... take account of discards (in the precautionary approach) ...; ... take appropriate measures to minimize waste, discards ...; ... develop technologies that minimize discards ...; use of selective gear to minimize discards; …
International Plan of Action (IPOA) on sharks	Minimize waste and encourage full use of dead sharks
IPOA on seabirds	Prevention of seabird capture and release of seabirds
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Under CITES, marine mammals, turtles and seabirds and some fish species are listed under Appendix I (species threatened with extinction that are or may be affected by trade), and Appendix II (species threatened with extinction unless trade is subject to strict regulations). CITES listing may have a significant effect on fisheries that catch such species
Convention on Migratory Species (CMS)	The Convention has provided a forum for the development of legally binding regional agreements on marine mammals and turtles (e.g. ACCOBAMS and ASCOBANS)
Convention on Biological Diversity (CBD)	Discards affect biodiversity[2] along at least three axes: species numbers, species densities and species dispersion. These impacts are not well understood, particularly with regard to benthos

[1] For a discussion of the references to discards in the CCRF, see Clucas, 1997.
[2] The role of discards in terms of broader ecosystem change, e.g. supporting seabird populations in the North Sea, has been well documented.

Resolution 53/33 of 1998 recognized the progress in the preparation of draft plans of action in relation to shark fisheries and the incidental catch of seabirds and drew further attention to incidental losses of sharks and seabirds.

Resolution 55/8 of 2000 *expressed concern* about the significant level of bycatch and discards in several of the world's commercial fisheries; recognized the importance of the development and use of selective, environmentally safe and cost-effective fishing gear and techniques for reducing bycatch and discards; acknowledged the value of FAO, UNEP and GEF initiatives; and urged further action to reduce discards.

Resolution 57/142 of 2002 urged action to reduce or *eliminate* bycatch and fish discards and drew attention to a range of appropriate measures.[78]

4.2.2 Ethics of discards

Many societies and religions adhere to the principle that human beings have a moral obligation to make best use of natural resources and minimize wastage. In others (Tucker, 1998), nature is seen as intrinsically valuable. Islam and many other religions support the concept of stewardship (Afrasiabi, 1995), or that humans hold nature in trust and are accountable to god for the use or misuse of nature. Buddhist "environmentalism" is also based on an underlying belief in causal relationships between living beings and human beings with an individual and general responsibility for the state of nature. Shinto purification is performed to restore the balance between humans, nature and the deities (Bernard, 1998). These themes are repeated in Judeo-Christian beliefs and echoed in the saying "waste not, want not" and in several Biblical ethical models (Bratton, 2000):

- "do not destroy", which prohibits wanton disturbance of a productive nature;
- neighbourliness, a concept that prohibits damage to another family's livelihood;
- divine ownership of and joy in creation, which assigns value to non-economic species and to biodiversity; and
- stewardship, which requires both active resource protection and careful resource use.

Throughout many of these belief systems there is an underlying theme that technology alone cannot resolve the issues of human beings' relationship with nature, but that greater harmony and balance in the use of natural resources depend on values, their application through governance[79] systems and lifestyles, and the distinction between wants and needs (Tamari, no date).

Good and bad discards[80]

The notion that discards are wasteful is closely linked to the assumption that most, if not all, discards are either already dead or subsequently die as a result of the fishing activity. However, many discarded animals survive, and live release of captured animals may make a significant contribution to the sustainable use of fisheries resources. Guidelines and criteria can be developed to identify "responsible" discarding. Examples of "good" discards may include:

- species with a high probability of survival (e.g. crabs, starfish);
- species targeted for release (e.g. sharks, rays, swordfish, turtles, dolphins);

[78] "... technical measures related to fish size, mesh size or gear, discards, closed seasons and areas and zones reserved for selected fisheries, particularly artisanal fisheries, the establishment of mechanisms for communicating information on areas of high concentration of juvenile fish, ... and support for studies and research that will minimize bycatch of juvenile fish".

[79] A broader analysis of these issues is provided in FAO, 2001b.

[80] "Again, the kingdom of heaven is like unto a net, that was cast into the sea, and gathered of every kind: Which, when it was full, they drew to shore, and sat down, and gathered the good into vessels, but cast the bad away". Matthew 13: 47–48.

- live egg-bearing females (e.g. berried lobsters); and
- small pelagics slipped without stress, i.e. schools that have a high survival rate.

"Bad" discards may include all dead discards that had a potential commercial value when alive, including juveniles of commercial species and endangered or threatened species, which indicate undesirable fishing practices.

As discard practices also impact on biodiversity and energy transfers within ecosystems, assessing the impact of discards in simple positive and negative terms may prove difficult. It may be of more practical value to prepare additional guidelines on best practices with regard to bycatch management on a fishery-by-fishery basis.

There are major differences in discard policies and practices between regions, between countries within a region and between fisheries within a country. National policies and objectives (e.g. prioritizing food supply), markets, food preferences, fishery economics and moral orientations all influence discard practices. In very broad terms, countries can be classified into four groups, those that:

- promote selective fishing and bycatch and discard reduction or elimination – mainly developed countries fishing mostly in temperate waters;
- pursue a strategy of full utilization of all components of the catch – these countries include most of the Southeast Asian nations, China and Cuba;
- steer a middle course between advocating bycatch reduction and promoting full utilization of the catch – these include the EU countries and many developing nations;
- by the nature of their fisheries, do not have a significant "discards problem". These include countries with either a small or no industrial fishery (e.g. many Pacific Islands and some Caribbean countries) and by default are "full utilization" countries.

Acceptable level of discards

Assuming that discards are unavoidable, the question of an acceptable level of discards has a moral dimension in addition to the more obvious biological and economic criteria. No-discard policies are consistent with the ethical orientations cited above and are addressed in more detail in Section 4.3.1. In the United States bycatch plan (see Section 4.4.2), "concerns" regarding bycatch and discards are considered under four indicators: (i) population concerns where discards contribute significantly to the status of the fish population; (ii) social and economic concerns; (iii) ecological concerns; and (iv) public concerns that are of particular relevance in the case of seals, marine mammals, seabirds and other marine animals of an aesthetically high profile. In practice, "acceptable" levels of discards are negotiated between interest groups with little reference to morality.

4.2.3 Incidental catch and discards of charismatic and endangered species

The incidental catch of most of these species is discarded, either because of a legal requirement or because of lack of commercial value. Endangered species are those threatened with local or global extinction. Several species or species groups are considered "charismatic" since certain societies accord their existence an additional value for numerous reasons. There are long-standing cultural and religious ties with some species such as dolphins and seabirds.[81] Many feature in children's stories or are used in advertising, films and cartoons, which contribute to their enhanced status in society.

Whatever the reason, society values these species and is willing to pay a price for their preservation. These perceptions and values have a direct impact on fisheries, which

[81] For example, the poem, "The Rime of the Ancient Mariner" by Samuel Taylor Coleridge (1789); frigate birds on amulets in the Solomon Islands.

incidentally catch and discard these species, through changes in fishing techniques (e.g. TEDs, Medina panels and pingers [acoustic deterrents]), and through trade (e.g. through CITES and unilateral measures such as tuna, shrimp and shark imports to the United States).

Assessing the impact of a fishery[82] on marine mammal, seabird or turtle populations poses several problems. There is a general shortage of information, e.g. in pelagic trawls where the incidence of cetacean bycatch may be higher than previously estimated (De Haan *et al.,* 1998). Reliable information on incidental catches is generally only available through observers. It is also difficult to assess population size (particularly for marine mammals) and to assess the consequences of a relatively low and unpredictable incidental catch rate. While over 2 million dolphins may be encircled by tuna purse seiners in the Eastern Tropical Pacific, fewer than 3 000 are killed by the fishery as a result of strict application of release procedures monitored by observers. However, the failure of the dolphin stocks to recover may indicate additional indirect[83] mortalities caused by fishing activities and the effects of other factors are not well understood. Information on incidental catches of manatees and dugongs is particularly scarce and it is likely that these animals are consumed rather than discarded if caught by artisanal fishers.

A number of NGO reports[84] indicate that fishing activities cause substantial mortalities of sea turtles. In contrast, at a recent FAO meeting[85] representatives of certain Asian fishing nations contested the level of turtle mortality resulting from longlines, indicating that incidental turtle catches were rare and survival is apparently high since most turtles are released alive. Trials of mitigation measures to avoid or reduce hooking have not proved promising since the incidence of hooking is so low that field trials have encountered difficulties in achieving statistically significant results.

Reliable current compilations (Brothers, Cooper and Løkkeborg, 1999) of global information on the interaction between fisheries and charismatic species are relatively scarce. This absence of a recognized (Gillespie, 2002) global database on incidental catches of such species tends to result in argument and conflict over the impact of fisheries, the effectiveness of mitigation measures and the impact of other factors such as pollution or destruction of breeding grounds and nesting sites on endangered populations.

Mitigation and conservation measures

Comprehensive legislation (FAO/UNEP, 1986) and numerous action plans[86] for the conservation of charismatic species exist at national and international levels. The United States' Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA), and Australian legislation provide good examples. Release of live rajids, bluefin tuna (United States and Canada) and other regulated species is mandatory in certain fisheries. The United States has a ban on shark finning and a similar ban is coming into force in the EU. Near real-time monitoring of discards and retention of incidental catches for monitoring purposes is obligatory in certain United States fisheries.

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[82] See Northridge, 1991; Perrin, Donovan and Barlow, 1994; and also the technical documents prepared for recent International Whaling Commission (IWC) meetings.

[83] Southwest Fisheries Science Center, 2002. Note that disease may also play a role in reducing some dolphin populations in the Eastern Tropical Pacific.

[84] Prepared for IUCN, the World Wide Fund for Nature (WWF), Pew Charitable Trusts and others.

[85] FAO file note on informal meeting held during the Committee on Fisheries (COFI) XXV, Rome, 2003.

[86] The Global Plan of Action for the Conservation, Management and Utilization of Marine Mammals was developed between 1978 and 1983 jointly by UNEP and FAO and was endorsed by UNGA. UNEP is to retool the Marine Mammal Action Plan in consultation with CMS, CITES, CBD, the regional seas conventions and action plans and relevant partner organizations, including IUCN.

Recent amendments[87] to United States fisheries legislation calls for the Secretary of State, in cooperation with the Secretary of Commerce, to seek an international agreement to establish standards and measures for bycatch reduction that are comparable with United States standards in any fishery regulated under the Magnuson-Stevens Act for which an international agreement is necessary and appropriate.

A range of mitigation measures is in force throughout the world, for example:

- TEDs are in widespread use and mandatory in many fisheries;
- Australia is emphasizing the improvement of post-hooking handling and release techniques for turtles to ensure greater survival;
- Australian longliners are undergoing trials with "capsules" and "chutes" to reduce hooking of seabirds;
- seal saver devices (SSDs) have been developed in New Zealand's squid fisheries;
- driftnets/gillnets are being replaced with longlines in cetacean bycatch hotspots;[88]
- national and international sanctuaries have been established, e.g. the Irish Whale and Dolphin Sanctuary and the Ligurian Sea Cetacean Sanctuary (Italy, Monaco and France);
- pingers[89] and interactive pingers (Amundin, Desportes and Goodson, 2002) are under continued development and testing;
- there is increasing international monitoring and cooperation[90] on identification of whale migration routes and establishment of marine protected areas (MPAs),[91] on elimination or reduction of certain fishing activities, on enforcement mitigation measures and on development of additional measures (Read, 2000);
- legislative provisions and other measures to avoid incidental capture of marine mammals in tuna[92] fisheries have been introduced.

Fishery managers, particularly those in developing countries, require: (i) a framework[93] for the introduction and acceptance of such measures by industry; (ii) more specifically, advice on the design, operation and financing of incidental catch monitoring; and (iii) assessments of the advantages and disadvantages of the different mitigation measures.

Trade and economic impact of incidental catch

The incidental catch of charismatic and endangered species is having a growing influence on fisheries and fish trade. Conservation activists and scientists have called for the cessation of tuna longline fishing to protect turtles and for trawl bans to protect corals and other benthos. Multinational companies are making purchases only from fisheries that implement mitigation measures, and ecolabels are intended to promote products from implementing fisheries. Trade disputes over mitigation measures

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[87] Magnuson–Stevens Fisheries Conservation and Management Act, Section 202 (h)(1), signed into law on 11 October 1996.

[88] See, for example, ASCOBANS Jastarnia Plan (Baltic harbour porpoise), ASCOBANS, 2002.

[89] Concern has been expressed over the effects of pingers in: (i) excluding marine mammals from certain habitats or zones; (ii) interference with migratory pathways; or (iii) long–term effects of aquatic noise.

[90] ASCOBANS and ACCOBAMS were both adopted under the auspices of the 1979 Convention for the Conservation of Migratory Species of Wild Animals (the "Bonn Convention"). There are similar arrangements in other regional seas conventions. Annex II of the Barcelona Convention Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean lists several marine mammal species as "endangered or threatened" and, as such, they are given special protection.

[91] EC Habitats Directive (92/43/EEC). The network of Special Areas of Conservation (SAC) is called Natura 2000.

[92] For example, the EC ban on the use of driftnets longer than 2.5 km, adopted by the Community in conformity with the UN resolution prohibiting the use of large pelagic driftnets (Council Regulation [EEC], No. 345/92 of 27 January 1992), and the prohibition of "dolphin sets" (Council Regulation [EEC], No. 3034/92 of 23 October 1992).

[93] A description of such a framework is given by Broadhurst, 2000.

regarding incidental catches of turtles and dolphins have disrupted trade in shrimp[94] and tuna respectively. Several important developments are likely to impact further on fisheries and fish trade:

- the pending conclusion of a memorandum of understanding between FAO and CITES clarifying the role of FAO in relation to fish and related species;
- a gradual move towards international consensus on ecolabelling in marine products (Wessells *et al.,* 2001);
- technical advances in traceability[95] of marine products that will facilitate enforcement of mitigation measures; and
- civil actions by conservation organizations.

The action of conservation organizations in the United States is of particular note in relation to bycatch and charismatic species and may be the precursor of other such activities. Oceana,[96] an NGO, requested the United States Department of Commerce to rule on the interpretation of fisheries legislation, specifically the legislation that requires the NMFS to "establish a program to count, cap and control bycatch in the nation's fisheries". Pursuant to a United States court finding the NMFS in violation of fisheries legislation (MSA), Oceana claimed that the NMFS had failed to apply national legislation. In a comprehensive response (Federal Register, 2003), the NMFS was effectively forced to set out such a programme and make financial and other provisions for its implementation. In a second case, a coalition of conservation NGOs led by the Earth Island Institute effectively blocked the United States administration's attempts to change the "dolphin safe" designation of certain tuna products, thereby pressuring for a cessation in fishing for tuna on "dolphin schools". Such trends are likely to expand to other fishing and fish-consuming nations.

4.3 FISHERY MANAGEMENT ISSUES

The central "discard problem" for the fishery manager is to design a management regime that meets multiple social, economic and biological objectives, while limiting or preventing discarding (Hall, Alverson and Metuzals, 2000).

Impact of discards

Design of effective management regimes may require assessment of the biological, ecological and economic impacts of discards. A parallel study[97] has addressed this question in some detail. Just as the quantity of discards is difficult to assess, it is equally clear that it is even more difficult to assess their impact. Few relevant studies exist, and it is not easy to disentangle the relative impacts of bycatch and discards. The economic and social impacts are briefly discussed in Section 4.6.3. The causal diagrams of discarding are presented as a means of structuring further studies on discards and their impacts (see Annex C).

Management frameworks

The following sections address three different approaches to bycatch and discards:

- a "no-discard" policy with comments on its management approach;
- generic management measures and their advantages and disadvantages with respect to discarding; and
- comprehensive approaches to bycatch and discards.

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[94] For example, World Trade Organization, 2001. The decision of the Appellate Body conditions market access on the adoption of a programme ... comparable in effectiveness [with that of the United States].

[95] For example, the EU's tracefish project and the introduction of radio–frequency identification device (RFID) tags in numerous products.

[96] www.oceana.org

[97] Poseidon Aquatic Resource Management Ltd, 2003. See also Horsten and Kirkegaard, 2002.

4.3.1 The "no-discard" regime

A number of countries[98] pursue a "no-discard" policy[99] and several prohibit discards at sea under their legislation. A "no-discard" policy is consistent with best practice and is likely to minimize discards in conformity with UNGA resolutions and the CCRF. The following key points are noted:

- "no-discard" legislation may be enforced to varying degrees, and at times selectively, in recognition of the unpredictable nature of fishing operations;
- effective discard bans are almost invariably supported by a range of other complementary measures (see below);
- there is generally some allowance made to ensure that fisheries maintain their economic performance or competitiveness;
- discard bans are more common in "clean" fisheries (i.e. fisheries with little non-commercial bycatch);
- discard bans have widespread support among fishers if they are applied in a fair and pragmatic manner;
- several countries that are recognized as leaders in fisheries management have a "no-discard" policy; and
- most important, a "no-discard" policy implies a distinctly different approach to the design of fisheries management measures when compared with a "minimize discards" policy.

A "no-discard" policy changes the focus of management and fishery indicators from landings to gross catches and from production to total fishing mortality. This is exemplified in the contrasting Norwegian and EC legislation:[100]

- Norway: "it is prohibited to *catch* …"
- EC:[101] "it is prohibited to *have on board* …"

This means that many of the Norwegian fisheries management measures are designed to ensure that unwanted fish is not caught. Thus, the choice is not between returning unwanted fish to the sea and obligatory landings for fishmeal or animal feed, but between catching and not catching unwanted fish. These complementary measures accompanying discard bans include:

- active rather than static management through close monitoring of fisheries and rapid closures of areas with excessive quantities of unwanted bycatch;
- obligations on fishers to move fishing operations when encountering unwanted bycatch;
- obligations to land all catches;
- no MLS and no (or reduced) benefits from landings of juvenile fish;
- usually a high level of observer coverage;
- bycatch quotas and closure of the fishery when the bycatch quota is reached;
- financially viable mechanisms for disposal of landings of unwanted bycatch (e.g. fishmeal, Iceland's "bycatch bank", long-term price agreements, promotion of markets for/products from unwanted bycatch, new product development and presence of a "buyer of last resort").

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[98] British Virgin Islands, Canada, the Comoros, Ecuador, Equatorial Guinea, Faeroe Islands, Iceland, the Islamic Republic of Iran, Indonesia, India, Lithuania, Namibia, Nicaragua, Nigeria, Norway, Peru, South Africa, Seychelles, United States and the United Republic of Tanzania.

[99] Known as a "full retention policy" in the United States.

[100] "Last year a Danish skipper was caught with more than 40 percent of illegal fish in the hatch. To the media the skipper says: 'I was in the Norwegian zone and because of their discard ban, I had to keep the fish on board'. As a reply, the Danish Ministry argues to us: 'the skipper has no excuse for having illegal catch onboard – he has to sail in Danish waters and dump the catch there'." – K. B. Christensen, Chairman of The Danish Society for a Living Sea (Web site).

[101] The EU regulation prohibits "retention on board of fish which does not comply with the regulations". The EU may propose a legal ban on discarding from 2006 (European Commission, 2002a).

In Iceland fishers are allowed to land a certain proportion of undersized fish, which is only partly deducted from quotas. Quotas are tradable, allowing fishers to purchase them to cover unanticipated landings. A similar system exists in Norway whereby fishers are allowed to substitute quotas in one species for quotas held in another in accordance with predetermined ratios (Kelleher, 2001). The ratios are partly based on the anticipated species composition ratios in the catch. This allows fishers to avoid discards when encountering a species composition that does not meet the species composition of their quota holdings.

A "no-discard" policy is precautionary since the "default scenario" is a ban on discards. It is incumbent on a particular fishery to justify discards or show why they are unavoidable. The legislation may then make an allowance for such unavoidable discards, e.g. applied only to commercial species. The country's development programme can examine means of reducing the unwanted bycatch, develop alternative fishing opportunities or finance the phasing out of such wasteful fishing technologies.

It is suggested that there is a fundamental difference between a "no-discard" approach and a "minimize discards" approach. "Minimize discards" often merely endorses the status quo by paying lip service to discard reduction. Policies and programmes that seek to minimize discards often do not determine the target minima and there is little consensus on how to determine an acceptable level of discards. Enforcement of discard regulations is likely to encounter the same practical problems whether the regulations are designed to prevent or to minimize discards. However, the ethical interpretation, management philosophy, regulatory framework and design and application of measures are substantially different in the "no-discard" approach. This approach would benefit from a detailed appraisal in terms of its impact on resources and broader application in other fisheries. For example, many fishers in the United Kingdom are opposed to a "no-discard" regime, regarding it as unworkable and claiming, with some justification, that discards are unavoidable (Agricultural Economics Research Institute, 2000). Further analysis of the rationale behind such views may be of value in seeking effective management approaches.

4.3.2 Implications of generic fishery regulations on discards

Many generic fishery regulations may promote discards or do little to minimize or eliminate them. As discard practices are determined by a wide range of factors, it is difficult to attribute changes in these practices to a given regulation or set of regulations. Fishery managers often face a regulatory dilemma since regulations designed to protect one species may increase bycatch or discards of another. The groundfish fisheries of Alaska provide a history of different regulatory approaches to discard practices.

Effort control

Overfishing often contributes to discards since declining average sizes tend to make the catch less marketable. A reduction of fishing effort (e.g. through fleet capacity reduction, closed seasons, days-at-sea programmes) can make a significant impact on discard practices.

Minimum landing size (MLS)

MLS regulations[102] almost invariably promote discards since MLS is difficult to harmonize with the selectivity of the fishing gear, particularly in multispecies fisheries. In these fisheries different sizes and shapes of fish are likely to have a wide range of MLS, often determined as a function of the size at first maturity of each species, rather than as a function of the gear selectivity. A recent change in MLS in the North Sea

[102] "... the only practicable method of checking the depletion of the North Sea fishing grounds and enabling the fish supply to recover is by legislation based on the principle of the size limit" (Holt, 1895).

simply "legalized" the previous discards of juvenile plaice caught in the trawl fishery targeting sole. In fisheries where there is a high discard survival rate (e.g. lobster), MLS regulations are important. When increased recruitment results in large year classes of juvenile fish, discards may increase if MLS regulations are applied. MLS regulations are often applied only at landing sites and not at retail markets or restaurants (which, for example, commonly serve undersized fish, including fish larvae and lobster). MLS regulations may also conflict with obligations to land bycatch.

Minimum mesh size (MMS)

MMS is closely linked to MLS. Increasing MLS without accompanying increase in mesh size will only increase discards. Several countries show inconsistencies between MMS, MLS and size at first maturity of the target species. Mesh alone does not determine selectivity of the net and hanging parameters may be equally important. Rigging of the fishing gear, and trawl gear in particular, exerts a major impact on selectivity and can entirely undermine mesh size regulations. Many jurisdictions lack trawl rigging regulations to complement those of trawl mesh size. This demonstrates poor awareness of such impacts or possible difficulties in framing and enforcing appropriate regulations. Codend mesh size is difficult to enforce without observers and costly sea inspection. Regulations limiting a vessel to carrying nets of one mesh size may encounter strong opposition by fishers who target different species on different grounds during the same trip. An increased mesh size may not reduce discards since 100 percent of many species are discarded (Allain, Biseau and Kergoat, 2003) and selectivity of gear may be highly variable in relation to the discarded species. Square mesh panels are obligatory in many fisheries.

Composition of landings

Senegal requires shrimp trawlers to land a minimum of 15 percent shrimp to retain a shrimp licence, thereby creating an incentive to discard. French dredgers keep worthless species on board merely to comply with the percentage regulations. Such regulations may be difficult to enforce effectively, particularly when weights have to be calculated as live-weight equivalent, as set out in the EC regulation.[103] However, although such measures have an economic cost, in the case of obligations placed on tropical shrimp trawlers to land bycatch, there is some evidence that these regulations reduce discards. Local landings of bycatch from distant water fishing vessels licensed to fish in coastal state waters may be considered an import by the coastal state and subject to import tariffs that render bycatch landings unprofitable.

Seasonal closures and time restrictions

These are common and useful measures, which reduce mortalities and discards of juveniles (Adlerstein and Trumble, 1998). Several Australian prawn trawl fisheries only open when the prawns have reached a certain size (e.g. Spencer Gulf, South Australia). Time restrictions are applied in varying levels of detail. For example, if hake comprises more than 10 percent of landings in Argentine fisheries that do not target hake, then vessels are required to stay in port for 48–96 hours. Certain vessels are required to fish south of 48ºS and remain in harbour for 120 hours between trips.

Closed areas and area controls

These are usually general, rather than discard-specific measures. Closed areas are normally established to protect juveniles,[104] spawning grounds or areas of special

[103] It is illegal to land more than a certain percentage of cod and haddock when using a mesh size <100 mm (Council Regulation [EC], 1998).

[104] In European waters the Norway pout Box protects juvenile haddock to the east of Shetland; the Plaice Box restricts fishing to smaller vessels and is intended to protect juvenile plaice and sole. In the Mackerel Box, purse seining is prohibited to protect juvenile mackerel.

biological interest (e.g. coral reefs, *Posidonia* beds). Area restrictions include the creation of marine parks, areas reserved for traditional fishing activities and areas where certain gears are prohibited (e.g. no-trawl areas). Closed areas are likely to be of particular use in countries that pursue a "full catch utilization" strategy (e.g. in Southeast Asia). Obligatory change of fishing area is a common complementary measure[105] under "no-discard" regimes.

High catches of unwanted fish may trigger area closures in some fisheries. Norway enforces an active closure scheme to protect juvenile cod in the Barents Sea, i.e. the closed areas change in relation to the distribution of the undesirable bycatch of juveniles. The closures are determined according to the percentage of juveniles in the catch, based on combined information from research cruises, observer reports and monitoring of chartered commercial trawlers. Australia's northern prawn fishery provides another example of "active closures" to avoid catches of juvenile prawns, while the Gulf of Maine fisheries also make extensive use of area closures and "rolling closures" to protect juveniles or marine mammals. While these active closures have the advantage of responding to the current conditions on the fishing grounds, the costs of administering such regimes can be high. In the BSAI/GOA groundfish fisheries information on bycatch is rapidly collated and disseminated to enable vessels to avoid areas with high bycatch or, if necessary, close certain fishing grounds.

Fish handling

EU pelagic freezer vessels may be prohibited from installing graders or must install automatic sorting machinery so that fish "cannot be easily thrown back into the sea". Under Australia's Sub-Antarctic Fishery bycatch action plan, the discharge of dead fish, fish offal or by-products of fish processing is not permitted in order to minimize feed opportunities for seabirds and marine mammals. Offal and retained bycatch are turned into fishmeal and stored on board. The release of unwanted live fish, crabs, tagged live fish, skates and large sharks is permitted.

Operation of the gear

In addition to obligations to use TEDs and BRDs, gear restrictions include mesh size and hook size limits, specification of longlines hook type and leader material and requirements for escape panels in traps. Extensive and detailed records of gear alterations may be required in some fisheries. Regulations[106] governing the operation of gear may be difficult to enforce.

Quota regulation and discards

A number of studies[107] have addressed the issue of whether quotas, and individual transferable quotas (ITQs) in particular, foster discarding. The regulatory framework is but one factor determining discards and the quota regulations may not be the most

[105] For example, the Australia Sub–Antarctic Bycatch Action Plan (BCAP): where any haul contains more than 100 kg of mackerel icefish, and more than 10 percent of the icefish by number are smaller than 240 mm total length, the fishing vessel shall move to another fishing location at least five nautical miles distant. The fishing vessel shall not return to any point within five nautical miles of the location where the catch of small icefish exceeded 10 percent for a period of five days. If, in the course of fishing, the bycatch in any one haul of any species for which bycatch limitations apply is equal to or greater than two tonnes, the fishing vessel shall not fish using that method of fishing at any point within five nautical miles of the location where the bycatch exceeded two tonnes for a period of at least five days (Australian Fisheries Management Authority, 2003). Similar regulations apply in the NAFO area. See NAFO/FC Document 02/9, Serial No. 4624.

[106] For example, in the Northeast Pacific midwater trawls must be kept off the bottom when the bottom trawl fishery is closed.

[107] Numerous studies have addressed this issue, *inter alia*: Copes, 1986b; Arnason, 1995, 1996; Pascoe, 1997.

important regulatory cause of discards in a given fishery (e.g. MLS regulations may be more important). Building flexibility[108] and allowing quota transfers may help reduce discards resulting from quotas. While many EU fisheries do not operate under formal ITQ systems, there is little doubt that the regulatory discards resulting from the EU's quota system is a major cause of discards in many EU fisheries. Trip limits may also cause discards of legal-sized fish.

Bycatch quotas

Bycatch quotas[109] exist in many fisheries (e.g. South Africa, United States, New Zealand). Under the United States Sustainable Fisheries Act, allocations of regulatory discards may be transferred to individual fishing vessels as an incentive to reduce per vessel bycatch and bycatch rates in a fishery, provided that "(i) such allocations may not be transferred for monetary consideration and are made only on an annual basis; and (ii) any such conservation and management measures will ... result in an actual reduction in regulatory discards in the fishery" (see Annex A.6.1 for further details of the Alaskan arrangements).

Observer programmes

Seagoing observers are crucial for monitoring discards. Observers normally have a range of monitoring functions (and possibly an enforcement role), and monitoring of discards may not be a priority function. Training and skills of observers vary widely, as do the quality of observer reports and the use made of them. The presence of observers may influence discarding practices, particularly if the observer role is to report infringements of regulations. The low cost of observers makes them an important tool for monitoring in developing countries. The EU has a particularly low level of observer coverage, while there is increasing public pressure for a high level of observer coverage in North American fisheries (e.g. the Oceana petition). Monitoring of discards is an essential observer function in the United States Northeast Pacific groundfish fisheries.

4.4 BYCATCH AND DISCARD MANAGEMENT FRAMEWORKS

Comprehensive bycatch and discard management frameworks are in place in several countries and fisheries. In contrast to the bycatch/discard reduction strategies described below, fisheries development and management plans in Southeast Asia focus on bycatch utilization and value added.

Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)

CCAMLR has adopted an ecosystem approach to fisheries management and provides a comprehensive framework of management measures, many of which address bycatch and discard issues. The measures (CCAMLR, 2002b) directly related to bycatch and discards can be grouped as follows: reporting, gear regulations, bycatch limits, area and time restrictions, and mitigation measures (primarily directed at reducing seabird mortalities). The comprehensive CCAMLR framework is reflected in several other fishery management regimes, in particular in those countries where incidental catches of endangered species have attracted a high level of public awareness. NAFO and ICCAT are among the other regional fisheries management organizations that have established discard databases.

[108] For example, some Norwegian fisheries allow individual fishers to substitute their quota in species A with quota in species B at predetermined ratios of substitution.

[109] The PFMC sets the discard rate at 16 percent for major species (range 5–20 percent). See the NPFMC Web site for regulations concerning numerous other bycatch reduction measures.

BOX 2
Guiding principles in Australia's bycatch policy

An overarching objective of the policy is to ensure that bycatch species and populations are maintained at sustainable levels. Within this are the following sub-objectives:

- reduce bycatch;
- improve protection for vulnerable/threatened species;
- minimize adverse impacts of fishing on the aquatic environment.

All decisions and actions to address bycatch will:

- foster stewardship of Australia's aquatic resource, i.e. maintain and improve the quality, diversity and availability of fisheries resources, including fish habitats, and the integrity of the aquatic ecosystem into the future;
- promote cooperative and transparent approaches involving all stakeholders for effective stewardship of our aquatic resources;
- integrate short-term considerations with long-term goals in managing aquatic resources;
- use robust and practical methods to assess bycatch so as to make decisions on management;
- recognize the unique biological, economic, cultural and social nature of individual fisheries;
- encourage cooperation in the development of complementary and effective arrangements among relevant authorities where stocks overlap, are split between jurisdictions or are migratory;
- ensure the widest adoption of bycatch mitigation measures through collaboration between the commercial, recreational, charter and indigenous fishing sectors, research and research funding organizations, environment and nature conservation agencies and fisheries management agencies; and
- apply a precautionary approach to the management of fish and aquatic resources.

Australian Fisheries Management Authority (AFMA)

4.4.1 Australia: bycatch policy and action plans

Discard problems are subsumed under Australia's bycatch policy and action plans. Central to the policy is a recognition that bycatch is a resource, environmental, educational, engineering and economic issue and needs to be addressed strategically and in a focused, coordinated manner.

The policy recognizes that there will be different requirements for addressing the bycatch issue in different fisheries. AFMA coordinates the efforts of various interest groups to develop fishery-specific bycatch action plans by establishing bycatch action plan working groups consisting of scientific, industry, government and conservation members. All 21 Commonwealth fisheries are required to prepare bycatch action plans to reduce the impacts of fishing on non-target species. The plans are in various stages of preparation, approval and implementation and cover a wide variety of fisheries including shrimp trawl, fish trawl, scallop, longline and tuna fisheries.

Bycatch action plans identify the specific bycatch issues in a fishery and detail actions required to address these issues. The bycatch action plan is then integrated into the management arrangements for the fishery to enable the actions to be implemented. Once completed, bycatch action plans will be reviewed annually in line with Commonwealth policy.

BOX 3
United States – Managing the nation's bycatch

"The fundamental national goal of NMFS' bycatch-related activities is to implement conservation and management measures for living marine resources that will minimize, to the extent practicable, bycatch and the mortality of bycatch that cannot be avoided. Inherent in this goal is the need to avoid bycatch, rather than create new ways to use bycatch."

To accomplish these objectives, the report on Managing the nation's bycatch (NMFS/NOAA, 1998a) made recommendations in the following areas:

- bycatch monitoring and data collection programmes;
- research on the population, ecosystem and socio-economic effects of bycatch;
- research to increase the selectivity of fishing gear and increase the survival of fish and protected species that are inadvertently encountered by fishing gear;
- incentive programmes for fishers to improve bycatch performance;
- analysis of the implications of conservation and management measures for bycatch; and
- exchange of information and development of cooperative management approaches.

Steps to be taken:

- determine the quality of information on the magnitude of bycatch;
- evaluate the impacts of current bycatch practices on populations, fisheries and ecosystems;
- evaluate the effectiveness of current bycatch management measures;
- identify potential management alternatives;
- evaluate the population, ecosystem and socio-economic effects of each alternative;
- choose and implement an alternative; and
- evaluate the effectiveness of the implemented measures.

4.4.2 United States: managing the nation's bycatch

The Magnuson–Stevens Fisheries Conservation and Management Act (FCMA), which is the principal United States fisheries management instrument, requires that bycatch be avoided or, where it cannot be avoided, that mortality be minimized. There are some differences between this and other major laws. The Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) require zero mortality rates while the Magnuson–Stevens Act indicates a reduction in bycatch "to the extent practicable".

Federal fisheries operate under fishery management plans (FMPs), which must contain management provisions to eliminate or reduce bycatch of all kinds. Under the Sustainable Fisheries Act (SFA) and as an integral part of each FMP, the fishery management councils (FMCs) were required to:

- standardize reporting methods to assess the amount and type of bycatch in managed fisheries;
- adopt conservation measures that minimize bycatch through avoidance; and
- minimize the mortality of bycatch that cannot be avoided.

4.4.3 European Union: Community action plan to reduce discards of fish

By virtue of the heavy reliance on quota systems in the Common Fisheries Policy (CFP) on conservation, discards in the EU are relatively high. Declining quotas and stocks result in significant discards of commercially valuable fish as a result of highgrading and quota limits.

BOX 4

European Union – On a community action plan to reduce discards of fish

"… the Commission will come forward with regulatory measures to reduce catches of younger fish, bycatches in mixed fisheries and discards.[1] Such measures will include:

- the introduction of more selective fishing gear, such as nets with larger meshes;
- square mesh panels, separator grids and changes in design and rigging of such gear in order to improve selectivity;
- restrictions on fishing to protect juvenile fish, sensitive non-target species and habitats;
- minimum landing sizes in line with the selectivity of the gear concerned;
- 'discard ban trials' in which representative samples of fishing vessels would be encouraged by economic incentives to retain their entire catch;
- the targeting of economic incentives for the use of more selective fishing practices;
- a voluntary code of conduct intended to reduce discarding;
- scientific and technical monitoring of fishing practices that result in discarding."

A/RES/57/142

[1] Extracted from European Commission, 2002a. See also European Commission, 2002c.

There is widespread recognition of "the discards problem" among fishers and administrators. Numerous studies by the EC and ICES have not adequately quantified discards in the EU, partly because of weak discard sampling and observer coverage. Several closed areas or boxes exist to protect juveniles. Bycatch and discard reduction relies heavily on technical measures, which are difficult to enforce. The preparation of production plans by producer organizations as provided under the CFP's markets policy may also provide an indirect entry point for discard management.

EU policy and practice on discards are substantially in arrears of the United States and Australia as illustrated by the preliminary nature of the recent "Communication from the Commission to the Council and the European Parliament" (European Commission, 2002a).

4.4.4 Private sector initiatives

Numerous authors have stressed the need for fisheries administration and researchers to work closely with the fishing industry (fishers, fishing companies, product developers, gear specialists) on bycatch and discard management. A variety of private sector initiatives exist. In Australia there has been close collaboration with industry in the gradual introduction of BRDs. Essentially similar approaches have been pursued in the New Zealand hoki fishery and the Alaska pollock fishery in the Northwest Pacific (see Annex A.6).

4.4.5 Planning framework

A comprehensive and structured approach to discards and bycatch is required. It implies a clear statement of policy with regard to discards, a description of strategies and an implementation plan. Ideally, the discard/bycatch plan(s) would be an integral component of fishery management plans. Southeast Asian countries have held discussions on discards and formulated an action plan to reduce unwanted catch in the region (SEAFDEC, 2003).

Monitoring of bycatch and discards needs to be an integral part of the fishery research component of the management plan. A clear understanding of discard patterns

BOX 5
Generic framework for a bycatch/discard management plan

1. Acquire information on bycatch and discards.
   - Determine magnitude of discards – observer programmes are usually indispensable.
   - Assess impacts (biological, social and economic) with a focus on major undesirable impacts.
   - Establish the spatial and temporal patterns and particularly the capability of fishers to control levels of unwanted bycatch.
2. Formulate bycatch/discard management policies and objectives as an integral part of a fishery management plan.
   - Account for the imputed costs of discards in the economic management framework of the fishery.
3. Measures.
   - Review/evaluate effectiveness of existing measures.
   - Identify/evaluate alternative measures.
4. Decision framework and evaluation.
   - Create decision framework/criteria in association with stakeholders.
   - Decide/implement new measures. Monitor effectiveness and review impact.

is required. Factors such as light intensity, tides, gear rigging and skipper habits all affect the discard pattern (Catchpole, Gray and Frid, 2002). Education and awareness have been shown to be an essential part of the discard management process. Similarly, stakeholder involvement is crucial (Lart, 2002), in particular with regard to initiatives to introduce gear modifications or regulatory measures. The effects of measures to reduce bycatch and discards must be clearly demonstrated and the costs of changes distributed equitably.

4.5 BIOLOGICAL AND ECOLOGICAL ISSUES

The provision of scientific advice relies on an accurate understanding of the state of fish stocks. Discard information is included in few[110] stock assessments partly because of the lack of adequate discard information. This omission may lead to inaccurate conclusions or substantial differences between assessments (Casey, 1996). However, if large, highly diverse fishing fleets are being sampled by a small handful of observers faced with many practical difficulties, there is a risk that stock assessments will be made less, rather than more accurate by the addition of the resulting raised estimates of discards.[111] Questions associated with discard sampling and raising of discard estimates are addressed in Annex C.

4.5.1 Selective fishing, discards and the ecosystem approach

Promoting more selective fishing is one of two principal approaches to discard reduction. Fisher behaviour and fishing gears are by nature selective. Fishers do not want to catch fish that cannot be sold or that create sorting difficulties. Typically, demersal trawling is considered to be at the less selective end of a range of fishing activities while handlining is at the more selective end. Fishing activities such as trawling, which cause mortalities across many trophic levels, marine communities or species groups, are more likely to generate discards. However, selective fishing is more

[110] Baltic stocks, North Sea haddock, northern hake (ICES) and some United States stocks are examples.
[111] ICES, 2002. See also ICES, 1985. There is a difference between short– and long–term stock assessments particularly if discarding is variable. If age–based stock assessment is not carried out then discard information may be of little or no value for stock assessment.

likely to alter the balance of species in the ecosystem and across the trophic levels. In the absence of an empirical framework for valuation of species and biodiversity, value judgements may be necessary to resolve apparent inconsistencies between advocating more selective fishing and the "ecosystem approach".

4.5.2 Discard survival

Determination of the survival of discards is important:

- where discard information may be used in stock assessments;
- to assess ecological impact of discards; and
- to assist in designing mitigation measures, including the design of the fishing gear, the use of the gear and the sorting and handling of catch.

A wide range of studies[112] have been made on discard survival and a number of clear relationships are well recognized.

- In trawl[113] fisheries, survival is related to the duration and depth of the haul, the type of bottom substrate and the species involved.
- Soak time, location and shape of the hook have a significant influence in longline and gillnet fisheries.
- Finfish with air bladders that expand as they are hauled to the surface have a low survival.
- Crustacean survival largely depends on the extent of the physical damage caused by the fishing and sorting activities (Wassenberg and Hill, 1989). Discards of benthic crustacea and molluscs tend to have a higher survival if discarded in the location in which they are caught.
- Fish released from sport fishing have a high survival rate.
- Post discard mortality through predation may be important.

4.5.3 Ecological impacts

Many of the ecological impacts[114] of discards remain unquantified. The combined impact of the trawl damage to benthos and of discards may have a positive impact on the growth of target species through an energy shunt along the food chain or fertilizing unproductive sea floor (Rijnsdorp and van Beek, 1991). Evidence suggests that benthic discards are rapidly reassimilated into the food chain (Groenewold and Fonds, 2000). The physical presence of decomposing discard materials, together with downcurrent odour trails, may lead to avoidance of the area and localized anaerobic conditions (Chapman, 1981).

A number of studies (Camphuysen *et al*., 1995) in European waters have shown that discards are a major food source for seabirds[115] (approximately 18 percent of 600 000 total food requirement were discards) in the North Sea. Overall consumption rates were estimated at 95 percent for offal, 80 percent for roundfish, 20 percent for flatfish and 6 percent for benthic invertebrates. The mass of discards eaten, including offal, was estimated to be more than the amount of live fish (265 000 tonnes) taken by seabirds. Thus the discards support substantial bird populations, which further prey on fish.

The impact of discards on biodiversity is not well understood. Isolating the effect of discarding from other effects of fishing is difficult (Lindeboom and de Groot, 1998;

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[112] For example, a study on the Great Barrier Reef showed that 98 percent of discarded finfish and cephalopods die. Approximately 12 percent of crabs, bivalves and echinoderms survived, thereby considerably altering the proportions of the phyla and species in the benthic biomass. There was a tenfold increase in crested tern populations caused by scavenging on the floating discards (Hill and Wassenberg, 2000). For further details see ICES, 2000c; Davis, 2002; Mesnil, 1996.

[113] Survival of fish passing through square mesh panels on top of the net is up to 65 and 90 percent for Scottish *Nephrops* and demersal fishing respectively.

[114] A separate FAO study addresses the ecological aspects of discarding (Poseidon Aquatic Resource Management Ltd, 2003). See also FAO, 2001a.

[115] "When seagulls follow trawlers, it is because they know sardines will be thrown into the sea." Eric Cantona cited by Cook, 2001.

ICES, 2000d). The measurement of discards at the species level and quantification of survival of the species present problems. As previously noted, reports also tend to lump together the discards of unknown numbers of finfish[116] and invertebrates. In general, discarding is likely to favour scavengers.

4.6 TECHNICAL AND ECONOMIC ISSUES

4.6.1 Bycatch utilization

Bycatch utilization has been addressed in a series of FAO reports, which make numerous recommendations that are not detailed in this publication (FAO, 1997; FAO/DFID, 1998; FAO/UNDP/Government of Madagascar, 1995).

Tropical shrimp trawl fisheries face a particular range of difficulties. Vessels are often small and have little room for bycatch.[117] Landing large volumes may undermine the price of bycatch and prices for artisanal producers. Collection at sea must be highly cost effective and processing and distribution must be simple and inexpensive to avail of limited purchasing power. Legal restrictions on transhipment must be removed. Collectors may require medical certificates (to comply with shrimp export requirements). Arrangements for crew compensation and avoidance of shrimp contamination are required. Creation of bycatch collector associations and codes of practice may be needed to avoid theft of shrimp and to conclude agreements with vessel owners. Radio communication systems may also be necessary.

Experiences from Latin America, India and Africa indicate that stable arrangements for at-sea collection of bycatch in tropical shrimp fisheries can be developed through broad-based commercial agreements between groups of bycatch collectors and the fishing companies; through provision of credit; and through support for processing, marketing and distribution facilities.

4.6.2 Gear technology and selectivity

Gear technology and selectivity are specialized subjects and are not addressed in any detail here. A wide range of developments continue to have a significant impact on bycatch and consequently on discarding.

- Longlines: hook selectivity,[118] restrictions on wire traces and minimum lengths of longline gudgeons to reduce unwanted shark bycatch or to increase survival rates; night setting; appropriate deck lighting to reduce bird attraction; disposal of offal; use of streamers, weights and line shooters for underwater setting; examination of the relationship between propeller rotation and line sinking.
- Biodegradable escape panels in pots (Alaska) to prevent ghost fishing.
- Halibut excluder devices in pot fisheries (Alaska).
- Fish behaviour studies to identify fish electronically prior to catching in the trawl.[119]
- Use of multiple rig trawls likely to reduce cod bycatch in industrial fisheries (Denmark).[120]
- Flexible grids[121] built into trawl nets to pass through rollers (approved for Norwegian waters).

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[116] Sharks and seahorses are among the exceptions.

[117] See Kungsuwan, no date, for a discussion of vessel design.

[118] "Small hooks catch a large proportion of large fish, and large hooks a considerable proportion of small fish." Cunningham, 1896.

[119] In order to distinguish between small pelagics (some are low quota) that look identical on shipboard electronics (Triple Nine, an Esbjerg [Denmark] fishmeal company).

[120] Using eight trawls on five warps bycatch of cod was "practically none" in the North Sea prawn trawls (*Fishing News International*, 42, of 9 September 2003).

[121] The use of grids in shrimp trawl fisheries is relatively widespread. Their use in finfish trawl fisheries is less common but used *inter alia* in Argentina, the Faeroe Islands, Greenland, Canada, Iceland, Norway, the Russian Federation and Sweden (data from 1998).

BOX 6

Mesh size and minimum landing size[1]

In 2001 technical regulations in the heavily overfished Baltic cod fishery were revised by the IBSFC on the basis of scientifically solid international research. However, managers refused to follow the recommendations of "a one net rule", likewise a harmonizing of selectivity and MLS. Thus the minimum landing size of 35 cm was maintained (subsequently increased to 38 cm) but the minimum mesh of traditional diamond mesh codend was increased from 120 to 130 mm and then to 140 mm in polyethylene codends and to 125 mm in polyamide codends.

The amendments of the fishing rules did not merely fail to meet their objectives. They made the situation even worse. The length distribution of annual landed trawl catch remained unchanged despite the increase in minimum mesh size until the MLS was increased in January 2003 to 38 cm. Because no change in the selectivity of the widely used traditional diamond mesh codend was made, all fish between 35 and 38 cm were now undersized and consequently discarded. Thus it was the MLS and not the mesh size that determined which part of the catch was landed, indicating that the objective of increased selectivity had gone terribly wrong.

Swedish fisheries observers on board estimated that in January 2003, on average, 34 percent of trawl catches consisted of undersized cod and in April 2003 this devastating waste of resources forced the EC to stop the trawl fishery in EU waters.

[1] Adapted from Valentinsson and Tschernij, 2003.

- Turtle excluder devices (TEDs) in many industrial shrimp fisheries.
- Bycatch reduction devices (BRDs), particularly in the Gulf of Mexico and Australian trawl fisheries and in the Argentine hake and shrimp fisheries.
- Use of square mesh panels in *Nephrops* fisheries.
- Regulation of soak times for gillnets.

The gear technology *per se* is not necessarily the limiting factor in discard and bycatch reduction. The economic consequences of introducing gear modifications[122] are possibly the single most important constraint. This further emphasizes the need for a close partnership with industry in the introduction of BRDs and more selective gears in a gradual and adaptive manner. Because of the steep slope of the selectivity curve of bottom trawl mesh, increases in mesh size are not likely to have major impacts on discard levels.

Studies[123] on BRDs for the Gulf of Mexico shrimp fishery (primarily intended to reduce mortality of juvenile snapper and related species), showed that an increase in finfish biomass as a result of the BRDs could result in an increase (up to 4 percent), or a decrease (up to 17 percent) in shrimp biomass. A linear relationship between predation and shrimp biomass was developed. The protocols developed for testing of TEDs and BRDs provide a useful model for such work in similar fisheries.

In some fisheries the introduction of BRDs including square mesh panels has been industry driven by the need to exclude jellyfish, reduce discards of target species, comply with trade practices regarding turtles or reduce the costs of sorting fish.

[122] Gear definitions can be problematic. "… shall be prohibited to use any demersals trawl …or towed gear …, gillnet or similar static gear incorporating hooks …". Council Regulation (EC), 2002.

[123] Modelling studies tested several predator/prey relationship scenarios. For a summary see NMFS/NOAA, 1998b; Robins, Campbell and McGilvray, 1999.

A BRD technology clearinghouse or network of expert resources would be of value. In addition to the technical aspects of BRDs associated fish behaviour studies, the clearinghouse could establish guidelines for the introduction and acceptance of BRDs by fishers. Advice on framing and application of the required regulations would also be valuable. FAO is currently preparing technical guidelines on bycatch reduction in shrimp trawl fisheries.

4.6.3 Economic issues

Two sets of economic issues arise in relation to discards:

- the costs associated with discards at the level of the fisher, the fisheries authorities and society in general; and
- the use of economic measures to reduce discards.

Costs and benefits to fishers

At the level of the fisher, the act of discarding involves an economic decision, usually of a short-term nature (day/trip/season). The fisher weighs the costs and benefits of a wide range of factors such as the following:

Cost factors

- Value/amount of hold space/freezer capacity
- Cost of sorting and crew share
- Cost of freezing/catch preservation
- Weather and composition of future catch
- Landing costs/taxes

Benefits/losses

- Price of fish/bycatch
- Loss of quality in target catch
- Bycatch quota (if existing)

Of particular interest are schemes for special compensation for crews regarding retention of species with marginal value, which might otherwise be discarded. Bycatch in tropical shrimp fisheries is often considered the "property" of the crew, although vessel operators may discourage bycatch retention because of loss of shrimp quality or fears of theft of shrimp through transhipment at sea.

Regulations on discards and incidental catch force fishers to adapt their fishing techniques and operations with possible loss of efficiency and returns. Discards have had a major economic impact in the Alaska groundfish fishery. Operators are obliged to discard Pacific halibut, which is managed under a separate regime (International Pacific Halibut Commission [IPHC]). When the halibut discard quota is filled, the fishery may close or move to less profitable fishing areas, resulting in major economic losses (Trumble, 1996). Fishers will assess the costs, potential losses[124] and possible benefits associated with the use of BRDs or other measures designed to reduce discards or bycatch, e.g. BRDs introduced in New South Wales resulted in a decline of 90 percent in discards and employment of one less crew per vessel. The economic impact of incidental catch and discards on trade has already been noted.

Costs to the administration

The costs of monitoring and control can be substantial. In the United States the costs associated with enforcement of the Marine Mammal Protection Act and Endangered

[124] Substantial financial losses can be incurred by the introduction of square mesh panels. See Rommel and Napier, 1999.

Species Act alone account for over 10 percent of total monitoring, control and surveillance costs. Observer programmes and efforts to acquire discard information for stock assessment may also involve significant costs.

Costs to society

Few comprehensive studies have been carried out on the cost of discards to society and on who bears such costs. The costs to society of losses of charismatic species or of ecosystem change resulting from discards (which could be positive) have not been identified. Assessment of the costs of discarding and the costs and benefits of measures relating to bycatch and discards will help in designing appropriate management programmes.

One of the most detailed studies on the estimated costs of discards was carried out in the North Sea. The study estimated that approximately 15 000 tonnes of landings of plaice, sole, cod and whiting were foregone as a result of discards in the North Sea *Crangon* fishery (Revill *et al*., 1999). These foregone landings were valued at 25.7 million euros. The estimated annual cost of discarding in three EU case studies varied from approximately 70 percent of total annual landed value in the Netherlands case to 42 percent in the United Kingdom whitefish case and 43 percent in the French *Nephrops* case (Nautilus Consultants, 2001). These studies focused on costs related to commercial species and did not address the more complex questions of costs associated with the ecosystem impact of discards.

In 1994, all BSAI groundfish fisheries discarded an aggregate total of 162 161 tonnes of allocated groundfish species for which a total allowable catch had been set. The opportunity cost of these discards exceeded US$92 million. The total retained catch of all groundfish species in these fisheries was just over 1 699 500 tonnes with a value in excess of $925 million. Thus, the ratio of the value of retained catch to discards (retained/discard value ratio), weighted by fishery across all BSAI groundfish fisheries, was 10:1. That is, for each dollar of bycatch "opportunity cost" imposed, $10.10 of output was produced from retained catch. Individual rates varied from a high of $29.20 in the pollock target fishery, to a low of $2.40 in the "other" groundfish target fishery. Discarding was estimated to have a social cost of $25 million per annum in the southern New England yellowtail flounder trawl fishery (1998–1994 period).

In contrast, the use of BRDs to reduce mortalities in the red snapper fishery was estimated to incur losses of $117 million in the shrimp fishery (NMFS, 1998). The costs of discards may be shifted. The Gulf of Mexico shrimp fishery discarded significant quantities of juvenile snapper, thereby depleting snapper stocks. The shrimp fishery has had to absorb the costs of snapper bycatch reduction, although the costs to the shrimp fishery may surpass the economic value of the snapper fishery.

Conflicts

Discards are a common source of conflict between artisanal and industrial fishers, particularly when large quantities of discarded fish are seen floating at sea or rotting on beaches. Apart from the waste of resources perceived by artisanal fishers, a common complaint is that the "trawlers are polluting" the sea with dying fish and destroying juvenile stocks. Even when unwanted bycatch is landed, competition with artisanal fish production can be the cause of further conflict.

Economic incentives for reduction of discards

Several authors[125] address the economic aspects of discards. Many such studies model the theoretical economic impacts or social optima of different discard and bycatch-

[125] For example, Copes, 1986a; Arnason, 1994; Boyce, 1995.

related measures based on assumptions regarding fishers' behaviour. A range[126] of economic incentives for discard reduction can be built into a fisheries management regime. Taxes[127] can be imposed on discards or a charge based on the estimated value of the entire catch, including discards, may be applied[128] through royalty or licence fee payments. It is then up to vessel operators to make best use of the entire bycatch for which they are already being charged. Development of theory on discard regulation may draw on regulatory frameworks and models that consider discards to be a form of environmental damage (Segerson, 1988). Iceland has operated a "bycatch bank" to assist in commercializing unwanted fish. Quotas may be debited for failure to land in proportion to a predetermined length frequency distribution or charges[129] may be levied for failure to land bycatch. Subsidies leading to fleet overcapitalization and reduced profits may pressure vessel operators to land previously discarded bycatch (Bostock and Ryder, 1995).

Licence or other fees may be discounted for use of BRDs. As a result of a Congressional ban on ITQs, they were not considered as an option in the important United States shrimp fisheries (e.g. Gulf of Mexico) as part of the 1996 regulatory impact review. Obligatory use of BRDs was recommended as a least cost solution ($117 million/year for a 44 percent reduction in red snapper bycatch) in this fishery.

Placing a monetary value on discards raises fundamental theoretical problems of valuation of natural resources, e.g. the use of cost–benefit analysis in relation to environmental issues. Existence values associated with biodiversity or discards (mortalities) of charismatic species may be highly subjective, possibly because no objective valuation framework exists.

[126] For a comprehensive discussion see Pascoe, 1997. For a discussion of deemed values and other options see Baulch and Pascoe, 1992; Willmann, 1996.

[127] For a theoretical model of such a scheme see Jensen and Vestergaard, 2000.

[128] This procedure is followed in Eritrea with respect to foreign vessels. The catch is monitored by 100 percent observer coverage.

[129] This is an option built into some fisheries access agreements, e.g. in Sierra Leone.

5. Conclusions

5.1 SCOPE OF THE STUDY

The study established a method for assessing discards at the global level by creating a fishery-by-fishery database of landings and discards. The estimate can be checked or updated through change to individual records of the fisheries. This database is supplemented by a searchable bibliographic database and electronic archive of many of the reference materials used in the study. It should be recalled that the sample excludes a number of important fisheries, notably those in the Russian Far East, the Democratic Republic of Korea, the Republic of Korea, New Zealand and in United States non-Federal fisheries. No allowances are made for illegal, unreported and unregulated (IUU) catches.

The assessment is based on a number of assumptions. A linear relationship between discards and total landings was assumed. The total quantity of discards was derived by raising the discard rates obtained from studies by total landings of these fisheries. Based on expert opinion, fisheries in some countries (notably South and East Asia) were assigned zero discard rates. Similarly, artisanal and subsistence fisheries in many countries were assumed to have low or negligible discards, while fisheries harvesting small pelagics for fishmeal were generally considered to have negligible discards. It has not been possible to eliminate double counting entirely, particularly with regard to the tuna fisheries, since the discard assessment for these fisheries used data from the international tuna management organizations rather than from national sources.

5.2 PRINCIPAL CONCLUSIONS

The current estimate of the global level of discards is concluded to be substantially lower than the 1994 estimate. The aggregate landings matching the discard data in the database total 78.4 million tonnes or 94 percent of the average global nominal marine catch of 83.8 million tonnes.[130] The corresponding discards total 6.8 million tonnes, giving a weighted discard rate of 8.0 percent for the sample. Applying this sample discard rate to the average global nominal catch gives an estimated annual total of 7.3 million tonnes of discards for the 1992–2001 period.

In geographical terms, the Northeast Atlantic (1.4 million tonnes), the Northwest Pacific (1.3 million tonnes) and the Western Central Atlantic (0.8 million tonnes) generate the highest discards. Differences in discard rates between developed and developing fishing nations are not readily apparent except in the case of Southeast Asia where discards are generally negligible because of almost full utilization of the catch. The global values conceal a wide range of discard rates. Trawl fisheries and shrimp fisheries account for 55 and 27 percent of the recorded discards respectively.

No coherent time series of discard rates is available at the global level. However, from case studies of a wide range of fisheries, it is apparent that the global level of discards has decreased in recent years. This is a result of both bycatch reduction and increased bycatch utilization. Bycatch reduction has occurred not only in Organisation for Economic Co-operation and Development (OECD) countries (e.g. Northwest Pacific, Gulf of Mexico, Gulf of Carpentaria, NAFO area) but also in other countries

[130] As recorded by FAO Fishstat for the 1992–2001 period and excluding plants and aquatic animals, i.e. marine mammals and reptiles.

that have introduced bycatch reduction measures (e.g. Argentina and other Latin American countries).

Increased bycatch utilization has been widespread in Asia, Africa and South and Central America. Increasing human consumption, improvements in technology (e.g. surimi products) and the expanding market for aquaculture and animal feeds have also contributed to this increase.

Incidental catch and discard of charismatic species are creating increased difficulties for trawl, longline, gillnet and purse-seine fisheries. Additional mitigation and trade measures may reduce the economic performance of such fisheries. The development of technologies and enforcement of measures for bycatch reduction and incidental catch mitigation continue to offset possible further restrictions and declines in these fisheries.

5.3 ISSUES AND FUTURE DIRECTIONS

5.3.1 Fishery management issues

Quantifying discards

Quantifying discards poses a range of difficulties in sampling, raising and making effective use of results. Observer programmes appear to be essential for accurate quantification of discards in most fisheries. The impacts of discards are not easily quantified and the methods for such impact assessment require further development, with particular reference to physical accounting and valuation of the broader ecological impacts.

Public policy

The United Nations General Assembly (UNGA) resolutions, the Code of Conduct for Responsible Fisheries (CCRF) and the International Plans of Action (IPOAs) are valuable starting-points for public policy on discards. The range of policy options is determined by both the biological characteristics of the fishery and the social and economic environment. Best practice in bycatch reduction is illustrated by a number of OECD countries, while East and Southeast Asian countries provide valuable experiences in utilization of bycatch.

A "no-discards" approach to fisheries management holds the high moral ground and is in conformity with UNGA resolutions and the CCRF. However, the comparative ecological and social benefits of such an approach need further assessment and its application in some fisheries may not be practical, at least in the medium term. A range of complementary measures is required to support an effective "no-discards" regime.

Management framework

Each fishery or management unit is likely to require a specific suite of measures to optimize bycatch and discard management. Such measures may best be structured through a bycatch strategy and action plan formulated as an integral part of a fishery management plan. In overexploited fisheries, effort reduction is likely to be an essential approach to decreasing discards. Effort reduction may be neglected if efforts to promote bycatch reduction devices or other technical measures take a central role. Economic measures can make an important contribution to discard reduction and bycatch management.

Selective fishing

More selective fishing is advocated as a means of reducing discards. However, selective fishing is likely to alter ecosystem balance. Any inconsistency that may exist between promoting more selective fishing and the "ecosystem approach" requires attention from both theorists and practitioners in order to formulate best scientific advice. Small-scale fisheries tend to be regarded as being more selective than industrial-scale fishing.

However, by virtue of their ability to exploit most habitats, niches and trophic levels, a range of small-scale fisheries may have a more damaging effect on the ecosystem.

Discard survival
A high survival rate may reduce the negative impacts of discards. Practices to foster discard survival can be further evaluated and promoted.

5.3.2 Technical and economic issues

Utilization
Increased utilization of bycatch is an important approach to discard reduction. The extent to which promotion of ever-greater utilization of marine resources is consistent with sustainable and responsible fisheries may require attention. The transfer of improved utilization technologies between fisheries and countries may be of value in reducing discards and fostering fish food security.

Gear technology
Techniques and technologies for bycatch reduction and incidental catch mitigation continue to develop. A clearinghouse mechanism to establish the relative merits of different technologies and develop approaches to their successful introduction may be of value.

Trade
Incidental catch of charismatic and endangered species poses a threat to certain fisheries, as mitigation measures may restrict fishing operations and raise costs. In particular, trade in fish products may be disrupted. Since many charismatic species are migratory, internationally agreed measures may be required. Internationally accredited databases of such incidental catches may be necessary in order to evaluate the threats posed by fisheries and determine appropriate mitigation measures.

5.3.3 Possible FAO actions

Balancing reduction and utilization approaches
Many fisheries, particularly those in developing countries, are likely to seek a balance between bycatch/discard reduction and bycatch utilization strategies. Guidelines may be developed that assist the development of a balanced approach consistent with sustainability of the fishery, the CCRF and the "ecosystem approach". Case studies on discards in particular fisheries may be of value in further identifying solutions to discard problems.

Best practice
Expert advice may be synthesized to provide a catalogue of best practice with regard to discards and bycatch. The catalogue may include, *inter alia*: sampling and raising methodologies and use of observers; approaches to economic analysis of bycatch and discard issues; the use of discard information in stock assessments, TACs and fisheries agreements; evaluation of the impacts of discarding; development of appropriate policies, strategies and plans for bycatch and discard management; and means of building stakeholder awareness.

Through consultations at a technical level the regional fisheries organizations may also wish to strengthen their discard-related policies and programmes.

Discards and trade
The discard database may be expanded (or a parallel database established) to assemble available information on discards and/or incidental catches of charismatic and endangered species. Such an information base may serve as an accredited source

of information on the interaction between fisheries and these species. Institutional arrangements may be established to assess mitigation measures and facilitate international consensus on best practice in such measures.

Guidance from COFI

Following appropriate discussion and review of the numerous issues relating to bycatch and discards, an action plan may be submitted for the consideration of COFI. Based on a consensus of FAO member countries, a programme may be established to address the most important discard issues.

The discard database – an evolving tool

In order to maintain[131] the discard database as a means by which global discards can be periodically reassessed, landings and discard values should ideally be verified and updated by competent authorities at regional and national level. Available catch, bycatch and discard information may also be collated by fishery in a standardized manner at national level. Time series of discard information may be compiled for important fisheries. The merits of compiling global catch statistics on a fishery-by-fishery basis may be further explored. A link between the discard database and the FAO Global Fisheries Information System (FIGIS) database has already been established and the discard database will remain as a "domain" within FIGIS. Cross-linkages between Fishstat and fishery-by-fishery catch/landings information may also be created.

The discard database is potentially a powerful tool, not only for discard assessment but also as an initial contribution to a quantitative description of the world's marine fisheries on a fishery-by-fishery basis. This database may be extended in several dimensions, in particular by completing the field on the status of exploitation of each fishery. Additional fields indicating the value of catches would allow basic economic analysis by fishery at a global level.

[131] Funding for FAO's discard-related activities is provided under programme entity 233A1: "Reduction of Discards and Environmental Impact from Fisheries (2002–2005)" and planned under 233A6 "Impact of Fishing on the Environment (2006–2011)" (FAO, 2001c).

Annex A
Results: supplementary tables

A.1 SUMMARY OF DISCARD ESTIMATE WITH CONFIDENCE LIMITS

TABLE 14
Summary of discard estimate with confidence limits

Sum of landings (discard database) (tonnes)	78 432 299
Sum of discards (discard database) (tonnes)	6 824 186
Weighted mean of discard rates (weighted discard rate)	8.00%
Arithmetic mean of discard rates	14.59%
Fishstat ten-year average marine nominal catch 1992–2001 (tonnes)	83 805 355
Discard database landings as percentage of Fishstat ten-year average nominal catch	94%
Variance of discard rates (weighted mean)[1]	0.057
Standard deviation (using the weighted mean)	0.238
Standard error of weighted mean	0.011
Confidence (95%) R –	– 0.059
Confidence (95%) R +	+ 0.101
Correlation coefficient	13.31
Range of total estimated discards (discard database):	
Lower	6 420 441
Upper	7 512 897
Range for discard rate:	
Lower	7.57%
Upper	8.74%
Range of discard rates applied to Fishstat ten-year average global catch:	
Lower	6 860 277
Upper	8 027 573

[1] Standard deviation and confidence limits have been calculated with reference to the weighted mean. The variance refers to that of discard rates in the discard database and does not reflect the internal variance of individual records.

Source: discard database.

A.2 DETAILS OF DISCARDS BY TYPE OF FISHERY
A.2.1 Trawl fisheries

TABLE 15
Shrimp trawl fisheries with highest discards (tonnes)

Country	Fishery	Period	Landings	Discard rate (%)	Discards
Tropical shrimp fisheries					
United States	Gulf of Mexico shrimp	2000	116 408	56.9	480 183
Indonesia	Arafura Sea shrimp trawl	1998	53 786	81.7	239 594
Ecuador	Ecuador industrial shrimp	1996	24 113	79.1	91 211
Venezuela	East and west industrial shrimp trawl	1997	50 423	60.0	75 634
United States	South Atlantic Shrimp	2000	14 646	83.3	73 230
Coldwater shrimp fisheries					
Peru	Industrial shrimp trawl	2000	17 405	81.0	74 200
Argentina	Red shrimp tangoneros trawl	2000	36 823	50.1	37 000
Portugal	Algarve Nephrops and deepwater shrimp	1996	5 543	70.0	35 000
Japan	Small sail trawl	1994	388	95.7	8 691
Norway	Shrimp trawl in Nordsjøen/Skagerakk	Annual average	6 000	51.2	6 300

Note: in addition the United Kingdom (Area 27) *Nephrops* fisheries have discards in the order of 30 000 tonnes.

TABLE 16
Non-shrimp trawl fisheries with highest discards (tonnes) and discard rates

Country	Fishery	Period	Landings	Discard rate (%)	Discards
Fisheries with highest discards					
All fleets	North Sea beam trawl (sole flatfish directed)	Average	148 261	69.0	330 000
Japan	Small otter and beam trawl powered, other than shellfish	1994	166 584	60.5	254 874
Argentina	Hake otter trawl south of 41°S	1997	468 664	24.0	147 999
United States	Washington, Oregon, California multispecies groundfish	2002	165 730	44.0	130 216
Morocco	Industrial otter trawl demersal for cephalopods, Sparidae, hake	Recent average	96 771	30.0	95 565
Fisheries with highest discard rates					
France	Deepwater trawl western waters	1996	13 352	90.0	11 921
Portugal	Tagus estuary beam trawl for flatfish and Crangon		1 750	90.0	
Bangladesh	Industrial finfish trawl for Saurida, Upeneus, Sepia	Average	7 140	83.0	34 860
Belgium	Flatfish beam trawl	1999	23 000	75.0	69 000
Brunei Darussalam	Multispecies finfish and penaeid trawl	1998	1 214	74.2	3 579
United States	GOA catcher processor trawl Rex sole directed	2001	7 621	69.1	5 268

TABLE 17
Selected demersal otter trawl fisheries with high discards (tonnes)

Country	Fishery	Period	Landings	Discard rate (%)	Discards
Morocco	Foreign demersal multispecies[1]	Recent average	146 746	30.0	106 308
Morocco	Industrial demersal for cephalopods, sparids and hake[2]	Recent average	96 771	30.0	95 565
France	Offshore multispecies demersal trawl for finfish and Nephrops	Recent average	162 484	28.1	63 502
Japan	Offshore trawl for walleye pollock, greenling and squid	1994	442 412	12.3	61 938
Bangladesh	Industrial finfish trawl for Saurida, Upeneus and Sepia	Average	7 140	83.0	34 860

[1] Fishery now largely ceased. [2] Moroccan flag.

TABLE 18
Midwater (pelagic) trawl fisheries with highest discards (tonnes)

Country	Fishery	Period	Landings	Discard rate (%)	Discards
Morocco	Foreign Atlantic sardine, mackerel, horse mackerel	Recent average	724 680	2.5	35 982
Ireland	Mackerel, horse mackerel, blue whiting	2001	155 450	11.0	19 213
Netherlands	Horse mackerel	1994	110 000	11.8	14 717
France	Sardine and tuna	Recent average	22 637	37.7	13 698
France	Celtic Sea and Biscay	Recent average	35 506	26.3	12 671

TABLE 19
Selected trawl fisheries with high discards (tonnes)

Country	Fishery	Period	Landings	Discard rate (%)	Discards
Belgium	Flatfish (plaice, sole) beam trawl	1999	23 000	75.0	69 000
Japan	East China Sea distant water cephalopod trawl	1994	45 420	38.2	28 070
South Africa	Hake trawl	1996	258 509	14.0	31 951
Chile	Industrial hake trawl (Regions V to X)	2000	176 033	12.5	25 148
Argentina	Coastal iced fish hake trawl (costera)	2000	100 000	13.0	15 000
Peru	Industrial merluza trawl	2000	83 361	15.0	14 711
United States	BSAI catcher processor yellowfin sole trawl	2001	99 173	29.9	29 667
United States	BSAI catcher processor flathead sole trawl	2001	30 196	40.6	12 270

These tables may show apparent inconsistencies. These are generally due to the fact that one or more of the values (landing, discard quantities or discard rate) may be derived from different sources, e.g. one report may provide only a discard rate, while the quantity of discards may be derived from a different source.

A.2.2 Other types of fisheries

TABLE 20
Discard rates and discards in other fisheries

Fishery	Discard rate for set of all records with a discard rate			Discard rate and discards for set of complete records[1]		
	Average discard rate (%)	No. records	Standard deviation	Landings (tonnes)	Discards (tonnes)	Weighted discard rate (%)[1]
Midwater trawl fisheries						
Tuna midwater trawl		4		62 050	26 532	30.0
Small pelagics midwater trawl	5.7	19	0.07	2 763 040	101 285	3.5
Net fisheries (other)						
Tuna purse seine	4.85	12	0.02	2 673 378	144 152	5.1
Small pelagics seine	2.0	52	0.03	21 664 338	351 111	1.6
Beach seine	31.9	6	0.27	23 061	1 068	4.4
Gillnet	7.2	48	0.12	3 350 299	29 004	0.5
Line fisheries						
Tuna pole and line	0.1	11	0.003	818 505	3 121	0.4
Tuna longline	22.0	37	0.16	1 403 591	560 481	29
Non-tuna line fisheries	8.5	50	0.12	581 560	47 257	7.5
Bottom longline (all)	8.2	20	0.08	209 927	10 988	7.5
Handline	1.8	16	0.02	155 211	3 149	2.0
Squid jig	0.2	9	0.004	1 134 432	1 671	0.1
Finfish jig	1.1	5	0.021	19 296	710	3.5
Dredge, pot and other fisheries						
Dredge (scallop, clam, whelk)	24.8	10	0.17	165 660	65 373	28
Hand collection	0.8	16	0.02	256 879	899	0.3
Crustacean pots (lobster, crab)	12.4	12	0.14	185 547	71 077	27.7
Multigear and/or multispecies[2]	2.4	109	0.07	6 023 146	85 436	1.4

[1] Records with landings, discards and discard rate. [2]Non-trawl fisheries.

TABLE 21
Discard rates and discards in gillnet fisheries

Country	Fishery	Period	Landings	Discard rate (%)	Discards
Fisheries with highest discards					
China	Chinese small drift gillnet	2000	2 288 713	0.5	11 501
Canada	Greenland halibut gillnet	1994	10 455	23.1	3 137
Norway	Cod gillnet in north Norway	Annual average	31 000	9.1	3 100
Iceland	Bottom gillnet for cod, saithe, haddock and ling	2001	63 665	3.0	1 969
France	Surface and bottom gillnet for flatfish, pollock, cod and tuna	Average	26 722	6.1	1 736
Fisheries with highest discard rates					
United States	California drift gillnet for swordfish			66.0	n.a.
United States	Northeast bottom multispecies (sink) gillnet			31.0	n.a.
EU Mediterranean countries	Cuttlefish trammel			25.5	n.a.
Canada	Greenland halibut gillnet (cod, pollock)	1994	10 455	23.1	3 137
Norway	Lumpfish gillnet	Average	300	23.1	90

TABLE 22
Percentages of hake discards by year class in the Argentine hake trawl fishery

Year/year class	0	1	2	3
1990	0.82	85	14	0.21
1991	0.94	89	10	0.12
1992	0.83	86	13	0.15
1993	0.90	88	11	0.09
1994	0.92	81	18	0.49
1995	0.90	84	14	0.34
1996	0.93	90	9	0.19
1997	1.27	93	5	0

Source: Dato, Villarino and Cañete, 2000.

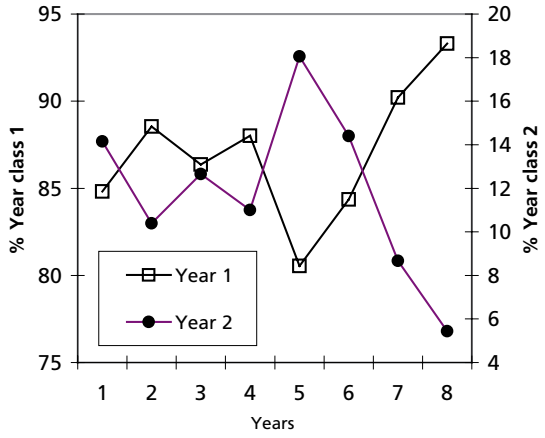


FIGURE 2
Percentage of discards by year class in the Argentinian hake fishery (1990-97)

A.3 DISCARDS BY LARGE MARINE ECOSYSTEM

TABLE 23
Indicative discards by large marine ecosystem (LME)

Number	LME	Recorded discards (tonnes)
22	North Sea	909 109
5	Gulf of Mexico	513 597
13	Humboldt Current	439 371
52	Sea of Okhotsk	361 905
27	Canary	269 205
1	East Bering Sea	156 551
3	California Current	150 161
11	Pacific Central-American coastal	139 396
14	Patagonian shelf	138 126
17	North Brazil shelf	136 740
34	Bay of Bengal (including Malaysia)	130 713
32	Arabian Sea	130 272
12	Caribbean Sea	130 184
4/5	Gulf of California/Gulf of Mexico[1]	119 166
24	Celtic-Biscay shelf	100 893
29	Benguela Current	95 896
7/8/9	Northeast USA, Scotian, Newfoundland/Labrador[1]	80 151
6	Southeast United States, continental	78 745
30	Agulhas Current	59 899
40	Northeast Australian shelf – Great Barrier Reef	47 655
59	Iceland shelf	45 564
39	North Australian shelf	42 750
2	Gulf of Alaska	41 918
28	Guinea Current	40 513
24	Celtic-Biscay	37 168
25	Iberian coastal	35 605
42	Southeast Australian shelf	32 976
36/37/38	South China, Sulu-Celebes, Indonesian Seas[1]	30 818
36	South China Sea	21 405
15	South Brazil shelf	20 372
26	Mediterranean	17 239
23	Baltic Sea	14 203
20	Barents Sea	13 455
7	Northeast United States, continental	11 533
31	Somali Current	8 874
36/37	South China, Sulu-Celebes Seas[1]	7 521
16	East Brazil shelf	7 062
21	Norwegian shelf	5 840
33	Red Sea	4 832
61	Antarctic	2 079
19	East Greenland shelf	1 770
9	Newfoundland/Labrador shelf	1 242
62	Black Sea	715
–	Other LMEs	676
–	Outside LMEs or not attributable to an LME[1]	2 227 489
	Total	**6 824 186**

[1] As some fisheries harvest from more than one LME, discards in certain areas are difficult to attribute by LME, e.g. distribution of Malaysian discards between the Gulf of Thailand and South China Sea.
Source: discard database.

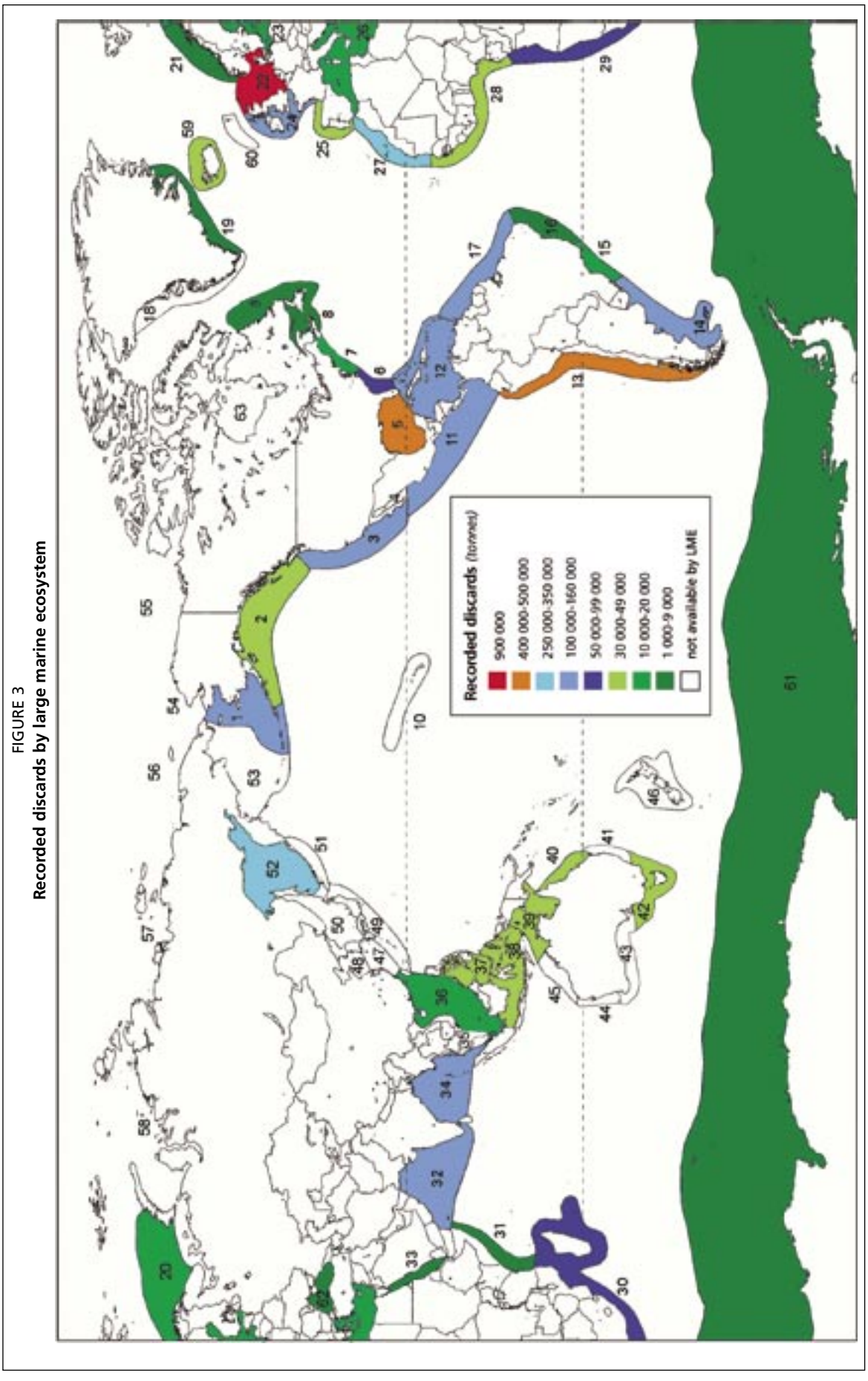


FIGURE 3
Recorded discards by large marine ecosystem

A.4 DISCARDS BY COUNTRY AND IN LOW INCOME FOOD DEFICIT COUNTRIES (LIFDCS)

TABLE 24
Landings, discards (tonnes) and weighted discard rate by country or area (EEZ, not flag state)

Country[1]	Landings	Discards	Discard rate (%)
American Samoa	460	0	0.0
Angola	232 325	46 594	16.7
Anguilla	225	0	0.0
Antigua and Barbuda	1 369	0	0.0
Argentina	622 964	109 000	14.9
Aruba	168	0	0.0
Australia	97 644	120 981	55.3
Bahamas	10 253	0	0.0
Bahrain	8 164	2 571	24.0
Bangladesh	314 966	64 578	17.0
Barbados	3 316	0	0.0
Belize	111	284	71.9
Benin	8 146	41	0.5
Bermuda	430	0	0.0
Brazil	480 574	54 892	10.3
British Virgin Islands	236	0	0.0
Brunei Darussalam	1 214	3 579	74.7
Bulgaria	3 353	436	11.5
Cambodia	49 343	0	0.0
Cameroon	61 407	367	0.6
Canada	789 061	90 021	10.2
Cape Verde	10 881	54	0.5
Cayman Islands	123	0	0.0
Chile	4 360 251	89 155	2.0
China	14 777 934	74 261	0.5
Colombia	9 095	14 377	61.3
Comoros	6 951	35	0.5
Cook Islands	836	0	0.0
Costa Rica	2 683	2 437	47.6
Côte d'Ivoire	30 000	151	0.5
Cuba	19 227	0	0.0
Djibouti	350	0	0.0
Dominica	1 104	0	0.0
Dominican Republic	942	3 964	80.8
Ecuador	24 113	91 211	79.1
El Salvador	37 678	10 397	21.6
Equatorial Guinea	5 400	27	0.5
Eritrea	16 989	3 792	18.2
EU (NEI*)	12 211	8 135	40.0
Falklands/Malvinas	228 417	11 127	4.6
Fiji Islands	20 832	0	0.0
Finland	104 000	200	0.2
France	729 517	194 268	21.0
France (Réunion)	2 722	27	1.0
French Guyana	9 324	49 822	84.2
French Polynesia	6 631	0	0.0
Gabon	25 000	253	1.0
Gambia	39 098	5 124	11.6
Ghana	105 936	1 445	1.3
Greece	35 000	17 070	32.8
Grenada	1 661	0	0.0
Guadeloupe	9 641	0	0.0
Guam	472	0	0.0
Guatemala	16 100	50 950	76.0
Guinea	103 913	16 684	13.8
Guinea-Bissau	50 021	18 500	27.0
Guyana	26 870	29 960	52.7
Haiti	398	1 402	77.9
Honduras	11 815	27 335	69.8
Iceland	1 969 672	45 564	2.3
India	2 849 066	57 917	2.0
Indonesia	3 104 788	270 412	8.0
Iran, Islamic Rep. of	43 272	29 208	40.3
Ireland	214 903	29 569	12.1
Japan	6 491 001	918 436	12.4
Jordan	116	0	0.0

* NEI: not elsewhere included

TABLE 24 (continued)

Country[1]	Landings	Discards	Discard rate (%)
Kenya	8 272	2 940	26.2
Kiribati	16 000	0	0.0
Korea, Dem. Rep. of	221 253	1 112	0.5
Korea, Rep. of	197 913	995	0.5
Kuwait	5 602	41 980	88.2
Liberia	4 494	23	0.5
Madagascar	69 184	31 618	31.4
Malaysia	1 027 276	10 377	1.0
Maldives	12 599	59	0.5
Marshall Islands	3 273	0	0.0
Martinique	5 352	0	0.0
Mauritania	15 000	75	0.5
Mauritius	10 694	54	0.5
Mexico	541 423	137 873	20.3
Micronesia, Fed. States	5 000	0	0.0
Montserrat	46	0	0.0
Morocco	924 450	222 457	19.4
Mozambique	68 787	26 525	27.8
Myanmar	880 594	27 371	3.0
Namibia	522 557	13 454	2.5
Nauru	425	0	0.0
Netherlands	110 000	14 717	11.8
New Caledonia	3 418	0	0.0
Nicaragua	5 776	6 346	52.4
Nigeria	190 722	2 792	1.4
Niue	206	0	0.0
Norfolk Island	0	0	0.0
Northern Mariana Is.	2 966	0	0.0
Norway	2 516 350	102 611	3.9
Oman	135 957	1 384	1.0
Pakistan	228 676	35 467	13.4
Palau	2 103	0	0.0
Panama	101 964	33 483	24.7
Papua New Guinea	33 167	6 150	15.6
Peru	10 291 633	350 215	3.3
Philippines	744 583	7 521	1.0
Pitcairn Islands	8	0	0.0
Portugal	6 303	35 605	85.0
Russian Federation	400 000	361 905	47.5
Saint Helena	781	0	0.0
Saint Kitts and Nevis	295	0	0.0
Saint Lucia	1 621	0	0.0
Samoa	7 190	0	0.0
Saudi Arabia	24 833	1 014	3.9
Senegal	376 153	25 209	6.3
Seychelles	4 433	22	0.5
Sierra Leone	45 910	231	0.5
Solomon Islands	16 634	0	0.0
Somalia	4 000	0	0.0
South Africa	872 935	37 570	4.1
Spain	6 343	212	3.2
Sri Lanka	274 760	1 367	0.5
Sudan	5 094	26	0.5
Suriname	5 500	29 500	84.3
Syrian Arab Republic	2 408	12	0.5
Tanzania, United Rep.	51 147	5 934	10.4
Thailand	2 752 878	27 807	1.0
Timor-Leste	381	2	0.5
Tokelau	200	0	0.0
Tonga	7 036	0	0.0
Trinidad and Tobago	6 639	8 859	57.2
Tunisia	29 295	147	0.5
Turkey	282 150	279	0.1
Turks and Caicos Is.	1 310	0	0.0
Tuvalu	1 100	0	0.0
United Kingdom	27 343	16 654	37.9
United States	3 344 438	927 599	21.7
Uruguay	112 572	18 649	14.2
Vanuatu	2 930	0	0.0
Venezuela	213 025	96 820	31.2
Viet Nam	3 547 346	17 826	0.5
Wallis and Futuna Is.	917	0	0.0
Yemen	50 523	531	1.0
Total	**69 580 728**	**5 207 041**	**7.0**

[1] LIFDCs are shaded in the table.

Values presented for landings are only those corresponding to the discards recorded in the discards database. The discard rates presented do not represent the aggregate discard rate for a country's fisheries.

Table 24 is provided for record purposes only. Because of the bias in the discard database towards fisheries that discard, discard rates and total discards on a country-by-country basis are not necessarily representative of total discards or discard rate of the aggregate fisheries of the country. Only complete records are used in the table so that some fisheries with high discard rates, but for which landings information is unavailable are *not* included. The table *excludes* tuna and HMS fisheries.

Table 24 also highlights discard information from low income food deficient countries (LIFDCs). The table does *not* provide a total of discards from these countries but is intended to draw attention to countries and fisheries where further actions may be directed to improve bycatch utilization. As the table is based only on records where the volume of discards is available certain fisheries are not included.

A.5 DISCARDED SPECIES AND INCIDENTAL CATCHES

TABLE 25
Commonly discarded species in different fisheries (indicative)

Fishery	Commonly discarded species
Penaeid shrimp trawl	Small finfish caught as bycatch. Species groups include *Leiognathidae* (ponyfish), *Nemipteridae* (threadfin), *Trichurius* sp. (hairtails), *Decapterus* sp., *Saurida* sp. (Synodontidae), small shrimp, sharks and rays, as well as jellyfish and juveniles of many commercial whitefish species such as croakers, snappers, and emperors
Nephrops trawl	Juvenile whiting, haddock, cod; broken, undersized *Nephrops* and flatfish
Finfish (roundfish) trawl fisheries	Juvenile commercial species, in particular demersal species such as whiting, haddock, hake, *Sciaenidae* and lower value commercial species such as horse mackerel, Rastrelliger and elasmobranchs
Hake trawl	Small hake and horse mackerel (all fisheries), kingklip and rattails (Africa), arrowtooth flounder, dogfish and ratfish (North Pacific)
Flatfish trawl	Juveniles and target species under MLS; molluscs, echinoderms (sand urchins and starfish), crabs, rajids. Cod, haddock, whiting, plaice, saithe, dab, dogfish, shrimp and *Nephrops* (EU). Arrowtooth flounder is a major component of discards in the GOA/BSAI fisheries for yellowfin sole, flathead sole and other flatfish
Deepwater trawl	Teleosts including grenadiers, whiptails, rabbitfish and oreos; chondrichthyans such as birdbeak dogfish (Deania), batoids and chimaeroids
Small pelagics midwater trawl	Small sizes of target species and non-target species such as horse mackerel in mackerel fisheries, horse mackerel (EU countries), sardine, pilchard, mackerel and sprat. Small-sized fish of the target species may be discarded as a result of highgrading in the quota-managed European fisheries or because processing equipment cannot handle smaller sizes. Dolphins (1.4 dolphins/100 tow-hours in French and Irish tuna fisheries) and sunfish are caught incidentally
Purse seine for small pelagics	Primarily non-target small pelagics including horse mackerel, *Scomber japonicus*, *Boops*, *Belone* sp., jellyfish, juveniles of other species and small quantities of sharks
Tuna purse seine	Non-commercial tunas (e.g. bonito, dogtooth tuna), rainbow runner, dolphinfish, jacks, shark, billfish, mantas and undersized skipjack and yellowfin, dolphins. Large quantities of jellyfish are discarded in the bluefish and bonito fisheries in Turkish waters. Incidental catches of dolphins
Tuna/HMS longline fisheries	The principal discards include *Prionace glauca* (blue shark), which is probably the most commonly discarded species, *Carcharinus* sp. and other sharks, shark/marine mammal-damaged fish, albatross, petrels and other seabirds. Frigate tuna, Kawakawa, Indo-Pacific king mackerel, and narrow-barred Spanish mackerel
Bottom longline	Non-quota species. Arrowtooth flounder GOA/BSAI fisheries), starry ray, dab and redfish (Iceland, Faeroe Islands), hake, shark and kingclip (South Africa), and macrourids and rajids in the CCAMLR area
Gillnet fisheries	Dogfish, skate, sculpin (Canada), cod, haddock, plaice, saithe and dab (Europe)
United States Northwest Pacific groundfish fisheries	Molluscs and crustaceans. Trawlers are obliged to discard large volumes of crabs. Many species of discarded shellfish survive.[1] These include lobster, crab, scallop and oyster. Discard estimates can prove difficult if landings are expressed in numbers, weight of meat or volume (e.g. in bushels)
Otter trawl ICES VIIe,f,h	Benthos discarded included echinoderms, *Marthasterias glacialis*, *Asterias rubens, Ophiura ophiura* and whelk (*Buccinum undatum*) (Lart *et al*., 2002b)

[1] Shrimp, giant spider crabs and ascidians have a high mortality. In the Bass Straits scallop dredge fishery under 3 percent of dredged items are bycatch, most of which are undamaged when discarded.

TABLE 26
Incidental catch of seabirds, turtles and marine mammals in selected fisheries

Fishery	Species	Incidental catch rate	Measures/notes	Source
Danish bottom set gillnet	Harbour porpoise	Mean 5, 129 (1987–2001)	Use of pingers in cod/wreck fishery judged 100% effective	STECF/SGFEN (2002), quoting Vinther and Larsen, 2002
Netherlands horse mackerel trawl	Dolphin	Nine dolphins in six tows		BIOECO/93/017 Morizur *et al.*, 1996
France hake pelagic trawl	Dolphin	1.2 dolphins /100 tow–hours		BIOECO/93/017 (data 1994) Morizur *et al.*, 1996
France pelagic trawl for seabass	Dolphin	1.5 dolphins /100 tow–hours		BIOECO/93/017 (data 1994) Morizur *et al.*, 1996
Ireland albacore midwater trawl	Dolphin	1.4 dolphin/100 tow–hours (French), sunfish	No bluefin quota except as bycatch	BIOECO/93/017 (data 1994) Morizur *et al.*, 1996
United Kingdom bass pelagic trawl – English Channel	Dolphin	61 common dolphin in 122 monitored tows, 2001 and 2002	Tows in mackerel, pilchard and blue whiting fisheries monitored but 0 mortality	STECF/SGFEN, 2002
Netherlands pelagic freezer trawl	Dolphin, pilot whale	Eight white–sided dolphin, common dolphin, pilot whale, 0.06 mm per haul	Observer reports, study of seasons and distribution of interaction	Couperus, 1997 (data 1995–1996)
Spain longline	Mammals, seabirds, turtles	Mammals, seabirds, turtles		Caswell *et al.*, 1998
France thonaille	Dolphin	0.6–1.2 per 100 tuna caught *Stenella coeruleoalba* (striped dolphin)	Mandatory pingers, ACCOBAMS	STECF/SGFEN, 2002
Australia states Queensland inshore commercial	Dugong	n.a.		Harris, A. 1997
United States Western Pacific pelagic longline	Seabirds, albatross	3 073 albatross (two spp.). 0.013 (tuna sets) to 0.76 (swordfish sets) birds per set	See FMP and EIA	NMFS/NOAA, 2001 (data 1994–1999)
United States Pacific halibut birds	Birds	6.1 per mill. Hooks	Tori lines, research on video monitoring, fisher interviews	IPHC Web site (Alaska) fisher interviews
Peru small–scale longline – northern Peru	Waved albatross (*Diomedea irrorata*)	0.74 to 1.75 birds/1 000 hooks	Change from gillnetting to avoid cetacean bycatch, fisher interviews	Guillen, Jahncke and Goya, 2000, p. 132 (data 1999)
United States Atlantic HMS	Birds, turtles	1 307 turtles, 48 birds, 200 marine mammals		US bycatch matrix

(continued)

TABLE 26 (continued)

Fishery	Species	Incidental catch rate	Measures/notes	Source
Spain Mediterranean swordfish longline	Turtles	0.18–2.73 per 1 000 hooks		Cramer, Bertolino and Scott, 1995 (data 1986–1995)
Spain Mediterranean surface and bottom longline	Cory's shearwater (*Calonectris diomedea*)	0.16 to 0.69 birds per 1 000 hooks	437–1 836 shearwaters killed annually in the area	Belda and Sanchez, 2001
All SPC tuna purse seine	Marine mammals	3.8 per 1 000 sets	SPC observer data	P. Sharples SPC, pers. comm. (observer data 1997–2003)
All SPC tuna purse seine	Turtles	0.9 per 1 000 sets	SPC observer data	P. Sharples SPC, pers. comm. (observer data 1997–2003)
All SPC tuna longline	Birds	0.12 per 1 000 hooks	SPC observer data	P. Sharples SPC, pers. comm. (observer data 1997–2003)
All SPC tuna longline	Reptiles	0.02 per 1 000 hooks	SPC observer data	P. Sharples SPC, pers. comm. (observer data 1997–2003)
All SPC tuna longline	Marine mammals	0.02 per 1 000 hooks	High % alive when hauling, survival rate unknown	P. Sharples SPC, pers. comm. (observer data 1997–2003)
IATTC purse seine	Dolphins	2 129 dolphins killed	Quota, international agreement, observers, experimental fishing	IATTC, 2001 (data 1999)
United States /IATTC tuna dolphin set purse seine	Dolphins encircled	2.34 million per year – number encircled, most are released, >300 per set	See IATTC rules	Southwest Fisheries Science Center, 2002 (data average of programme years)

Notes

With regard to the absolute levels of cetacean and endangered species discards, it should be noted that the entanglement and mortality of, for example, a single North Atlantic right whale (population 300) is of greater concern than the capture of several common dolphins (population 200 000 in the area).

Records of discards of lesser–known aquatic animals such as saltwater crocodiles and sea snakes are uncommon.
Source: discard database.

A.6 EXAMPLES OF TRENDS IN DISCARD REDUCTION AND INCREASE

As this report gives a substantially lower estimate of global discards, further evidence of this reduction is provided in Table 27.

TABLE 27

Examples of discard reduction in selected fisheries

Area	Fishery	Discard reduction	Period	Principal reasons	Source
21	Canada northern shrimp	Bycatch reduced from 15.2 to 5.6% of catch. "… groundfish mortality in Canadian shrimp fisheries has been reduced markedly, and virtually eliminated in the sensitive groundfish areas"	1991–1994	BRD (Nordmore); reduction in groundfish stocks, responsible fishing practices, requirement to change area	Duthie, 1997a
21	US Atlantic pelagic longline	16.5% for pelagic shark 22.1% for large coastal shark	2001 compared to 1999–2000 average	Time, area closures	NMFS/NOAA, 2003
27	France *Nephrops* and whitefish trawl	86–100% of fishers believe that discarding has declined	2000		Agricultural Economics Research Institute, 2000
27	Norway shrimp trawl	… greatly reduced, resulting in improved catch handling times and quality of the shrimp catch	n.a.	Sort–X™ BRD	MacMullen, 1998
31	Central American shrimp fisheries	"… [bycatch]…caught was still high (between 90 and 97% of the total catch) but … utilization of the bycatch has increased"		Growing consumption of bycatch	FAO workshop, Cuba, 1997
31	Gulf of Mexico shrimp trawl (United States)	40% reduction in finfish bycatch mortality; 10% increase in shrimp catch (2001); red snapper (main discard) landings doubled	In comparison with1998 levels	FMP and BRDs	Federal Register, 2003, p. 11512
41	Argentina	Juvenile hake	Late 1990s	Use of BRDs	IMARPE
47	South Africa, West Coast rock lobster	Major reduction in discards in late 1990s		Increase in MLS	Poseidon Aquatic Resource Management Ltd, 2003, p.75
51	Madagascar shrimp trawl	Bycatch reduced by 49%	2000	Use of BRDs	Mounsey, 2000
57	India – Visak shrimp freezer trawl	Early 1990s		Freezer fleet has disappeared	BOBP–IGO, pers. comm.
57	Myanmar trawlers	60% down to 7–8% for trawl fleet	Mid–1990s to 2003	Building of fishmeal plants, use for animal/fish feed/human consumption	Myanmar Fisheries Federation, 2003, pers. comm.
67	BSAI/GOA	See Tables 28 and 29			
71	Western Central Pacific	"… available quantitative information indicates that there has been a considerable increase in the utilization of the fishery catch over the last decade"	1986–1996		Harris, 1997
87	Peru hake demersal trawl	A "significant reduction" from 30% in 1996	1996 – late 1990s	Use of juveniles and other bycatch for surimi and fish blocks	R.G. Carrasco, IMARPE, pers. comm.
	United States (in general)	"In general, discard levels in the United States have declined over the past several years"	1994–1998	"… [attributed to] … new technologies and management measures … decline in stocks … increased retention of fish previously discarded"	Alverson, 1998
	Various countries	Unknown		Legislation designed to reduce bycatch and/or discards in place in over 30 countries Bycatch reduction programmes in over 20 countries	Poseidon Aquatic Resource Management Ltd, 2003
	Global/high seas shark	Unknown	2000–2003	Implementation of the IPOA on sharks. United States, EU, Costa Rica and others require landing of carcasses	United States legislation, Council Regulation (EC), 2003

A.6.1 Declining discards in Alaskan and United States West Coast fisheries

The walleye (Alaska) pollock fishery in the North Pacific is the world's largest demersal whitefish fishery. Over 90 percent of landings are harvested by midwater trawl and the fishery represents approximately 25 percent of United States landings by volume. The following tables show the decline in certain categories of discards in recent years in the BSAI fishery.

TABLE 28
Estimated pollock and non-target groundfish total and discarded catch in directed BSAI pollock fisheries from 1997 to 2000 (tonnes)

Year	Total catch	Total discarded	Discards (% total catch)
1997	1 097 657	41 505	3.78
1998	1 022 374	10 472	1.02
1999	957 713	9 704	1.01
2000	1 109 250	12 81	1.1

Source: Bernstein *et al.*, 2002 (Table 7).

TABLE 29
Average rate of incidental catch of halibut, crab and salmon in the directed BSAI pollock fishery from 1997 to 2000

Year	Per tonne of groundfish		
	Halibut (kg)	Numbers of crab	Numbers of salmon
1997	0.243	0.026	0.062
1998	0.345	0.070	0.066
1999	0.180	0.003	0.077
2000	0.112	0.001	0.062

Note: all incidental catch of these species must be discarded.
Source: Bernstein *et al.,* 2002 (Table 9).

Reasons for the reduction in BSAI/GOA discards

The reasons for these declines are closely linked to the management regimes for the BSAI/GOA fisheries and require some understanding of the complex nature and history of these fisheries (see references for details). Some of the principal reasons for effective bycatch management are that:

- BSAI/GOA fish stocks are not overfished;[1]
- there are strong incentives for bycatch reduction;
- enforcement is effective;
- bycatch is cooperatively managed; and
- fishery bycatch information is used as a real-time management tool.

Incentives

When bycatch limits on crab, salmon and halibut are reached, the legislation requires that the fishery be closed, creating a strong incentive to avoid bycatch. The bycatch of individual vessels is published, creating peer pressure on vessel operators.

Effective enforcement

A 100 percent observer coverage (larger vessels) ensures that all bycatch and discards are recorded. Demersal finfish discards are recorded by weight. Salmon and crab discards are recorded by number. Regulations require that all salmon, crab and halibut be discarded. Vessel operators actively cooperate with observers to ensure that discard records are accurate.

[1] Out of 244 fish stocks only two are considered to be overfished (NMFS, 2001).

Cooperative management of the bycatch allocation

The Pollock Conservation Cooperative (PCC) and High Sea Catcher's Cooperative (Joint Report of the Pollock Conservation Cooperative and High Sea Catcher's Cooperative, 2002), operational since 1999, effectively acts as a voluntary/cooperative ITQ system, giving many of the benefits of an ITQ system to the eight PCC members, which control approximately 37 percent of the catch allocation of the directed pollock fishery.

The members contract a private firm to which observer data, including bycatch data, are uploaded once or twice a day. Two observers on board each vessel sample 98.9 percent of hauls. Groundfish discards are less than 0.5 percent. Information on bycatch levels is shared between operators in near real time, identifying bycatch "hotspots" and allowing vessels to move rapidly to grounds with low bycatch. The cooperative arrangement has forfeiture (penalty) clauses for breach of bycatch limits and there has been full compliance with these limits. The benefits of the cooperative management regime have included:

- improved processing yield (larger fish) and more time to search for larger fish (no "race for fish");
- processing at optimum speed for product quality and yield (recovery rate);
- reduced capitalization in vessels and processing equipment (although there was increased investment to vary product mix and meet market requirements);
- substantial contributions to fisheries research;
- reduced bycatch of unwanted species through movement to low bycatch areas; and
- reduction of the Olympic-style fishery (race for fish), reduction of over 30 percent in effort and increased economic rent generation

Similar cooperative arrangements with regard to bycatch exist in the Pacific whiting fishery (see Box 7), Weathervane scallop fishery in the United States (Brawn and Scheirer, 2002) and the Hoki fishery in New Zealand (Hoki Fishery Management Company, 2003).

BOX 7

Pacific Whiting Fish Harvesting Cooperative

Pacific Whiting Conservation Cooperative (PWCC) members have achieved significant reductions in bycatch. Pacific whiting, like Bering Sea pollock, is harvested using midwater trawl nets. Bycatch rates for both fisheries are from 1 to 2 percent. The whiting catcher/processor fleet operating within the construct of a cooperative achieves even greater bycatch reductions. The bycatch rate for yellowtail rockfish decreased by more than 60 percent from 2.47 kg of yellowtail rock per tonne of whiting under the race for fish to 0.96 kg per tonne under the cooperative arrangement. During the same period, yellowtail rockfish bycatch by smaller trawl vessels delivering to mother ships increased from 3.43 to 6.51 kg per tonne.

A major contributor to the reduction in bycatch is the fisher's ability to discontinue fishing in high bycatch areas without sacrificing harvesting opportunities. To help avoid bycatch "hotspots", PWCC members report catch and bycatch data electronically to Sea State, a private sector firm specializing in fisheries data collection and analysis. Sea State collates the data and reports back to PWCC vessels on a "real-time" basis, advising vessel captains to avoid areas in which high bycatch is likely to occur. Because they do not have to race for fish, boats can take the time to move to areas with low bycatch.

A.6.2 Examples of increases in discards

There are few examples of fisheries with increasing discards. Some deepwater fisheries are producing discards that did not hitherto exist, although active market promotion is under way for such unfamiliar species. Quota restrictions in EU fisheries are resulting in high discard rates, although overfishing reduces the absolute quantity of discards. There is evidence of substantial discarding in a number of major fisheries in the Russian Far East.

Annex B
Evolution of global discard estimates

As already noted, the current updated estimate of global discards is substantially lower than that given in FAO Fisheries Technical Paper No. 339 (the Alverson assessment). Annex B aims to:

- briefly outline the method used in the Alverson assessment;
- examine some of the reasons for the differences; and
- provide an overview of the evolution of the discard estimates.

Following the publication of the Alverson assessment, FAO held a Technical Consultation at which regional experts provided revised estimates of discards for selected FAO statistical areas and suggested reasons why the assessment may have overestimated discards in certain fisheries and areas.

B.1 METHOD USED IN THE ALVERSON ASSESSMENT

The Alverson assessment estimated discards by region and in relation to target species, using FAO Fishstat for the global catch data. The 1 700 discard records included information both on numbers of fish discarded and on weights of fish discarded. The fisheries of the North Atlantic and Northwest Pacific provided over 70 percent of the records. Average discard rates associated with target species and each FAO statistical area were applied to nominal catch by species or species group, as provided in FAO Fishstat. As there is no a priori relationship between landings of target species and discards, and as the nominal catch of a species may often represent the retained catch of several different fisheries, each with a different fishing gear, target species and different level of discards, the extrapolation to area and global level may have resulted in some double counting (Murawski, 1996).

In 1998, the lead author of the 1994 assessment recognized its various shortcomings together with the substantial changes that were occurring in many fisheries, and an update on discarding practices and unobserved fishing mortality was published (Alverson, 1998). However, the global estimate was not recalculated.

B.2 TECHNICAL CONSULTATION ON REDUCTION OF WASTAGE IN FISHERIES

In 1996, the FAO Technical Consultation on Reduction of Wastage in Fisheries identified a number of difficulties arising with the methods used in the Alverson assessment, which were considered to contribute to an overestimate of global discards. As part of the contributions to the Technical Consultation, several authors prepared revised estimates of discards for selected FAO statistical areas, e.g. 4 million rather than 9.13 million tonnes for the Northwest Pacific.

The comments on the Alverson assessment in Box 8 are taken from the various papers in FAO Fisheries Report No. 547 (Clucas and James, 1997). It is stressed that the authors of the comments indicated that these were not intended to undermine the major contribution made by FAO Fisheries Technical Paper No. 339, but to contribute to a more accurate estimate of global discards.

B.2.1 Alternative approach to global discard estimation

The Technical Consultation suggested an enhanced approach[1] to include reference to the type of fishing method and provided a practical demonstration of the methodology. The current study has attempted to apply the methodology proposed by the Technical Consultation in the wider global context. The matrix of three spreadsheets (Table 30) was found unmanageable at the global level, partly because of the lack of information on many fisheries. Species–by–species information was also considered too detailed and unnecessary in the context of a global study, although clearly of considerable value at the country or fishery level.

BOX 8

Specific comments on the Alverson assessment[1]

Area 21 Duthie, 1997a,b	• Significant digits and error variance lacking (remains a problem in current study) • Further consideration of factory vessels (remains a problem in current study)
Area 21 Kennelly, 1997	• Lack of detailed explanation as to how the estimates were made • Lack of clarity regarding assumptions • Impossible to judge validity of assumptions • Use of target species, particularly in multispecies fisheries
Area 27 Smith, 1997	• 20–30 references for entire Northeast Atlantic and possible application of North Sea discard rates to all of Area 27 • Species–by–species approach requiring greater number of records for multispecies fisheries • Species with low discard rates accorded high discard rates by default as no discard information exists • Interpretation problems regarding Norway pout (110 000 tonnes discarded), sand eels (806 000 tonnes discarded), capelin (492 000 tonnes discarded) and blue whiting
Area 34 Balguerías, 1997	• Limited source material and some reference material on discards overlooked
Area 47 Japp, 1997	• Lacking specific information on Area 47
Area 61 Matsuoka, 1997	• Overestimate of discards because of double counting and an estimate of approximately 5 million tonnes lower provided
Area 71 Harris, 1997	• No allowance made for retained bycatch in shrimp fisheries. Major difference between estimate for shrimp fisheries and that made by Andrew and Pepperell (1992) – 1.38 million tonnes compared with 0.29–0.59 million tonnes. Discard ratios from temperate waters apparently applied in tropical waters. No allowance made for artisanal fisheries

[1] From papers presented at the Technical Consultation on Reduction of Wastage in Fisheries, Tokyo, November 1996. FAO Fisheries Report No. 547 (Suppl.). (FAO, 1996b).

[1] Developed by Smith (1997) and Duthie (1997a,b). See Appendix C to the Technical Consultation (FAO Fisheries Report No. 547).

TABLE 30
Matrix for calculation of discards as proposed by the Technical Consultation

1. Catch/landings	Gear 1	Gear 2	Gear 3
Species 1			
Species 2			
Species 3			

1.

2. Discard ratios	Gear 1	Gear 2	Gear 3
Species 1			
Species 2			
Species 3			

2.

1 x 2 = 3

3. Discards (tonnes)	Gear 1	Gear 2	Gear 3
Species 1			
Species 2			
Species 3			

3.

B.3 GLOBAL DISCARD ESTIMATES PRESENTED IN SOFIA

The conclusions reached in the Alverson assessment were presented in *The State of Fisheries and Aquaculture 1996* (*SOFIA*) (FAO, 1996a). A revised estimate of 20 million tonnes was presented in *SOFIA 1998* (FAO, 1998). This estimate has been largely ignored and is rarely cited in the literature, possibly because the revised estimate was not substantiated by FAO in any published documents.

Based on information provided at the Technical Consultation, the probable basis for the global discard estimate in *SOFIA 1998* has been reconstructed (Table 32) and derives a similar quantum of discards. Although not directly comparable, but in order to demonstrate the evolution of the discard estimates, the results of the Alverson assessment, the Technical Consultation, the *SOFIA* estimate and this reassessment are presented in Table 31.

B.4 REVISION OF ALVERSON ESTIMATE USING TOKYO WORKSHOP INFORMATION

The sources of major changes in discard estimates (see also Box 8) indicated in the Tokyo workshop were as follows:

- Area 27 – substantial change in source of discards although little change in total quantity (Smith);
- industrial and artisanal fisheries in South and Southeast Asia (Chee, Harris);
- China, which is reported to have no discards (Zhou and Ye); and
- revision of Area 61 discard estimate (Matsuoka).

BOX 9
Discard estimates in SOFIA 1996 and SOFIA 1998

SOFIA 1996

"In 1994, FAO showed that the proportion of the world fish catch made up of bycatch might be much larger than previously considered and estimated that discarding amounted to an average of 27 million tonnes per year (or about 32 percent of the total reported annual production of marine capture fisheries)."

SOFIA 1998

"A subsequent re–evaluation of these estimates, together with adjustments allowing for subsequent reductions in discarding, indicates that current levels are at the lower end of the range. The most recent FAO estimate of 20 million tonnes, if correct, is equivalent to 25 percent of the reported annual production from marine capture fisheries, which are those from which most of the discards derive."

However, assuming that the 20 million tonne estimate in *SOFIA 1998* was based on the type of calculation provided in Table 32, it is clear that it was not really a re-estimate, but a modified version of the estimate provided in the Alverson assessment. As the papers presented in the Tokyo workshop did not cover many of the FAO areas (e.g. South America, Indian Ocean), the *SOFIA 1998* figure was at best a partial re-estimate. The adjustments made as a result of the Tokyo workshop reduced the discard estimate by approximately 45 percent for the six FAO areas considered.

Again, it is stressed that the different methods and approaches used in the two studies do not make the estimates directly comparable and considerable caution is required in drawing conclusions.

TABLE 31
Evolution of discard estimates (tonnes), 1994–2004

FAO area		FAO Fisheries Technical Paper No. 339 (Alverson Table 5)	FAO Fisheries Report No. 547/SOFIA 1998 (approx.)[1]	Current study
Arctic Sea	18			0
Northwest Atlantic	21	685 949	699 689	92 926
Northeast Atlantic	27	3 671 346	2 891 080	1 408 931
West Central Atlantic	31	1 600 897	1 600 897	831 808
East Central Atlantic	34	594 232	185 956	309 718
Mediterranean/Black Sea	37	564 613	564 613	17 954
Southwest Atlantic	41	802 884	802 884	197 618
Southeast Atlantic	47	277 730	116 652	120 283
West Indian Ocean	51	1 471 274	1 471 274	205 428
East Indian Ocean	57	802 189	802 189	151 190
Northwest Pacific	61	9 131 752	4 000 000	1 355 822
Northeast Pacific	67	924 783	734 069	192 829
West Central Pacific	71	2 776 726	1 200 000	407 826
East Central Pacific	77	767 444	767 444	167 351
Southwest Pacific	81	293 394	293 394	35 475
Southeast Pacific	87	2 601 640	2 601 640	530 582
Multiple area	31, 77			27 335
Multiple area	67, 77			150 161
Multiple area	71, 77			2 138
Global shark fin				206 815
Tunas, bonitos, billfish				
Atlantic and Mediterranean (ICCAT area) (21, 27, 31, 34, 41, 48)				159 466
Indian Ocean (IOTC area) (51, 57)				139 465
Pacific E. Central (IATTC area) (67, 77, 87)				56 508
Pacific SW and W. Central (SPC area) (71, 81)				162 068
Subtotal tuna				**517 507**
Antarctic				
Atlantic, Antarctic		35 119	35 119	
Indian Ocean, Antarctic		10 018	10 018	
Pacific, Antarctic		109	109	
Subtotal Antarctic CCAMLR (48, 58, 88)				**2 079**
Global estimate of discards		**27 012 099**	**19 185 303**	**6 931 776**

[1] See Table 32 for derivation of estimate.

TABLE 32
Possible derivation of the estimate of discards referred to in SOFIA 1998

(in tonnes)

FAO Area	FAO TR339 (Alverson, Table 5)	FAO R547 Suppl. Tokyo discard estimate	FAO R547 Reference	Reduction	Comment
Northwest Pacific 61	9,131,752	4,000,000	Matsuoka, Zhou	-5,131,752	
Northeast Atlantic 27	3,671,346	2,791,080	Smith	-780,266	R547 estimate excludes Norway Estimated total discards less than in TR339. There are major differences in the source of discards.
		100,000	Norway (current study, not R547)		
West Central Pacific 71	2,776,726	1,200,000	Harris, Chee, Zhou (combined)	-1,576,726	Southeast Asian countries (not directly equivalent to area 71 but difference of order of magnitude evident (Chee). Shrimp discards (1.34 million tonnes) overestimated by approx. 0.45 million tonnes (Harris). Zero discards in Chinese fisheries (Zhou and Ye).
Southeast Pacific 87	2,601,640	na			
West Central Atlantic 31	1,600,897	na			
West Indian Ocean 51	1,471,274	na			
Northeast Pacific 67	924,783	734,069	Newton	-190,714	Change in the fisheries
Southwest Atlantic 41	802,884	na			
East Indian Ocean 57	802,189	na			
East Central Pacific 77	767,444	na			
Northwest Atlantic 21	685,949	699,689	Duthie/ Kennelly	13,740	
East Central Atlantic 34	594,232	185,956	Balguerias		Shrimp and cephalopod fisheries only
Mediterranean /Black Sea 37	564,613	na			
Southwest Pacific 81	293,394	na			
Southeast Atlantic 47	277,730	116,652	Nolan/ Yau	-161,078	
Atlantic Antarctic 48	35,119	na			
Indian Ocean Antarctic 58	10,018	na			
Pacific Antarctic 88	109	na			
Total TR 339 (Alverson)	27,012,099			-7,826,796	
Revised estimate derived from R547 (Tokyo)				19,185,303	Approximates the value in SOFIA 1998

Annex C
Method

This annex provides:

- additional information on the structure of the discard database;
- support for assumptions regarding certain discard rates used in the database; and
- discussion on the problems of determining accurate estimates of discards, with particular reference to discard sampling and raising or extrapolating the sample estimate to the population (i.e. the fleet, species or fishery).

An accurate determination of bycatch and discard rates is important for fisheries management. If the rates assumed for a fishery are too low, then TACs are likely to be exceeded (Pacific Fishery Management Council, 2001). The long–term biological stability and yield of the fishery may be affected and rebuilding strategies for depleted stocks may not be successful. Chronic underestimation of fishing mortality places the future economic benefits to the industry at risk through further depletion of resources. If the bycatch and discard rates assumed for the fishery are too high, then total mortality is overestimated and TACs may be set too low, which unduly restricts fishing, resulting in less economic benefit to the industry.

C.1 DIAGRAMMATIC REPRESENTATION OF CATCH CONCEPTS

Figure 3 provides a diagrammatic representation of the catch concepts upon which the FAO Fishstat statistical system is based.

C.2 DISCARD SAMPLING

Accurate estimates of discards depend on discard sampling and the subsequent raising or extrapolation of the sample estimates to the entire population. Sampling discards and raising of sample values to the species, fleet or fishery level pose numerous technical difficulties that are briefly discussed below.

The complex nature of many discard investigations can make them costly in terms of financial and human resources. Costs can prove prohibitive to many fisheries administrations. A recent investigation into the discard and escape mortality of *Nephrops* and roundfish from demersal trawls required the concerted efforts of six different institutes and other parties from five different countries (Denmark, Norway, Sweden, the United Kingdom and the United States), at a cost of 1.9 million euros (Fisheries Technology Committee, 2000). Multivariate analysis of discard sampling data may also provide insights into the design of management measures (Murawski, 1996).

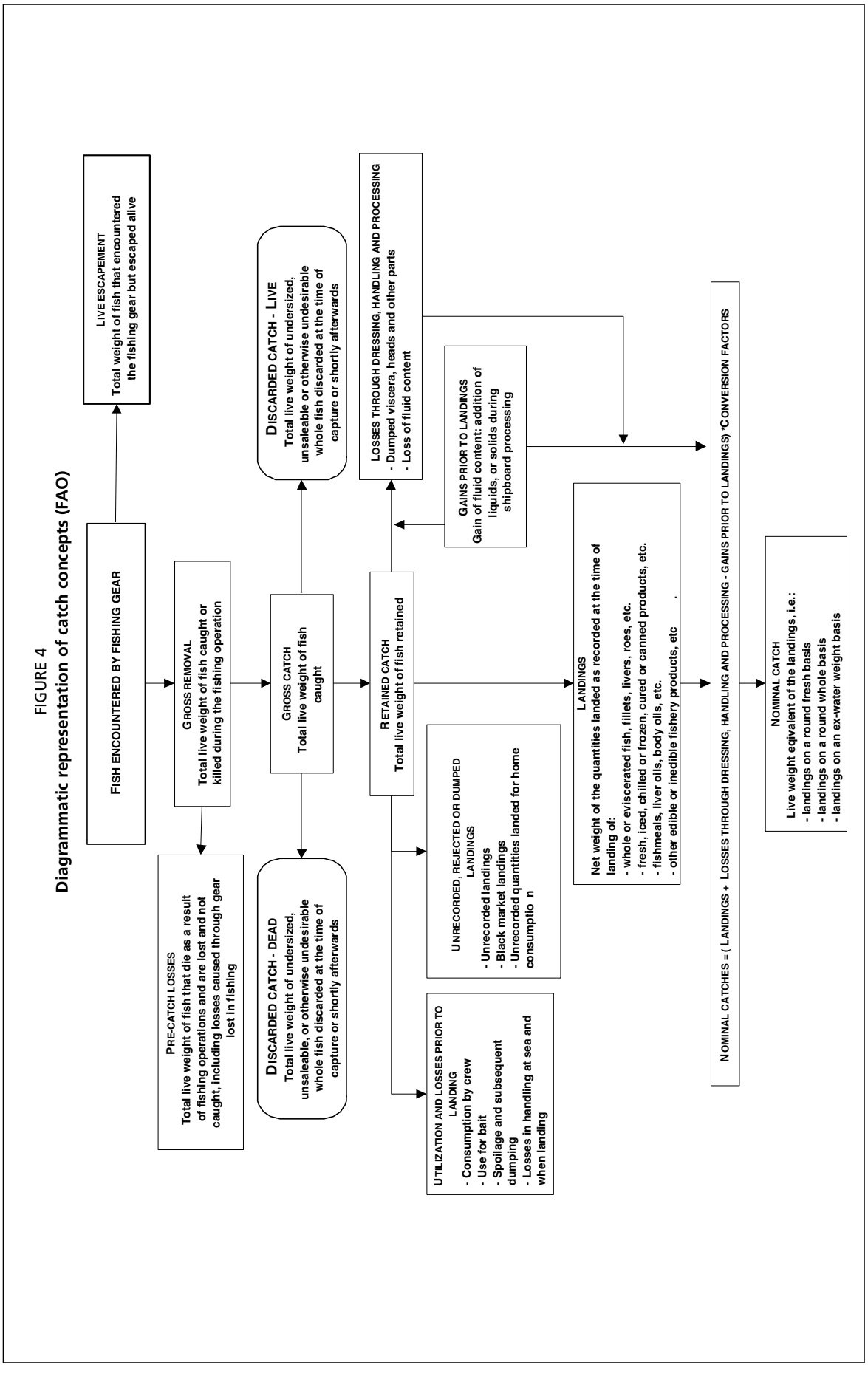
Clarity regarding the purpose of sampling[1] is essential for design of an effective sampling protocol. If the discard estimates are to be used as an input to stock assessments, then detailed information on parameters such as sex, weight, age, length, maturity and fecundity may be required.

There are several approaches to estimating discarding in a commercial fishery:

- observers
- retention of discards by fishers
- questionnaires
- simulated commercial fishing
- modelling
- Delphi.

[1] See ICES, 2000b (CM 2000/ACFM:11) for a comprehensive discussion; Hall, 1999.

FIGURE 4
Diagrammatic representation of catch concepts (FAO)



C.2.1 Use of trained observers

Sampling of discards by observers is generally regarded as the most effective and accurate method (Punt, 1999), but not if discarding is illegal.[2] Many national authorities and regional fisheries bodies (e.g. NAFO, ICES/EC, NEAFC, CCAMLR) make use of observers for sampling of discards.

Observer programmes encounter a range of difficulties. Discards cannot be assessed accurately where catches are slipped. Safety of observers at sea is a concern, particularly if the vessel crew are "hostile". In situations where there are a limited numbers of observers and several fleets (vessel strata), there are problems in selecting the vessels on which to place observers, as there is a need to cover all strata and in particular the strata with the greatest inherent discard variability (Cotter *et al*., 2002). Vessels also change gear on trips. Discard variability tends to be higher between trips than between hauls or sets, requiring more trips rather than more fishing operations to be sampled. Vessels are the primary sampling units and days and trips may prove difficult to use for random sampling. In addition to the difficulties in designing discard sampling programmes to reflect the variability in fleet characteristics, fisher behaviour and the spatial and seasonal variation in fish distribution, some sampling may require consideration of the diurnal variation in fish behaviour, placing additional burdens on observers (van Beek, 1998).

Observer schemes are only useful for estimating total bycatch where there is also an adequate measure of total fleet activity. Furthermore, observer schemes can only provide a minimum estimate of bycatch (European Commission, 2002b). Even the most vigilant observer will miss some events. Animals that are trapped in fishing gear underwater, but then fall from the gear before it is hauled back to the boat, for example, will almost never be counted. Observers must also be able to see the net or other gear as it reaches the boat and access the catch as it is sorted. During the hours of darkness

BOX 10

Sampling difficulties encountered by observers

"Two fishing boats, even if similar outwardly, seldom process their catches in exactly the same way. Fish pounds are of various shapes and sizes; fish may be picked out by hand or with a conveyor belt; the whole catch may or may not be containerized initially; discards may be selected by eye or by measurement; they may be tossed overboard immediately or accumulated and shovelled over in one or more large lots; and the fish for landing may or may not be gutted and sorted. Discarded fish can be mixed with varying quantities of marine weed, rubbish, etc. ('trash') depending on grounds and gear type, making sampling difficult. Sampling can also be constrained by the space and shelter available for working, the weather, and by time. It is important that observers conduct their work without unduly holding up the normal processing of fish for landing and marketing. A further time constraint arises because, for safety, the observer should not usually remain on deck alone when the crew have finished their work. For these reasons, samples often represent only a small proportion of the catch, leading to sampling variance."

From BIOECO 93/003 (Cotter, 1995), cited in ICES CM 2000/ACFM:11 (ICES, 2002b).

[2] The observer effect refers to a situation in which the fishing practices of a vessel differ in some significant way when an observer is aboard. When this occurs, the observer–collected data are not representative of the fishery as a whole.

BOX 11
Observer procedure in Canada's northern shrimp fishery

"The established observer procedures, as outlined in the observer manual, for estimating regular discard (broken shrimp) will be continued. However, these procedures will not be applied for instances of significant highgrading of shrimp.

- The observer and the vessel captain will conduct independent determinations of bycatch and discards. The observer will notify the captain immediately if bycatch/discards are of concern.
- The observer and the captain will record the bycatch/discards on a daily basis. These will be recorded on the daily report form (copy attached).
- In the event of a disagreement between the reports of the observer and the captain, both parties will document their findings on the daily report, which will become a part of the observer's trip report.
- The observer and the captain will seek to reconcile the difference. However, this does not imply that the observer and the captain must agree.
- All such differences will be included in the observer's trip report.
- The fisheries authorities' Department of Fisheries and Oceans (DFO) will forward to the licence holder a weekly summary of catches, bycatches, discards, etc. The DFO will supply the licence holder with a copy of the observer's trip report upon completion of the trip."

this ability may be compromised, depending on lighting conditions, and this can also lead to underestimation. If automatic sorters are used, the observer may never get a full view of either the catch or the discards. Moreover, the presence of the observer may alter the discard behaviour of the fishers.

A general impression obtained from the literature on discards is that insufficient attention is devoted to discards of non–commercial invertebrate species, such as echinoderms, tunicates, sponges and crabs. This may be because the primary focus of observer reports is on commercial species or because of the notion that such invertebrates are "rubbish", "debris", or of no interest. Even in regimes that prohibit discards, allowance is made for discarding of non–commercial species (such as in Iceland).

Real discards are always higher than visual estimates made by *experienced* observers, at times more than ten times higher (NAFO, 2000). However, observer reports are still the most reliable[3] means of determining levels of discards and bycatch, even though the reports may reflect a minimum, rather than total level of discards. Where bycatch quotas are managed at the vessel level, managers and owners quickly recognize the potential consequences of biased sampling, and the sampling and estimation process may receive greater scrutiny.[4]

The reply of NOAA/NMFS to Oceana

The reply of NOAA/NMFS to Oceana provides a valuable and comprehensive summary of the issues relating to the sampling of bycatch and, by extension, the sampling of discards (NOAA [Department of Commerce], 2003). The reply provides a balanced discussion on the objectives, needs, priorities, coverage and costs of bycatch

[3] A close correspondence ($r^2 = 0.8$) between observer and logbook reports of discards was recorded in the Hawaii longline fishery (Walsh, Kleiber and McCracken, 2002).

[4] "Sample sizes are often small relative to catch sizes … and the random sampling requirement may be compromised by vessel operations such that observers only have access to, for example, the first fish to be spilled from the codend after the catch has been dumped." From Karp *et al*, 2000.

sampling, with particular regard to the use of observers and the legal obligations on the administration to provide accurate estimates of bycatch.

C.2.2 Logbooks and retention by fishers

Requiring or requesting fishers to record discards in logbooks can provide a valuable source of discard information. For example, NAFO (NAFO, 2002) and NEAFC have rules on logbook discard data.

Comparison[5] of discard information recorded by observers and in vessel logbooks may enable the correction of vessel logbooks to provide improved estimates of discards. While individual trip logbooks may not provide a high level of accuracy, discard rates based on logbook data averaged across trips, tows or fleet may be closely correlated with observer-based discard rates. If such a correlation can be shown, a correction factor may be applied to the logbook data, which are generally shown to underestimate discards.

Fishers may be asked (or paid) to collect, preserve and hold samples of discards from their own catches. Scientific staff then process the samples when the vessel returns to port. This approach may place a heavy reliance on the fisher to do the sampling or respect the sampling protocol but may be more cost effective than observer programmes (Lart, 2002).

C.2.3 Questionnaires and interviews

Responses to questionnaires may be inaccurate, or those fishers willing to complete the questionnaires may bias the results. Interviews must be confidential, they require a knowledgeable interviewer and a relaxed atmosphere, and they can be expensive. The Delphi method is a subjective method using the accumulated experience of recognized experts in the field. All approaches have mixed results.

C.2.4 Simulating commercial fishing

A research vessel or a chartered commercial fishing vessel is chartered and deployed with gear similar to that used commercially. The level of discarding can be estimated from the length distributions found in the catches by comparison with the length distributions in landed commercial catches (Medley, 2001). It is necessary to assume that fishing techniques successfully simulate those of commercial vessels and that fishing is geographically and temporally representative of how the fleet fishes. Similar inferences can be made from the composition of landings or even the size grades of exports of different fleets fishing the same fishery (*The Irish Skipper*, 2003).

C.2.5 Modelling

Discards may be estimated using data for total landings by the fleet, knowledge of the size selectivity of commercial fishing gear, and knowledge of the length distributions of the fish population (Casey, 1996). The latter may come from a research vessel survey using a small mesh trawl. This method may be helpful when no direct measures of discarding can be obtained. Although many assumptions are inherent in the method, no raising problems arise because modelling is applied to the total landings data. The approach may not be suitable for the estimate of total discards, i.e. fish that are not commercial and not length sampled, or for factory vessels. Models can also be of considerable assistance in designing a more effective sampling protocol; in testing discard reduction measures; and in replacing average discard rates with a more robust interpretation of the variability (Helser, Methot and Hastie, 2002).

[5] Sampson (2002) shows that logbooks underestimated discards by approximately 20 percent, but that the boat–to–boat variability can be high.

C.2.6 Sampling design, sampling strata and data storage

If the primary objective of discard sampling is to improve the catch estimates used for stock assessments, it is advantageous to use the same sampling strata and to ensure compatibility between landings and discard databases. Raised discards can then simply be added to landings to give the total catch[6] for that stratum.

However, in practice, use of these strata for sampling discards is not necessarily efficient. First, quantities of fish discarded are not necessarily proportional to quantities landed, depending also, for example, on the size selectivity of the fishing gear and the availability of quota to land a species. Second, it is possible to sample the landings of several vessels during one visit to a port, but one discard sampling trip may take two to three weeks. Third, the variability in discards is unlikely to be similar to the variability in landings. Therefore, a statistically valid sampling scheme (Tamsett *et al*., 1999; Allen *et al*., 2001) is likely to require different sampling strata and, to obtain accurate estimates of discards, sampling effort must be designed to concentrate on the levels of largest variability (Rochet *et al*., 2000; Allen *et al*., 2002). Furthermore, large numbers of sampling strata are not practical for discard sampling with small numbers[7] of observers, as in most European countries. In many sampling periods it simply will not be possible for observers to sample trips from each of many strata. The result is that unbiased estimation is made very difficult. Several other factors constrain establishing standardized, at–sea sampling schemes for discards:

- high diversity of fleets in different countries;
- different levels of information available about these fleets (e.g. vessel lists, total effort);
- different trip lengths (e.g. one day or 30 days);
- different observer resources (from two covering a long coastline, to all trips observed, as in Canada); and
- to some extent, differences of opinion regarding the statistical framework and theory suitable for discard surveys.

While many countries are embarking on new discard programmes there may not be an effective system for the storage, retrieval and analysis of discard data. Logbook information on discards often remains unanalysed. Considerable additional efforts are required to establish statistically sound, cost–effective discard sampling protocols.

C.2.7 Transboundary stocks and fisheries

Transboundary stocks may require different approaches to sampling, particularly if international quota stocks are involved. Among ICES[8] members, the country of origin generally makes arrangements to sample discards and associated landings. Observer programmes in international fisheries pose particular problems regarding responsibility for observers.

The country of landing

Observers in the country of landing often have difficulty in finding out when and where a foreign vessel will be landing. This makes scheduling of the trips with their main sampling programme for national vessels very difficult. Having successfully boarded a vessel in the observer's own home country, the observer may be disembarked in another distant country and be faced with an expensive return journey. The observer may have language difficulties on board. There may subsequently be difficulties

[6] See tables prepared by ICES (2002).

[7] A 100 percent observer coverage is mandatory in several United States fisheries and in many industrial fisheries in West and southern Africa, in Canada and in New Zealand.

[8] Several paragraphs in this section of Annex C are quoted or adapted from ICES reports, e.g. ICES, 2002.

obtaining data from the foreign country to permit raising of results from the sampled trip to the appropriate fleet. Alternatively, results may be sent to the foreign country for their own use. Teams of observers tend to be so busy with sampling their own national vessels that they are reluctant to sample for other countries. This could be altered by making contractual arrangements, but the scheduling problem remains.

The country of ownership
Observers are likely to have to travel both to and from the country of ownership. The country of ownership may not have comprehensive lists of all the vessels owned (but only those registered with them). Inclusion of all vessels in a sampling scheme may therefore be difficult. The country of ownership is unlikely to have the information necessary to raise trip results to the appropriate fleet level. Observers from the country of ownership are likely to speak the same language as the crew.

The country of registration (flag country)
The flag country will have all available information about the vessel and will therefore be in a good position to schedule sampling and raise trip results to the appropriate fleet. Transportation and language problems are likely to arise for observers. However, contracting the country of landing to undertake the sampling and to send back the data for the trip may be practical, provided that sufficient notice is given.

International discard database
Baltic countries have established a common database (BALTCOM) which demonstrates (ICES, 2002) the opportunities for holding discard data regionally. However, it is necessary to assess carefully how such a database could be applied to regions other than the Baltic. Possible problems are:

- difficulties in drawing boundaries between seas;
- fishers may disapprove of the level of disaggregation of the data, which may reveal the identity of a vessel to fishing competitors or to enforcement agencies, even though the name of the vessel itself is not stored. Fishers might withdraw their cooperation with sampling activities as a result;
- national legislation on data privacy may constrain sharing of "raw" data;
- national sampling authorities may claim intellectual property rights over some data or fail to contribute required information for other reasons, e.g. concern that national quotas may be reduced;
- different types of fishing vessels, discard sample surveys and data raising methods in each region may cause significant computational problems; and
- linking of discards and landings data in one database, if thought desirable, could cause various technical difficulties in each region.

C.3 RAISING OF DISCARD ESTIMATES

Raising factors are required to convert sample results for individual catches, trips or vessels to estimates of discarding by the total fleet or fishery over a given sampling period, e.g. one year. The design of sampling protocol is highly relevant to the raising of discard data. Raising of results for a trip to an estimate for a fleet may utilize the number of vessels in the fleet, the total effort or the total landings. Whichever factor is selected, reliable data must be available to fit the chosen sampling strata. For example, a fishery with a defined gear type (or mesh size) as a sampling stratum should have matching landings (catch) declarations.

One common way to establish the fleet estimate is to raise the quantity of discards in a sample of a catch to an estimate of the discards in the total catch, then to extrapolate from the individual catch to the trip, from the trip to the vessel, and finally from the vessel to the fleet. Quantities may be recorded as weights or numbers of fish. Estimates

of discards based on the mean of individual tows appear to overestimate discards. Using the sum of the discard weights and landing weights from all sampled hauls has been shown to give a more accurate estimate of discard rates (Allain, Biseau and Kergoat, 2003). Common raising methods[9] include those:

- by landings (or catch)
- by number of vessels
- by number of trips
- by trips per vessel and number of vessels (two step)
- by other measures of effort, e.g. hauls, 1 000 hooks
- by probability of sampling;
- by strata
- in accordance with a model.

Each approach has its advantages and disadvantages and each is based on assumptions regarding the relationship between discards and parameters recorded during sampling. In most cases the assumption is that this relationship is linear. This is the assumption that has been used in raising discards to fishery level in the discard database. However, in some fisheries it is suggested (Rochet, Péronnet and Trenkel, 2002) that there is no auxiliary variable upon which discards can be accurately projected, i.e. sampling is essential to determine discards. The absence of a coherent theory upon which discards can be forecast suggests that no one method can currently be judged as the superior for all fisheries (Trenkel and Rochet, 2001).

Problems with estimates

A comparison between raised retained quantities and officially reported landings may reveal substantial anomalies, which may have consequences at a political level. Autoconsumption and illegal landings may account for substantial unreported catches. The use of unreliable landings records to raise discard estimates may render these estimates inaccurate. As many national fisheries statistics are not readily available by fleet, by gear or by fishery, discard information may be difficult to raise to the fleet or fishery level. There may be significant differences between effort–based and landings–based discard estimates, particularly with regard to the incidence and quantity of discards of shoaling species in trawl fisheries (Walmsley, Leslie and Sauer, 2003; Trenkel and Rochet, 2001).

C.4 DISCARD DATABASE FILE STRUCTURE

The database file structure is given in Table 33. Access to and use of the discard database will be determined by FAO.

C.5 ASSUMPTIONS REGARDING DISCARD RATES

Most small-scale and artisanal fisheries in developing countries have been allocated a discard rate of either 0.5 or 1 percent, as a zero discard rate was considered to be unrealistic for some artisanal fisheries. The rate assigned to a particular fishery is based on additional information from the country, the region or fisheries assumed to be similar.

Certain highly selective fisheries have been assigned a zero discard rate based on the available literature, contacts with experts and the author's own experience. These fisheries include diver fisheries for abalone, sea urchins, lobster; squid jig fisheries and artisanal troll fisheries. Some of the supporting evidence is presented in Table 35.

[9] For further discussion see ICES, 2000b.

TABLE 33
Description of the discard database fields

Code	Description of field	Notes/comments
FAOA	FAO area code	Sometimes difficult to assign the fishery to an FAO area, e.g. South China Sea
LMESP	Large marine ecosystem code	Not inserted as yet (several uses foreseen)
SA1	Type of sub-area	For example, ICES will also insert other FAO sub-area codes
SA1C	Sub-area code	For example, IV for Irish Sea, CECAF 34.3.2. for Cape Verde insular
SA2	Second sub-area	For example, name of RFMO – ICCAT
SA2C	Second sub-area code	For example, RFMO code, e.g. ICCAT 22 = Brazil, etc.
Country	Name of country	Standard UN/FAO name (check); can be a group of countries (e.g. "all ICCAT members")
F	Fishery, usually a function of the available information	Text description of fishery. Not all entries are "fisheries" as, for example, total catch is sometimes given for a small country in absence of other information (or as check)
Main species	Target species	Species names as in bibliog. ref., e.g. "bonga", "peixe pedra"; at times "multispecies"
G	Gear name from the bibliographic reference	For example, trawl, gillnet, matanza, basnigan, "multigear" sometimes used
L/C	Flag indicating landing (L) or catches (C). Coded "N" when referring to numbers in incidental catches (marine mammals, seabirds, etc.)	Major problems in determining exact nature of quantities, nominal landings or catch. TAC is used if no other information available. The source material is often unclear as to whether the value described as "catch" is landing, nominal catch or gross catch
Yr	Year to which the L/C refers	Sometimes average used if time series available
LCTonnes	Landings in tonnes; incidental catches in numbers	See L/C above; numbers used with regard to seabirds, etc.
RefT	Bibliographic reference/source of tonnage information	
Main discards	Species or species groups as described in source material	Substitute with FAO codes/insert extra code field; some species names in local language
Discard rate	Discards as % of total catch (landings + discards)	Direct from source material or calculated from information in reference; at times assumed
Dtonnes	Tonnes of discards	Direct from reference material or calculated from information in reference, e.g. shrimp: bycatch ratio and % of bycatch discarded
Basis	Note on basis for discard calculation	For example, observers, survey, applied discard rate from adjacent country, assumed/similar fishery
RefD	Bibliographic reference for discard information	
RefYr	Reference year for discard information	Important because of changing regulations, e.g. obligation to use square mesh from 1999
Reason	Reason for discards	Field often not completed, D = discretionary, R = regulatory, H = highgrading, etc.
Measures	Notes on measures applied	For example, TEDs obligatory, BRDs used, obligation to land ...% of bycatch, no-discard policy
Exp	Status of the fishery	Fully exploited, overexploited, etc.; check conforms to FAO/ national classification
Other comment	Any other comments	
LIFDC	Low income food deficit country	Flag – may be used in later analysis; data available partly inserted
PerCap	Per capita fish consumption	To obtain from FAO Fishstat, may be used in later analysis
ProSpec	Protected species	Flag – separate lines inserted and flagged with P
XtraWkSheet	Reference to additional worksheet (country.xls)	Flag – refers to subsidiary sheets for certain countries/fisheries where discard data in the source material were transformed to discard database format
DT	Discard total	Flag – records selected for calculation of total discards
D	Double counting	Flag – indicates possible/probable source of double counting
SS	Small-scale fishery	Flag – indicates small-scale fisheries
Country code	Field not in spreadsheet as yet	Standard UN/FAO code to be inserted
Species code	Field not in spreadsheet as yet	Use standard FAO code – species/species group/family, etc.
ISSCFG	Field not in spreadsheet as yet	International fishing gear classification code ISSCFG – to be inserted (note other class, e.g. United States)

TABLE 34
Number of records by country or area

Albania	1	Germany	10	Pakistan	11
Algeria	4	Ghana	5	Palau	1
American Samoa	1	Greece	7	Panama	3
Angola	12	Grenada	1	Papua New Guinea	2
Anguilla	1	Guadeloupe	1	Peru	31
Antigua and Barbuda	1	Guam	1	Philippines	34
Argentina	48	Guatemala	4	Pitcairn Islands	1
Aruba	1	Guinea	6	Poland	5
Australia	39	Guinea–Bissau	7	Portugal	20
Bahamas	2	Guyana	6	Puerto Rico	1
Bahrain	5	Haiti	2	Qatar	1
Bangladesh	9	Honduras	1	Romania	1
Barbados	8	Iceland	20	Russian Federation	61
Belgium	4	India	18	Saint Helena	1
Belize	1	Indonesia	13	Saint Kitts and Nevis	1
Benin	2	Iran, Islamic Rep.	4	Saint Lucia	1
Bermuda	1	Ireland	24	Samoa	1
Brazil	62	Israel	5	Sao Tome	2
British Virgin Islands	1	Italy	5	Saudi Arabia	9
Brunei Darussalam	4	Jamaica	2	Senegal	13
Bulgaria	1	Japan	53	Seychelles	2
Cambodia	12	Jordan	1	Sierra Leone	4
Cameroon	6	Kenya	2	Slovenia	1
Canada	50	Kiribati	1	Solomon Islands	1
Cape Verde	5	Korea, Dem. Rep.	4	Somalia	3
Cayman Islands	1	Korea, Rep.	32	South Africa	31
Chile	61	Kuwait	3	Spain	18
China	36	Latvia	4	Sri Lanka	12
Colombia	3	Lebanon	1	Sudan	4
Comoros	1	Liberia	4	Suriname	7
Congo	1	Libyan Arab Jamahiriya	5	Sweden	9
Cook Islands	1	Lithuania	1	Syrian Arab Republic	2
Costa Rica	5	Madagascar	5	Taiwan Province China	18
Côte d'Ivoire	3	Malaysia	60	Tanzania, United Rep.	2
Croatia	1	Maldives	9	Thailand	24
Cuba	2	Malta	4	Timor-Leste	1
Cyprus	3	Marshall Islands	1	Togo	1
Denmark	25	Martinique	1	Tokelau	1
Djibouti	1	Mauritania	8	Tonga	1
Dominica	1	Mauritius	3	Trinidad and Tobago	12
Dominican Republic	2	Mexico	44	Tunisia	8
Ecuador	1	Micronesia, Fed. States	1	Turkey	18
Egypt	9	Montserrat	1	Turks and Caicos Islands	1
El Salvador	5	Morocco	27	Tuvalu	1
Equatorial Guinea	1	Mozambique	7	Ukraine	1
Eritrea	5	Multiple countries	99	United Arab Emirates	1
Estonia	4	Myanmar	9	United Kingdom	36
European Union	7	Namibia	17	United Kingdom (British Indian Ocean Territory)	1
Faeroes	8	Nauru	1	United States	136
Falklands/Malvinas	12	Netherlands	6	Uruguay	15
Fiji Islands	1	New Caledonia	1	Vanuatu	1
Finland	7	New Zealand	7	Venezuela	17
France	34	Nicaragua	7	Viet Nam	15
France (Mayotte)	1	Nigeria	3	Wallis and Futuna Is.	1
France (Réunion)	4	Niue	1	Yemen	7
French Guiana	4	Norfolk Island	1	Yugoslavia/Serbia and Montenegro	1
French Polynesia	1	Northern Mariana Islands	1		
Gabon	2	Norway	57		
Gambia	2	Oman	6	**Total**	**1 791**
Gaza strip/Palestine	1				
Georgia	1				

Note: not all records contain discard information. The number of records is an indication of the number of fisheries recorded.

TABLE 35
Supporting evidence for low or negligible discard rates in certain fisheries

Area	Comment/fishery	Source
Small–scale and artisanal fisheries		
Morocco	"… considered non–existent, since local fishers sold or consumed the total catch"	Baddyr, 1989
Cameroon	"… there are no discards in artisanal fisheries. In Cameroon, even the immature fish is used so there is nothing to be discarded at all"	O. Njifonjou, pers. comm.
Senegal	"… no discards in artisanal fisheries"	CRODT, pers. comm.
Mozambique	"… insignificant in artisanal fisheries"	IDPPE, Maputo
Pacific Islands	"… statistically not distinguishable from zero"	T. Adams (SPC), pers. comm.
Samoa	"… very rare"	A. Wright (SPREP), pers. comm.
Caribbean Islands	"Negligible"	Chief Fisheries Officer, Saint Lucia; FAO Regional Fisheries Officer
Myanmar	"… discards are negligible in artisanal fisheries"	Myanmar Fisheries Federation, 2003, pers. comm.
Other fisheries and countries		
Eastern Central Atlantic	"… discards have never been assessed but are supposedly negligible"	Balguerías, 1997
Sri Lanka	"… no discards in Sri Lanka fisheries as all fish landings are utilized for human consumption"	A. Hettiarachchi, Director–General, pers. comm.
Thailand	"… we make use of everything"	SEAFDEC
Cambodia	"… there are no discards"	Delegate to COFI, 2003
Viet Nam	"… we do not collect information on discards as discarding is not of concern. Discards are low or negligible"	Delegate to COFI, 2003
Malaysia	"… not common in Malaysian capture fisheries" … "trash fish … is being used as fishmeal by the aquaculture industry"	bin Nuruddin, (2003), Samut Prakan workshop
Malaysia and Thailand	"RSW [refrigerated seawater] systems … allowed nearly all the bycatch to be kept on board" … "… quantum of discards expected to decrease"	Chee, 1997
Indonesia	"Very low in all fisheries except the Arafura Sea trawl fishery." … "Negligible in most artisanal fisheries"	P. Martsubroto (FAO), pers. comm. L. Engvall, pers. comm.
China	"Although much of this catch is low market, none is discarded." … "Discarding is not believed to exist any more"	Zhou and Ye, 1997
	"We use everything … some discards in the long-range trawl fishery in the South China Sea"	
	"All species are targets"	China delegate to COFI, 2003 Ministry, 2003, pers. comm.
India	"very very low"	Ministry, Delhi, pers. comm. MPEDA, Kochi, pers. comm.
	"1–2%." … "India imports large quantities of animal feed"	
South Africa, Japan, other	Zero discards in squid jig fisheries	Japp, 1997
South Africa	Zero discard rate in abalone diver fisheries	Japp, 1997
Cape Verde	Lobster diver fishery	Ministerio do Mar
Mauritania	Octopus pot fishery	DSPCM
Senegal	Kayar linefish	Fisheries inspector
Celtic Sea/Biscay	Tuna pole and line	Melnychuk *et al*., 2001
Norway	Mackerel troll	Valdemarsson and Nakken, 2002
Fishmeal fisheries		
Peru	"… discards estimated to represent <5% of total landings"	IMARPE (R.G. Carrasco), pers. comm.
Denmark (Baltic)	"… no, or minor discards … impossible to sort … discards in these fisheries are negligible"	ICES, 2000a
Morocco	>5% caused by net damage (coastal sardine used for food and fishmeal)	Haddad, 1994
	"… insignificant" (industrial pelagic vessels)	
Iceland	Blue whiting caught for fishmeal	Fishing News International, 2003
CECAF region	Russian pelagic midwater trawlers for small pelagics (targeted as food fish, not for fishmeal). "… bycatch entirely processed to fishmeal ... insignificant discards of invertebrates only"	N.M. Timoshenko, pers. comm.
South Africa	Purse seine and midwater – minor regulatory discards only	Japp, 1997
Black Sea	Fishmeal plant capacity is greater than supply of anchovy	Fisher cooperative, Trabazon, pers. comm.
Scotland	Argentine and blue whiting fishery	Pierce *et al*., 2002
Norway	Industrial fishing 1–2.4% discard	Valdemarsson and Nakken, 2002
Baltic	Swedish herring and sprat trawl	ICES, 2000a

Annex D

Summary of the reasons for discards

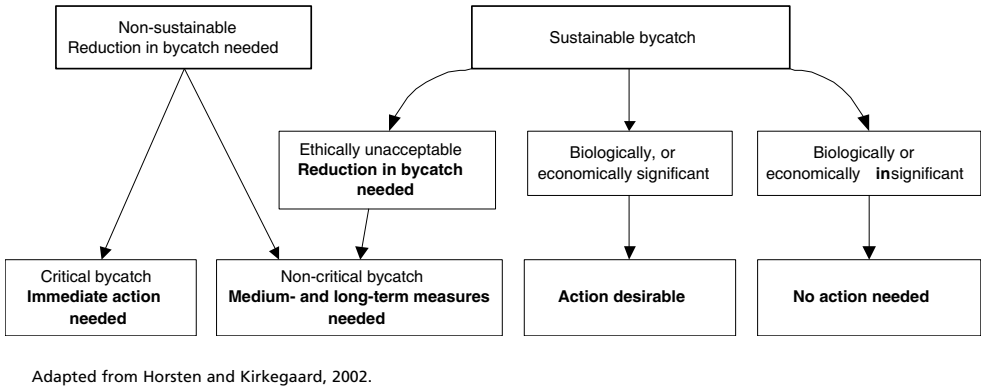
D.1 CAUSES OF DISCARDS

A clear understanding of the reasons for discarding is necessary in order to change discarding practices and help design sampling and raising protocols. A basic classification of the catch may be made into: (i) fish (species/sizes/sex) always retained; (ii) fish always discarded; and (iii) fish partially/occasionally discarded. The reasons for the discards are likely to vary by type of fish and discard reduction efforts may be most effectively focused on fish that are partially discarded.

D.2 CAUSAL DIAGRAM AND DECISION FRAMEWORK

D.2.1 Evaluation of bycatch

FIGURE 5
Evaluation of bycatch



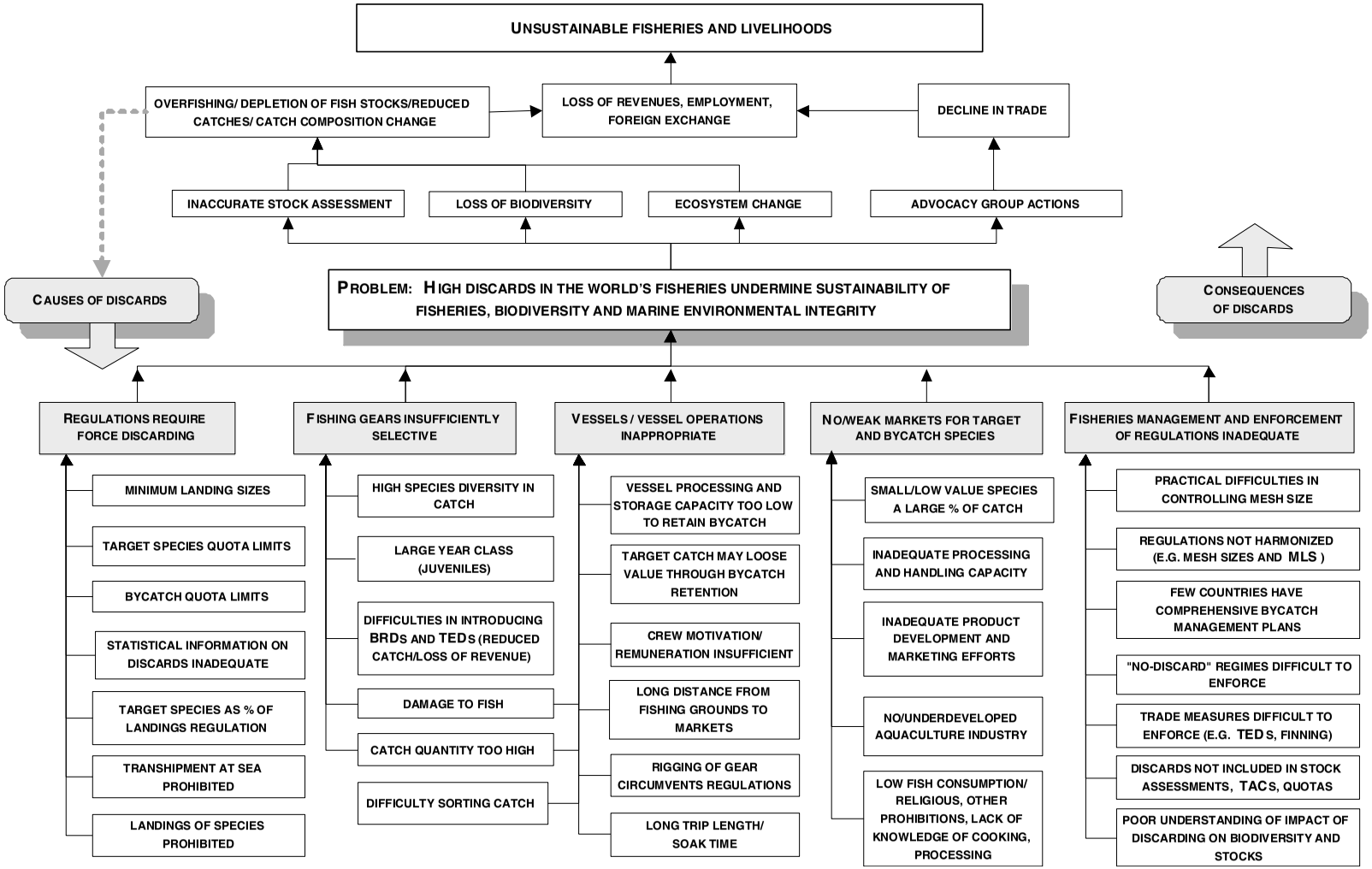
Adapted from Horsten and Kirkegaard, 2002.

Figure 5 presents the causes and consequences of discarding.

TABLE 36
A classification of causes of discards

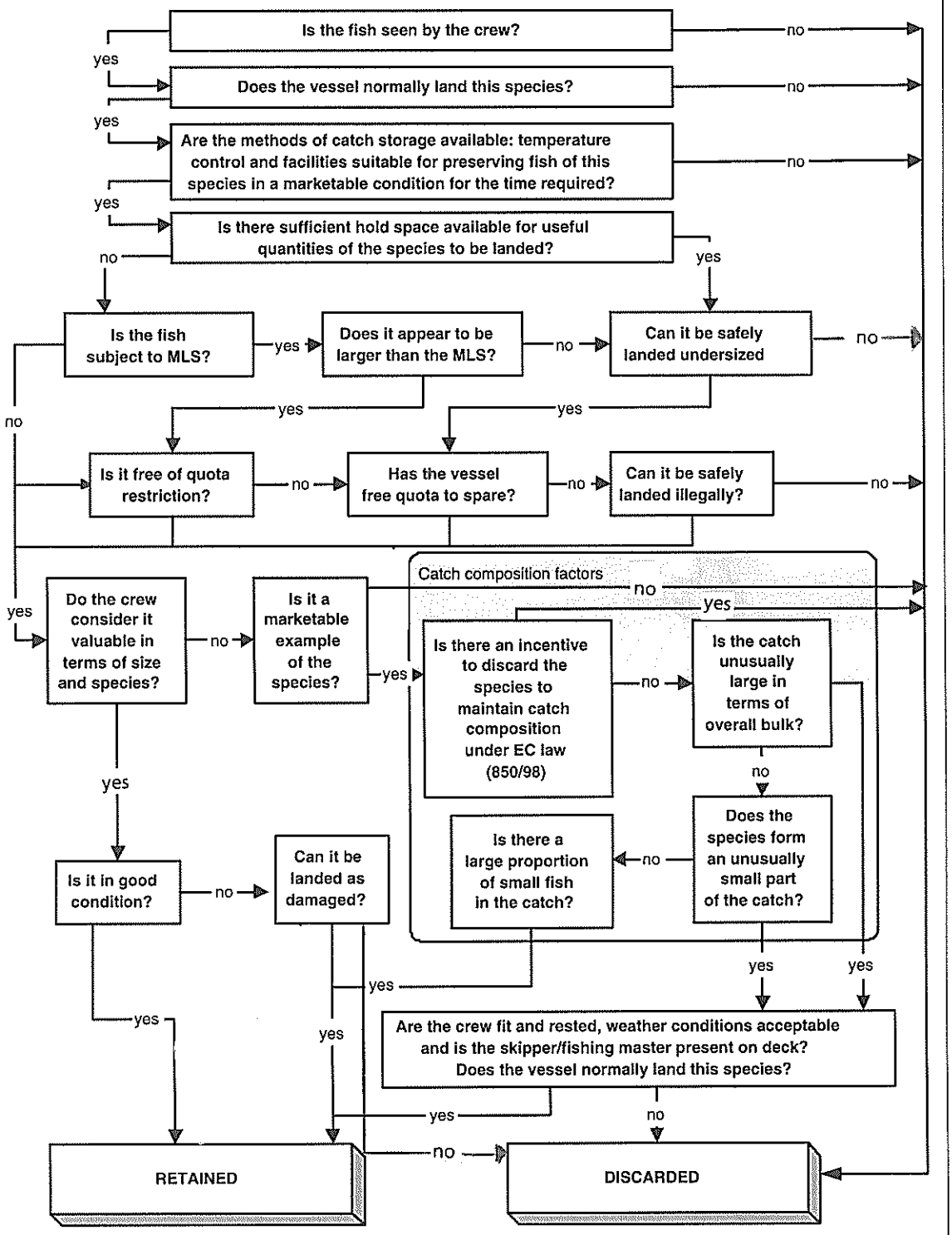
Cause/parameter	Comment/examples/trends
Biological	
Species composition	High species diversity is likely to increase untargeted species harvested. Changes in the species composition in fisheries may increase or decrease discards and may be directly linked to overfishing. Changes in discarding practices are likely to be related to change in the proportion of target species
Year class	Large juvenile year class may increase discards
Exploitation status (overfishing)	Overfishing may result in a larger proportion of smaller fish in the catch and large discards of juveniles or fish under the MLS; low stock density of target species may lead to increased fishing effort and unwanted bycatch
Sex	Target is roe fish only, immature/male fish may be discarded
Poisonous/dangerous	For example, landings of Lujanus bohar are prohibited in Réunion; stingrays
Vessel characteristics	
Size of fish hold	Bycatch may occupy space designated for target species
Freezing capacity	Quality of more valuable target species may suffer; insufficient freezing capacity; different freezing duration for shrimp and bycatch, for example
Limited ice on board	Quality of target species may suffer if ice is used for bycatch
Catch quantity	If catches are large, then discards may be higher
Processing plant	Catches exceed capacity of plant (e.g. surimi plant, fishmeal plant). Small/very large sizes cannot be handled by filleting machines
Catch composition	Small sizes, damaged fish, impossible to sort (small pelagics)
Fishing operations	
Skipper	Payment mechanism, personal preferences, skills
Selectivity	Wide range of effects on target species and bycatch
Crew remuneration	Payments linked to bycatch recovery, or not
Trip length	Discards higher at start of long trip
Haul length	Discards may be higher if trawl haul time is long, because of damage to fish
Soak time	Discards higher with long soak time because of damage to fish, e.g. Celtic Sea French gillnets
Time of trip	Differences in fish behaviour day/night /tides, e.g. Nephrops North Sea; discards may be higher at the start of a trip
Fishing area	Some areas known to have high concentrations of juveniles/unmarketable fish/predators (line fisheries)/jellyfish
Fishing season	Restrictions often applied to avoid large unwanted catches of juveniles
At–sea transfer	Payment, theft of target catch
Gear	
Rigging of gear	May have a major influence in trawl and longline fisheries, e.g. chafers
BRDs	Major effect in some fisheries, e.g. in Norway, in NAFO, square mesh panels in Nephrops trawls, numerous Australian trawl fisheries
Hook/line type/bait	Related to mouth, feeding behaviour and fishing depth, e.g. tuna/shark
Mitigation measures	Assessment of effectiveness difficult because of low incidental catch rates
Selectivity	Gear characteristics may not be in harmony with regulations, e.g. MLS
Market	
No/poor market for bycatch	Common in many fisheries, e.g. Guianas shrimp, Mozambique shrimp. Uneconomical to freeze low–value bycatch
Damaged fish	For example, crushed in the codend, decomposed, shark damaged
Taboos, customs	Low or non–consumption of shark in Jamaica
Bycatch retention reduces value of target species	Use of crew time for sorting, reduced efficiency of freezers, cold store efficiency compromised
Highgrading	Common in many quota fisheries (e.g. EU, United States)
Poor economic performance	May result in retention of more bycatch to cover costs (marginal profitability). May also result in reduced fishing effort and reduced discards
Regulatory	
Licensing	Fishing licence may restrict catch/landings to certain species
Observer effect	Presence of observer may result in greater retention of bycatch, increased discards (e.g. if the observer is monitoring quotas), or increased reporting of discards
Highgrading/quotas	Common where quotas are strictly enforced
Target species as % of landings	May result in "discards" or disposal of non–target species after landing, i.e. bycatch retention only until landing and subsequent dumping, e.g. France
MLS	The less selective the gear the higher the discards
Bycatch quota	Requires effective enforcement, probably by observers and possibly retention of bycatch
Time/season	Effective in reducing bycatch and discard of juveniles
Level of enforcement	All regulatory discards are closely related to the level of enforcement or fishing community peer pressure

FIGURE 6 **Causal diagram of discards**



D.2.2 Discard decision framework (United Kingdom)

FIGURE 7
Discard decision framework (United Kingdom)



Adapted from Lart, 2002.

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Discards represent a significant proportion of global marine catches and are generally thought to constitute waste or suboptimal use of fishery resources. A number of United Nations resolutions have drawn attention to the need to monitor and reduce discards and unwanted bycatch, in order to assess the impact of discards on marine resources and promote technologies and other means of reducing them. This paper provides an update of the quantity of discards in the world's marine fisheries based on a fishery-by-fishery approach. The previous FAO estimate of discards at a global level, based on data prior to 1994, is now considered outdated. The present study re-estimates discards at a global level using information from a broad range of fisheries in all continents. Selected policy and technical issues are highlighted and suggestions made for future actions. A road map for achieving further precision in the global estimate is described and associated initiatives are outlined.

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