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Final Report:
The problem of discards in fisheries

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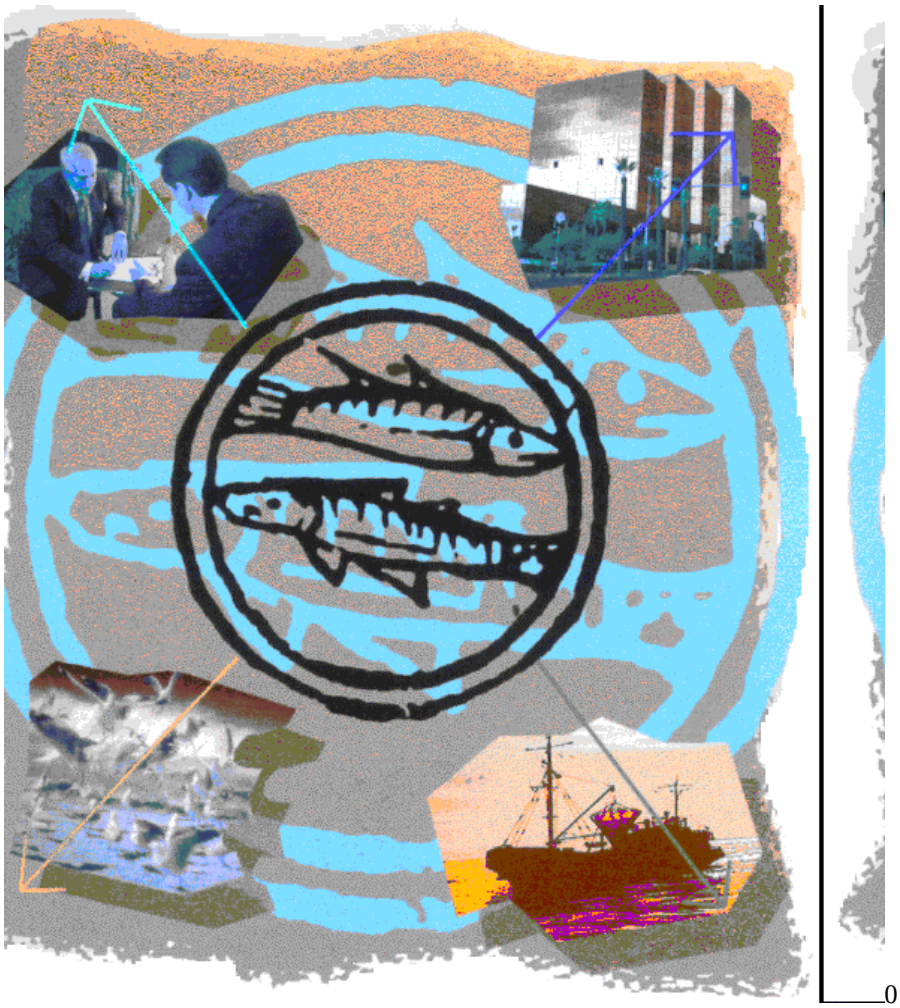

June 1999/Portugal

Options brief

Study on the problem of discards in fisheries

Megapesca Lda.

Portugal
April 1999

POLICY OPTIONS FOR DISCARD REDUCTION IN EU FISHERIES

Rationale and scope for discard reduction policies

To safeguard EU fish stocks, present EU policy (expressed in Council Decision 97/413/EC) is directed at cutting fishing mortality by up to 30%. Discussions with senior scientists covering North Sea stock management suggest that an "appropriate" discard reduction policy might result in a 5% reduction in fishing mortality. Discard reduction policy alone, no matter how successful, will not solve the major problem in EU fisheries, that of too much capacity to catch the resource available. The principal policy measure for achieving sustainable exploitation of fisheries resources must therefore continue to be reduction of fishing effort.

Policy options

Discard bans would reverse existing EU policy, which forces, under penalty, the discarding of certain species and sizes of fish. Variant options in discard bans include total, selective (species-related) or partial (area-related) bans. Norwegian experience shows that a discard ban is workable where there is good access to shore-based infrastructure, where it is relatively easy to comply, and other measures have already reduced discarding to a minimum.

Various factors mitigate against a discard ban in EU waters, including inherently higher discard rates, geographic dispersal of fisheries, high proportion of the juveniles and lack of a compliance culture. An enforced general discard ban would therefore be likely to close many EU fisheries, and is not a feasible policy option in the short term. However if other management measures show positive results in discard reduction (as they have in Norway), the subsequent introduction of discard bans for selected areas or fisheries could then be realistically considered.

The option of **flexible closed areas** is becoming increasingly available as new technology provides opportunities for rapid or real-time reporting of fishing outcome and better vessel monitoring. Preferential access to partial close areas could be provided to vessels which meet certain conditions (such as adopting technical measures for discard reduction). Threshold conditions for closure would be related to discard rate and/or composition.

For timely implementation, closed area decision making would have to be decentralised, which would involve delegation of fisheries management authority to regional organisations, which might beneficially include stake-holder participation. The flexible use of real-time area closures could provide a workable discard reduction option for North Sea sole and plaice fisheries and the hake, megrim, and monk fisheries in Area VII (West of Ireland) and VIII (Biscay).

More flexible quota allocation provides another option for some fisheries, in the form of **multi-annual** or **multi-species** quotas, which would reduce discards and illegally landed fish (Ablack fish@) which would become discards if regulations were fully enforced. This policy would permit above-quota catches to be landed but may result in undesirable increased fishing mortality of stocks already under pressure.

This policy would operate most effectively where quotas are already allocated to individual vessels and at present this would focus on the North Sea fishing nations. This option would also require more detailed scientific assessment of mixed species and multi-annual TACs that provide equivalence with existing limits. This option may be of benefit for the haddock, cod and whiting fishery in Area IV (North Sea).

Mitigating the effects of **minimum landing sizes** (MLS) provides another option, since MLS rules compel the discard of under-sized fish. Discard reduction could be achieved by reducing or eliminating the MLS or permitting the retention of a percentage of sub-MLS fish. For the policy to be effective there must exist a market for smaller sized fish, otherwise they will be discarded irrespective of the regulatory MLS. The policy would therefore be applicable to fisheries such as hake and horse mackerel pursued by Spanish or Portuguese vessels. However, there is a general opinion that the existing MLSs should not be further reduced.

Another policy option is to permit the landing of up to a specified percentage of target-species fish below the MLS, and to deduct that percentage from the quota for that vessel, whether or not it is landed. Such measures would create an economic incentive to land, rather than discard, the sub-MLS fish. This policy is successfully implemented in Norwegian small pelagic fisheries to overcome the problems of Ahigh grading@ and Aslipping@.

Recent developments in technical measures to improve gear selectivity provide new and promising policy options in **technical gear regulation.** These include square mesh panels, separator trawls, sorting grids and acoustic avoidance devices, all of which are being actively considered by EU fisheries managers. Effective use of technical measures is difficult to enforce since fishermen can adjust their gear to negate any effect but resistance to their use can be overcome by incentives such as subsidies and preferential access to closed areas. These measures would seem to present realistic short-term options for *Crangon* and *Nephrops* fisheries.

In some circumstances a **gear ban** is a workable policy option for discard reduction. Such a policy is now applied to the EU drift net fisheries for tuna, tuna-like species and swordfish. Gear bans are easy to enforce, but involve substantial cost. For example, the most effective measure to reduce the considerable discards of plaice in beam trawling for sole and plaice in the North Sea Area IVb would be a

prohibition of this gear, but the cost to the industry or the tax-payer would be several hundred million Euro.

Abstract

The problem of discards in fisheries

This study, undertaken by Megapesca Lda. of Portugal, on behalf of Science and Technology Options Assessment of the European Parliament, defines the extent and nature of the problem caused by discarding in EU fisheries, and analyses the key issues involved.

Discarding is shown to be mainly a problem in the North Sea and Atlantic fisheries, most commonly involving demersal trawl fishing, especially for flatfish and crustacea. Most discards are caused by economic and legal constraints on fish landings. The main impact of discarding is direct and future losses of fish of commercial value, although indirect impacts are on the ecology of non-commercial species, the marine food-web and loss of fisheries mortality data.

Because of their impacts, the issue of discards has received considerable research and policy support. Although no specific EU policy operates on discards, a range of conservation measures aimed at discard reduction are implemented.

The discard policy framework in Norway was investigated. This is based on progressive introduction of discard reduction measures, followed by a general discard ban. Due to significant structural differences such a policy is not considered to be an option at present for the EU, although selective discard bans may have a role in some fisheries in the longer term.

Other EU policy options are also considered, including mitigation of minimum landing sizes, flexible closed areas, use of multi-annual and multi-species quotas, technical gear controls and gear bans. For each policy option, the advantages and disadvantages are explored, and the pre-conditions outlined. Suggestions are made as to how specific EU fisheries with discard problems might benefit from the options presented.

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Executive summary

Study on the problem of discards in fisheries

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Portugal
June 1999

Discarding is the practice of returning to the water fish which are caught by a fishing operation. Many EU fisheries, particularly trawl fisheries, are characterised by high discard rates of unwanted or unmarketable fish, and of juvenile or undersized commercial species.

Science and Technology Options Assessment of the European Parliament contracted fisheries consultants Megapesca Lda. of Portugal to undertake a policy options study on the problem of discards in EU fisheries. The objective of this multi-disciplinary study is to define the extent and nature of the problem of discards in fisheries, analyse the key issues involved, evaluate existing policy approaches, and present the policy options available for consideration by the European Parliament.

The type and quantity of discards depends on the selectivity characteristics of the fishing gear for species and size. Trawls and dredges tend to be the least selective methods. Baited hook and line gear can be made quite selective for both species and size. Purse seining is an encircling gear for schools of pelagic fish and is selective for species, but not necessarily for size. Traps and pots are static gears which are generally highly selective.

Fishermen seek to maximise profits and this economic motivation is a common reason for discards. Target species may be discarded because they are below market size or damaged upon capture. Target species which are acceptable to the market may be discarded in favour of better sized or quality individuals. Commercial non-target species which have a lower value than the target species may be discarded to reduce workload and preserve storage capacity. Non-target species may be discarded if they have no value. At the beginning of a lengthy trip discards may also occur of species which do not keep well.

Discards may also be induced by management measures. Present conservation policy in the EU applies requirements for minimum landing size (MLS). Retaining fish below the MLS on board is an offence, so undersize catch is discarded, often on a large scale. Quota arrangements and Total Allowable Catches (TACs) also tend to have the same effect, although there is evidence that most fisherman prefer to take marketable fish home, even if this is illegal. This is the so-called Ablack fish@ problem. Discard rates would certainly increase in the short term if there was better compliance with quotas.

Large hauls of a single species of shoaling fish such as herring or mackerel may contain juvenile fish, or a mixture of species. Such hauls have reduced value and it is common practice to discard the unwanted catch, to Asave@ quota for higher

value fish, a practice known as Ahigh grading@. However, blame can only partly be placed on quota restrictions; low market value also plays a part in these discards, and in some cases fish may be Aslipped@ in the absence of any quota regime at all.

There is considerable evidence that large quantities of discards represent production and yield forgone, that is future economic losses to the fisheries. However few studies estimate the economic costs and benefits of discards. A FAO report estimates that the total costs of bottom fish discards in the North Sea could approach the value of landed catches (about _700 million in 1997). OECD estimates that the value of haddock discarded in the North Sea to be over _100 million. Discards also carry an opportunity cost, being the value of lost future catches of commercial species. Although it is extremely difficult to estimate these values with any accuracy, the recent DGXIV-funded ECODISK study calculated that discarding of plaice in the 1996 *Crangon* fishery in the North Sea resulted in subsequent losses worth _18 million.

There is also growing evidence that intensive fishing with unselective gears may alter the habitat and affect biodiversity and abundance of both target and other species within the food web. Discarded components of by-catch usually die and enter the food chain. Discards of commercial and non-commercial fish and offal are estimated to sustain a significant part of the North Sea seabird population. High volumes of discards may also result in large amounts of fish reaching the bottom; there are anecdotal accounts of bottom trawlers Acatching@ quantities of decomposing pelagic fish. Discards also represent a loss of fishing mortality data which provide a key input into population models used by fisheries scientists to estimate sustainable catch levels although most models do include a factor for discard fishing mortality.

Because of their effects on fish stocks and the marine ecosystem, discards of fish are considered to be undesirable, and policy initiatives have been discussed to deal with them. The issue of discarding has been discussed in many international fora, including the EU Council and the UN General Assembly.

Because of the extent of the discard problem much recent research has concentrated on this issue. The European Union currently supports two major research programmes which include work in the area of discards. Within the EU FAIR Programme of Research and Technological Development (1994-98), _130 million was available for fisheries research. Of the 106 projects funded, seven studied discards directly and a further seven studied related issues. The cost of these studies was about 11% of the fisheries budget. The Biological Studies Programme (1994-98) funded c.200 fisheries studies of which about 50 were related to the issues of discards, by-catch and selectivity.

Research topics have focused on both quantification of discards, and means of reducing their occurrence. This latter area has included means of making fishing gears more selective and investigation of the survival of fish that are discarded, or pass through the fishing gear. APingers@ have been designed to alert porpoises to the presence of gill nets. Bio-economic models of discarding have been developed to predict discard quantities and composition. Research (such as the FISHCAM project) is continuing into computerised onboard data collection and analysis systems which may permit more appropriate and timely corrective fisheries management action.

Discards are difficult to quantify with standard measures since there is a wide variety of different fisheries within the European Union. Some countries (e.g. Scotland) have established routine sampling programmes. In other countries discard data has only been collected on an *ad hoc* basis. Sampling is the main problem, because discard rates vary substantially, even in the same fishing operation. Data from 67 EU discard surveys were reviewed as part of this study. These data provide the only factual basis presently available for the development of policy options in the EU, and the consultants used this information to compile a discard impact index, which represents the severity of the discard problem in each fishery studied. The index takes into account the sensitivity of the discard species, discard rates and quantities and the relative market price of the discarded species.

The index is used to define the main EU fisheries which present a discard problem, which are as follows:

Area	Fishing method	Target Species
IV bc	Beam Trawl	Sole, dab, turbot, brill, plaice
IV	Demersal Trawl	Haddock, Cod, Whiting
VII/VIII	Demersal Trawl	Hake, megrim, monk
VII/VI /IV	Demersal Trawl	*Nephrops*
Ivb	Beam Trawl/ Shrimp Trawl	*Crangon*
VII Celtic Sea	Gill net	Hake
NE Atlantic	Bottom trawl	Roundnose grenadier
NE Atlantic	Bottom trawl	*Nephrops* and shrimp
Greece	Otter trawl	Hake, sea bream, flatfish, shrimp
Ionian Sea	Bottom trawl	Demersal species

It is evident that demersal trawls are the most significant gear for discarding especially in the North Sea and NE Atlantic, and particularly bottom trawling for

Crangon (brown shrimp), *Nephrops* (Dublin bay prawn or scampi) and beam trawling for sole and plaice. Mixed demersal trawls for cod, haddock and whiting also result in significant discards. Total quantities are not known for certain, but in the North Sea they are certainly in the region of hundreds of thousands of tonnes. More than 70% of recorded discards consist of demersal roundfish and flatfish. About half of the discards occur in beam-trawling. In pelagic trawling discarding can be high at times, depending on season and target species. This gear might also accidentally catch marine mammals such as dolphins and grey seals.

Little discard research has been undertaken in Baltic fisheries, but relatively selective fishing methods and high utilisation of small pelagic fish suggests that discarding is not such a problem. Mediterranean fisheries are characterised by a wide range of fishing gears and species, for which there is demand (even in the case of small fish). In most Mediterranean fisheries discard levels are relatively low, with the exception of large-scale driftnet fisheries for tuna and swordfish, and trawl fishing for deepwater crustacea.

In terms of policy frameworks for discard reduction the Norwegian experience is instructive, since there are similarities in species and gear types. Here the policy has been a progressive introduction of discard reduction measures, to the point where a discard ban could be successfully implemented. Early measures enacted rules on selective gear (mesh sizes and use of sorting grids). This was supported by flexible fishing area closures (up to hundreds of km^2) introduced when captures of undersized fish reach more than 15% by number. There is a requirement to land a fixed percentage of sub-MLS sizes of pelagic species, with automatic quota deduction whether or not they are landed. All of these measures made the subsequent introduction of the discard ban quite feasible, since the most important problem of reducing unwanted or unmarketable catch to the optimal level, had already been solved. Evidence suggests that the discard ban is flouted to an extent, but this is not widespread. On the whole therefore, the policy is considered to be successful in achieving its objective of minimising discards.

In the EU on the other hand, no specific discard reduction policy is in operation, but there is a series of *ad hoc* conservation measures intended to preserve stocks whilst maintaining Arelative stability@ in fisheries activity. Current conservation policy is implemented in Council Regulation 850/98, presenting current measures for fisheries conservation, which came into force on in October 1998 and will be applicable from 1st January 2000.

Technical measures are used to modify the type of gear which is used. Present requirements cover minimum mesh sizes (MMS) in most fisheries, with the objective of allowing smaller fish to avoid capture. Drift nets will be banned from

2002. There are also several closed areas within EU waters, such as the ANorway Pout Box@ and the APlaice Box@ where fishing gear and effort is restricted, with the intention of preventing the catch of juvenile fish of both target and non-target species which would otherwise be discarded. The requirement for mandatory escape devices (sorting grid, separator trawl or square mesh panels) is not used extensively in the EU, but much promising research is underway which will provide new options for policy makers.

The regulatory approach suffers from the problem of dilution of policy by political pressure, and from difficulties of enforcement. Many of these regulations have been opposed by the EU=s fishermen, leading to derogations. Fishermen have also often proved adept at circumventing regulations. New regulations attempt to close the loopholes, resulting in ever more complicated measures which confuse and alienate fishermen, and are difficult to enforce.

Clearly there is scope for new options in the area of **discard reduction policies** within this broader policy framework. The options, described in the options brief which follows, need to focus on the areas where discards have the most impact, and some suggestions are made where this may be.

Final Report

Study on the problem of discards in fisheries

Megapesca Lda.

Portugal
April 1999

Preface

Science and Technology Options Assessment of the European Parliament has contracted fisheries consultants Megapesca Lda of Portugal to undertake a policy options study on the problems of discards in fisheries.

The objective of this multi-disciplinary policy options study is to define the extent and nature of the problem of discards in fisheries, identify and analyse the key issues involved, define and evaluate existing policy approaches, and present the most significant policy options available for adoption by the European Parliament.

CONTENTS

Glossary

For the purposes of this study, we have adopted the following terminology:

Target Catch	The intended catch of fishing activity in terms of species or group of species
Incidental Catch	Retained catch of non-targeted species.
Discarded Catch	That portion of the catch returned to the sea as a result of economic, legal, or other considerations
By-catch	Discarded catch plus incidental catch.
Incidental Catch Rate	The proportion of total catch which is incidental catch.
Discard Rate	The proportion of total catch which is discarded
Discard Mortality Rate	The proportion of the discarded catch that dies as a result of catching or handling processes.

1. Introduction

Many fisheries, particularly trawl fisheries, are characterised by high discard rates of unwanted fish, and of juvenile or undersized commercial species. There is considerable evidence that large quantities of discards represent production and yield forgone, or future economic losses to the fisheries. Community and ecosystem level impacts of discarding are more difficult to prove. However, there is growing evidence that intensive fishing with poorly selective gears may alter the habitat, and affect biodiversity, community structure, species composition and abundance of both target and other species within the food web. The most recent FAO estimate sets global discards at 20 million tonnes, which is equivalent to about 25% of reported annual production from capture fisheries[1].

For these reasons the practice of discarding in fisheries is generally perceived as a problem that should be eliminated or reduced. The issue of discarding has been discussed in many international fora, including the UN General Assembly, which passed resolutions in 1994 calling for a more sustainable use of marine resources. The UN Commission on Sustainable Development will again address the issue at its forthcoming session in April 1999.

Within the European context the Science and Technology Options Assessment of the European Parliament has commissioned this study to review the issue of discards in fisheries within the European context, and to develop workable policy options for consideration by the Fisheries Committee of the European Parliament.

In the course of preparing this report the authors have consulted many sources of information. To avoid disrupting the text, only the principal references are quoted in the main body of the report. A full bibliography is however provided in Annex 1.

2. Assessment of existing practices of discards

2.1. Definition of by-catch and discards

The first comprehensive study of global by-catch and discard levels was published in 1983[2]. ABy-catch@ was defined as Athat part of the gross catch which is captured incidentally to the species towards which there is directed effort@. Since then, there has been a proliferation not only in the number of studies and publications on these subjects, but also in the ways the terms Aby-catch@ and Adiscard@ have been used. Thus, the term "by-catch" has been used in reference to:

species which have been retained and sold
specimens or sizes or sexes of species discarded as a result of economic, legal, or personal considerations, and
non-targeted species retained and sold, plus all discards.

Discards may be classified on the basis of the nature and extent of their biological or ecological significance. Discards may also be classified on the basis of the reason behind them, being either regulatory or economic.

2.2. Discards in different fishing operations

The types and quantities of discards in fishing operations will depend on the species and size selectivity characteristics of the gear used in relation to the target species. Other relevant factors include the fishing grounds, the time of the year, and the fishing tactics. Because the same gear used under different circumstances may result in very different catches and thus discards, the term Amétier@ is often used to distinguish particular fishing operations on the basis of the above combination of factors.

Although some métiers catch a wide range of species, others can be extremely selective, with most of the catch dominated by one or a few species. For example, for all practical purposes, only one species is caught in octopus pots, and thus there is no discarding of other species. However, gears such as trawls are relatively non-selective with regards to species and consequently will catch many non-target species which may or may not be discarded. All fishing gears are to some degree selective in terms of the sizes of a particular species which are caught. In other words the probability of capture will vary with characteristics of the fish, because of selection processes associated with the gear.

In general, fishing gears can be classified as active or static/fixed. Active gears are those which involve motion and include trawls and dredges which are towed and purse seines which surround the school of fish. Static gears are those which are anchored or fixed and depend on the movements of the fish to come into contact with the gear. Such gears include longlines, gill nets, trammel nets, pots, and traps. Hook and line gear and traps usually require the use of natural bait as an attractant.

The following is a brief review of the main fishing gears and their selectivity.

2.2.1. Trawls and dredges

Trawls and dredges are active gears towed by one or a pair of fishing vessels. Various types of trawls are used to target demersal[3] species from relatively shallow inshore waters to depths of more than 1000 m, as well as schooling or pelagic species in the water column. Towing speed and the height and width of the opening of the trawl are important factors affecting catch composition and discards. Size selectivity is also a function of the mesh size used in the cod-end, which is regulated by law in all EU fisheries. However, because of their nature, trawls and dredges have low selectivity for demersal species.

2.2.2. Gill nets

Gill nets are single sheets of netting, usually monofilament, with a weighted footrope and a headrope with floats, which are usually fished anchored on the bottom to catch demersal and benthic fish. However, many variations exist, including pelagic or drift gill nets which fish at the surface, and encircling or >run-around= gill nets which are set around schools of fish and act partly in the manner of purse seines. Gill nets are generally considered to be highly selective in that, depending on the mesh size and the tautness of the netting, a very precisely defined size range of target species is caught. They may, however, catch or entangle other fish and animals. Some gillnets are capable of incidentally entangling large numbers of crustaceans such as crabs. These are often destroyed, as this is the only practicable way of removing them from the nets. Regulations exist to prevent the misuse of these nets in targeting crustaceans, limiting the by-catch that can be landed, or prohibiting the landing of, for example, crab claws.

2.2.3. Trammel nets

Trammel nets consists of three sheets of netting: an inner small mesh panel (e.g. 80 mm stretched mesh) between two large mesh outer panels (e.g. 140 mm stretched mesh). While some fish may be gilled or wedged in the smaller mesh netting, larger fish will push the small mesh netting through the larger mesh, forming a pocket in which they are tangled. Trammel nets are widely used for species of flatfishes, sea breams and cuttlefish. In comparison with gill nets, trammel nets are considered less selective because of the different ways that fish are caught (wedged, gilled or entangled).

2.2.4. Tangle nets

Tangle nets are large mesh nets (single sheet of netting) which have little or no buoyancy in the floatline. The target species are monkfish, and crustaceans (lobsters and crabs). Soak time in some fisheries, particularly those in deep water may be several days, resulting in significant discarding due to spoilage and scavenging of the catch. Little is known of the size selection of tangle nets, but because of the method of capture (entanglement) it is to be expected that this gear is undoubtedly less size selective than either gill nets or trammel nets.

2.2.5. Baited hook and line gear

Baited hook and line gear includes handlines, electric reels for fishing in deep water and longlines. In the case of handlines and electric reels, the terminal tackle consists of a lead weight and a small number of hooks, usually not more than six. Longlines consist of a mainline to which is attached branch lines at regular intervals with hooks. Different types of longline exist; bottom, semi-pelagic, vertical and pelagic. Bottom longlines target demersal species such as sea bream and cod. The semi-pelagic longline has floats which lift the mainline off the bottom, and is used for species such as hake. Vertical longlines are often used for very deep water species, whilst pelagic or drifting longlines are mainly used to target large pelagic fish (tunas, sharks and billfish) with hooks suspended in the water column. Generally speaking longlines and other hook and line gear can be made quite selective for both species and size by adjusting their location, hook and bait characteristics.

2.2.6. Purse seine

A purse seine is an active encircling gear, supported by floats, which is used to catch schooling fish in the upper part of the water column. The depth and length of the net can be considerable, more than 100 m deep and 500 m long in the case of large tuna purse seiners. Once the net has been set around the school, the net is >pursed=, closing the bottom as the net is hauled and trapping the fish. While most purse seining is an open water activity targeting pelagic species, in some areas purse seines have been adapted to fish demersal species. Because they target schooling fish, which by definition tend to relatively homogeneous groups, the gear is quite selective for species, but not necessarily in terms of size.

2.2.7. Traps and pots

Traps and pots are static capture gears which may or may not use bait as an attractant. Many different types of traps exist, with the design and size usually dependent on local custom, target species and available construction materials. Traps have one or more openings and chambers in which the catch remains until the gear is hauled. The fish, crustaceans or molluscs may escape back out through the opening or, if small enough, through the netting, or between the slats making up the sides and top of the trap. These gears are generally thought to be highly selective.

2.3. Discards in different EU waters

2.3.1. Baltic

Very little research has been undertaken on the subject of discards in Baltic fisheries. The range of commercial species of significance is limited to cod, salmon, sprat and herring. Discards of under-sized cod are relatively low due to the use of large-meshed gill nets as the main gear targeting this species in Sweden. However, some discards of juvenile cod are reported at certain times of year and recruitment is notoriously variable.

The International Baltic Sea Fisheries Commission has therefore recently recommended the installation of escape panels in trawls to enhance escapement of small cod.

The good market for small pelagic fish such as sprat and herring has meant that discarding has not been a particular problem in these fisheries. However, the collapse in 1999 of the Russian market for canned sprat produced by the Baltic states is now likely to alter this situation. The relatively selective fishing methods used for salmon result in neglible discards.

2.3.2. North Sea and NE Atlantic

Recent studies[4,1] reveal that discards of fish, bottom living creatures and offal can be considerable in the North Sea. In 1990, an estimated total of almost 800 000 tonnes of fish, invertebrates and offal were discarded, whilst total landings of fish were about 2.7 million tonnes. More than 70% of discards consisted of demersal roundfish and flatfish. About half of the discards occurred in beam-trawling. Demersal otter trawlers were also implicated in high discard rates, except during industrial fishing. In pelagic trawling discarding can also be quite high, depending on the target species. This gear might also accidentally catch marine mammals such as dolphins and grey seals.

Purse seines in the North Sea are mainly used to catch pelagic species such as herring, mackerel and pilchards where discarding is relatively low. However, occasionally the catch may be so large that it can not be brought aboard, resulting in a large amount of discards. Anchor and Scottish seines are gears used to target bottom species. Discard rates are below those found in demersal trawlers participating in the same fishery, because the fishing operation involves herding fish towards the net with heavy lines or cables. Smaller fish, which tire quickly, drop back over the cables and do not end up in the net.

Since the mid-1980´s there has been a significant increase in the use of static nets in the North Sea and NE Atlantic. There are a number of different types of operation which require consideration because of their importance in terms of catches. These include deepwater gill nets for hake, and tangle nets and trammel nets which target monkfish, turbot, rays and crustaceans such as crawfish. Because time in the water may be considerable (four or more days, particularly in deepwater fisheries), discarding may be significant due to spoilage and scavenging of the catch.

Drift nets or pelagic nets are also used in the Atlantic to catch species such as tuna, and along with bottom nets are responsible for the accidental capture of marine mammals and sea birds.

2.3.3. Mediterranean

[1] Garthe, S., Camphuysen, C.J., and R.W. Furness, Amounts of discards by commercial fisheries and their significance as food for seabirds in the North Sea. Mar. Ecol. Prog. Ser. 136: 1-11, 1996

Mediterranean fisheries are characterised by a wide range of fishing gears/métiers and a wide range of species for which there is demand, even in the case of small fish (for example for A*fritto misto@* in Italy). While seiners account for the bulk of the Mediterranean landings, there are significant trawl and artisanal components. As can readily be seen by visits to local markets and restaurants, compliance with minimum legal sizes in Mediterranean countries is generally poor.

In most Mediterranean fisheries discard levels are relatively low. However there are two major exceptions. Substantial discards and by-catches of fish and marine mammals are occurring in the large-scale driftnet fisheries for tuna and swordfish. These losses have become a reason for great concern, and following the UN agreement to impose a moratorium on large scale drift-netting, the EU has passed regulations to prohibit this gear from 1 January 2002. Mediterranean trawl fisheries, especially the deepwater crustacean fisheries, are also characterised by significant discards of non-marketable species of fish and invertebrates.

2.4. Reasons for discarding

2.4.1. Economic motivation

In the developed world fishing is an economic activity: it has moved beyond being primarily a food gathering activity to being a means of generating income and profit. Therefore, it may be argued that most discards are based on economic considerations. Fishermen seek to maximise profits by generating the highest possible financial returns on a trip whilst aiming to keep the costs, particularly of processing and storage, to a minimum. For example:

Target species may be discarded because they are too small or below minimum landing size or damaged upon capture (perhaps as a result of being towed for too long) and so will either not be acceptable to the market or will command an uneconomic price.

Target species which are acceptable to the market and legal may still be discarded in favour of better sized or quality individuals. This type of discarding is commonly referred to as Ahigh-grading@[5] and results from the economic desire to land the highest value catch given the vessel's physical and legal constraints.

Marketable non-target species which have a lower value than the target species may be discarded to reduce the workload on the crew or to preserve storage capacity required for higher priced target species.

Non-target species will be discarded if there is no financial return to be generated once they are landed e.g. starfish have no commercial market value.

At the beginning of a lengthy trip discards may occur of species which do not keep well, such as shark

Discards may thus consist of marketable species (e.g. over-quota or lower value catches)

or of non-marketable fish (e.g. juveniles or species with no market). It should be noted that lack of acceptability or marketability may be a local phenomenon; in other regions the discarded species might be highly prized.

2.4.2. Discards induced by management measures

Whilst it is certain that the establishment of minimum landing sizes (MLS) for fish results in discards, it is less obvious that quota arrangements and Total Allowable Catches (TACs) have the same effect. Although the presence of over-quota fish is regularly cited by fishermen as being the principal reason for discarding fish that is suitable for human consumption, there is evidence that most fisherman prefer to take marketable fish home, even if this is illegal (so-called Ablack fish@).

Some countries with a more established practice of remaining within quota limits will allow catches of fish for which the vessel has no quota to become >legal= retrospectively. This may be achieved through a system of fines and quota transfers within the Producer Organisation[6].

It is rare, although not unknown, for a PO to exhaust its quota allocation and for its members to be prevented from pursuing a certain fishery. In some EU countries it is much more common for PO members to attempt to land fish illegally, and then to book this fish into their logbooks if it looks as though they will be checked. This permits them to make their scarce quota last for the entire fishing period, without discarding a single marketable fish. If quotas and reporting requirements were more strictly enforced, discard rates would certainly increase, at least in the short-term.

At present, in some fisheries, over-quota discards may on occasions be considerable. Although modern fish finding devices help vessels to target adult fish of the desired species, they are not 100% reliable. Large hauls of a single species of shoaling fish such as herring or mackerel may contain juvenile fish, or a mixture of say mackerel and horse mackerel. Such hauls are worth less and it is common procedure in such cases to >slip= the unwanted catch by emptying the net overboard rather than into the boat. These >slipped= discards rarely survive. However, blame can only partly be placed on quota restrictions; low market value also plays a part in these discards, and in some cases fish may be slipped in the absence of any quota regime at all.

The discard decision making process has been illustrated by FAO in a flow chart as shown overleaf in Figure 1.

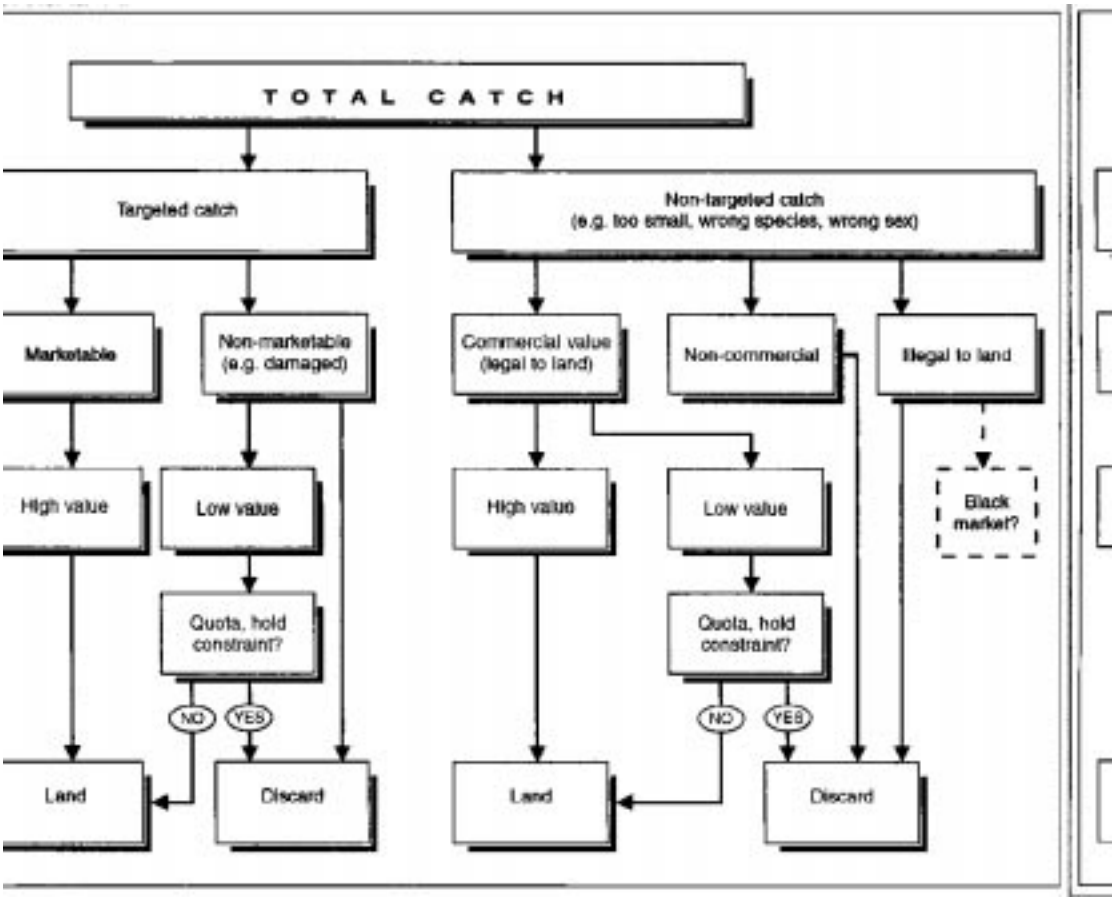

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Figure 1: Flow chart illustrating decision tree for discarding fish at sea.
Source: FAO Fisheries Technical Paper 339: 'A Global Assessment of Fisheries By-catch and Discards' FAO 1994; Reproduced by permission of FAO

3. Quantification of discards

3.1. Measuring by-catch and discards

The great variety of fisheries found within the European Union means that no uniform method for monitoring discards is possible. A number of countries have established sampling programmes, which have evolved to take into account different fleets and situations. While Scotland has the longest running discard sampling programme (since 1975), other countries such as England, France, Ireland and Northern Ireland also regularly monitor discards. In other countries however, discard data has only been collected on an *ad hoc* basis.

In designing a sampling programme for monitoring discards, a number of problems and factors must be taken into consideration.

3.2. Sampling the catch

Sampling on commercial fishing boats is constrained by the conditions on the vessel, the weather, the way the catch is normally processed, and by the attitudes and degree of co-operation of the crew. In some fisheries, particularly small-scale coastal fisheries, catches are small enough that the entire catch can be analysed. However, in most fisheries this is not the case and monitoring of discards is based on samples of the total catch.

The sampling effort necessary to achieve the required accuracy will vary according to the nature of the fishery. Discard rates vary substantially even in the same fishing operation. Sampling rates need to be high to get statistically representative results which can be extrapolated to the whole fishery. While optimal sampling strategies for the more Asingle@ species fisheries of the North Sea may be relatively easy to design, this may not be the case for fisheries with multiple species, or where there is considerable variability in the catch composition. For most fisheries there is little or no information on discard sampling rates and levels of accuracy.

The fact is that, with few exceptions, there is insufficient sampling to provide adequate data for measuring the impact of discards on the resources.

3.3. Overview of discards within the EU

This section reviews the availability of discard data for fisheries management, and attempts to quantify and characterise the discard problem in the different fishing operations undertaken by EU fishing vessels.

Information on the practice discarding fish in European waters is of variable quality, with incomplete data for some fisheries and no data at all for others. The consultants have undertaken a review of discard studies and of continuous or periodical surveys conducted in EU waters. The results of 67 such data sets are summarised in Table 1 in

the technical Annex.

The results show the wide range of discard rates experienced both between different fisheries, and within a single fishery at different times. Although some studies have attempted to estimate total discards for particular fisheries or regions (e.g. the North Sea) most are restricted to a particular gear(s) or métier(s). Furthermore, most are national studies, which do not consider the impact of fleets from other nations. Small variations in fishing practices can have a significant impact on discard rates. Many studies only report discards of commercial species, and provide no data on invertebrates and other species of low or no commercial value.

Despite all of these problems in trying to estimate the global extent and impact of discarding, these data provide the only sound basis presently available for the development of policy options.

4. Impact of discards on the marine environment and the economics of fishery activities

4.1. Direct effects

Discarded components of by-catch either survive or die. Dead discards enter the food chain and generally either are consumed at the surface, mainly by sea birds, or sink to the bottom where they are fed upon by scavengers. The contribution of recycled discards to the energy budget may be significant in some marine ecosystems. Discards contribute a significant part of the diet of many species of sea birds in areas such as the North Sea.

By-catch and discarding impacts can be considered at the population, trophic (food chain) and ecosystem level.

4.1.1. Population level impacts

At the population level, discarding suggests high or unsustainable levels of fishing mortality of the target species. It may also have an important effect on the population dynamics of by-catch species. The consequences may be changes in yield of target and non-target species, and future losses in terms of production. If discards are significant in numbers and consist largely of under-sized individuals (i.e. high juvenile mortality) then a reduction in yield-per-recruit and spawning potential can occur. However, in practice it can be difficult to demonstrate the impact of discarding on a population, because of the lack of detailed data on many fisheries to separate out this factor from other causes of mortality.

Several studies in this area have used a modelling approach to simulate the effects of by-catch mitigation measures for fisheries in which significant numbers of under-sized fish are discarded and do not survive. The models show that a reduction of juvenile mortality is likely to be beneficial in terms of future production and yields. The models also show that for species which are rare or endangered, by-catch mortality can be the critical factor in determining population viability.

4.1.2. Ecosystem and trophic level impacts

Ecosystem and trophic (food chain) effects are closely linked. The effects of discarding on community structure, trophic interactions, and stability are poorly known. These may depend to a large extent on the magnitude of discards in time and space. Changes in species composition and dominance, which may possibly be due in part to discarding (e.g. removal of top predators, differential survival of discards), have been reported for a number of important fisheries such as Georges Bank in the Northwest Atlantic and Northwest Africa.

A number of studies in European waters have shown that discards are a major food source for sea birds. Recent studies have estimated that approximately 40% of North Sea discards are consumed by sea birds, including 78% of the roundfish discarded by seiners and demersal trawls and 13% of flatfish discarded by beam trawlers. The mass of

discards eaten, including offal, was estimated to be more than the amount of live fish (265,000 t) taken by seabirds.

Based on these estimates, it was concluded that 5.9 million seabirds could be supported by the total amount of North Sea discards. It should be noted that the actual number of scavenging sea birds is estimated to be between 3 and 6 million, suggesting a substantial dependence. This was illustrated by decreased breeding success when a trawling moratorium coincided with the breeding season. These findings suggest that measures to reduce discarding, such as reduction in fishing effort and increased mesh sizes are likely to have important effects on seabird populations in European waters.

Although few studies have looked at the fate of discards in the water column, an ongoing study of the crustacean trawl fishery in Southern Portugal suggests that there is little consumption as they sink to the bottom.

The impact of discards on the bottom communities is likely to depend on the amount of discards in time and space. Studies have shown that in general, only a small proportion of discarded animals float, and in most fisheries the smaller size ranges are largely taken by seabirds. Thus, discards reaching the bottom are composed mainly of larger fish, or fish of a shape that can not be swallowed by sea birds (e.g. flatfish), and invertebrates. High volume discards (e.g. slippage) may result in large amounts of fish reaching the bottom. This may happen in small pelagic fisheries, and there are a number of anecdotal accounts of bottom trawlers Acatching@ quantities of decomposing pelagic fish which were on the bottom.

4.2. Indirect effects

Scientific advice for fisheries management in Europe is founded on complex age-based population models. Examples are Cohort Analysis, Virtual Population Analysis (VPA), and Multi-Species Virtual Population Analysis (MSVPA). The management of the most important stocks is based on ICES[7] Working Groups which meet to review data compiled from different countries, assess the status of stocks and project the stock development under different fishing scenarios. These assessments are then reviewed by the ICES Advisory Committee on Fisheries Management (ACFM) which provides the scientific advice on the basis of which managers propose Total Allowable Catches (TACs) for approval of the Ministerial Council.

The TAC recommended for a given stock is a level of catch which corresponds to a given level of fishing mortality considered by scientists to be sustainable. In order to calculate a TAC, scientists need information on the current condition of the stock in terms of numbers of fish and biomass, the exploitation pattern, the exploitable biomass for the next year, and the optimal state of the resource. Routine data collection and sampling provides information on the numbers and sizes of fish caught, and where they were caught.

Good estimates of fishing mortality rates are therefore essential for stock assessment and the formulation of scientific advice. Estimates of fishing mortality include factors to

account for discards, based on data collected through sampling schemes. Lack of discard data, or imperfections in data can cause mortality estimates to be inaccurate. The 1985 ICES Working Group on Methods concluded that the absence of discard data was not important for short-term forecasts when discarding rates are constant. However, when discarding is variable or when long term forecasts are attempted, significant errors will occur if discard data are not incorporated in the analysis. The general consensus is that discarding rates in most fisheries are high and variable. Therefore there is a strong need for long term monitoring of discards in order to improve age-based stock assessment. The worst case is a situation where large numbers of one or a few age classes are discarded and this is not taken into account. In this case, fishing mortality for the stock will be underestimated and the analysis will give wrong estimates of population age structure, possibly resulting in inappropriate TACs.

Discard data are included in the assessment of North Sea stocks. For example Scottish data on haddock and whiting are used by the ICES North Sea Demersal and Northern Shelf Demersal Working Groups. Incorporating discard data in routine stock assessment is possible in this case because Scottish landings account for a large proportion of the total international landings of these species. French data are used by the Southern Shelf Working Group, and Irish and Northern Irish data by the Northern Shelf Demersal Working Group. However, for many species and stocks, where fishing effort is distributed among several nations and different gears, complete or suitable discard data may not be available for stock assessment purposes. This is a particular problem in the in the multi-species, multi-gear fisheries of the Mediterranean. However, in this region there is little or no data for age-based stock assessment, so even if perfect discard data were available, it would be of limited value.

One of the indirect benefits of reducing discards by requiring landing of some or all of the by-catch is, it is argued, that more data would become available for fisheries scientists. Some fisheries such as the North Sea haddock fishery already have good discard data and the scientists already factor fishing mortality of discards into their advice on TACs. Limited extra benefits would be derived from additional samples landed. Data benefits from reduced discarding would therefore only occur where there was sufficient biological data to permit application of the stock assessment models, but where existing discard sampling systems were weak. These are quite specific circumstances and there is unlikely to be much short-term benefit to stock assessment estimates by reducing discards.

4.3. Economic impacts of discards and by-catch

4.3.1. General estimates of economic impact

Few studies estimate the economic costs and benefits of discards. A 1994 FAO Fisheries Technical Paper[8] suggests that the total costs of bottom fish discards in the North Sea could approach the value of landed catches (approximately 470,000 tonnes with an estimated first sale market value of around _700 million in 1997). A recent OECD study[2] reports that the number of haddock individuals discarded in the North Sea have been estimated to exceed the number landed (84,000 tonnes of haddock in 1997 with an approximate first sale market value of over _100 million).

These values are likely to over-estimate the cost of North Sea discards since the majority of discarded fish could not realise market values if landed as a result of their small size or poor quality. Despite this reservation, potential future losses to the direct target or other non-target fisheries of a proportion of these values are significant.

The FAO report does not estimate marine mammal discards, except to say that several hundreds of thousands of animals are involved annually around the globe. Even if numbers of discards and resulting mortalities were known, it is particularly difficult to value losses of these species. However, there are economic considerations, illustrated by the value placed by consumers on in their preferred choice of cans of so called 'dolphin friendly' tuna.

The references above for discard valuation refer to direct values i.e. the market value of species actually thrown overboard and presumed not to survive. However, indirect impacts of discards also carry a value, for example, the value of lost future catches of target and non-target species.

4.3.2. Target species discards

Discard induced mortalities affecting mature, immature or females of target species not only incur immediate economic loss, but if mortality is significant then the future biological reproduction of the target species can be limited, particularly if the species is at or near over-exploitation.

4.3.3. Discards of commercial non-target species

Discards of commercial non-target species may occur when by-catch species are of small size or of a lower value to the target species. Such discards can also be the result of quotas set at levels which do not reflect the natural changes in abundance and shared habitats. The resulting costs in non-target species discards are borne directly as lost catch and indirectly as lost future catch by other fisheries.

Discards of commercial target and non-target species incur costs of immediate and

[2] OECD, Towards sustainable fisheries; Country reports, European Union OECD/GD (97) 119, paris 1997

future lost catches. This reduction in landings also impacts on the associated shore-based processing and service industries, and potentially employment and the structure of fishing communities.

The discarding of juveniles of commercial fish species (plaice, sole, whiting, cod etc.) in the EU fishery for brown shrimp (*Crangon crangon),* which uses small meshed nets is a long recognised phenomenon. In 1996 a comprehensive pan-European discard study was undertaken in this fishery and the results are now becoming available[9]. Some key results are shown in Table 1.

Table 1. Numbers of juvenile fish discarded by the European *Crangon* fleets in one year (1996)

Species	**Number of juvenile fish discarded (million)**
Plaice	928
Sole	16
Cod	42
Whiting	55

In terms of the average number of recruits in areas targeted by the *Crangon* fishery, these discards are significant for plaice and sole, fairly small for cod and negligible for whiting. Survival rates of these discards, even those that have passed through sorting machines, is quite low, due in part to scavenging by sea birds**.**

The subsequent analysis of the impact of these losses was made to determine the likely economic and biological impact of this discarding on other commercial fisheries. The analysis demonstrated that the discarding of plaice in particular was of significant biological and economic importance (Table 2). Losses to North Sea spawning stock biomass of plaice resulting from discarding in the *Crangon* fishery were estimated to be between 6% and 16%. Potential annual lost landings were between 7,300 and 18,800 tonnes with an average European fish market value of _17.9 million. The analysis also showed that the discarding occurring within the Waddensee was of most significance.

Table 2. The biological and economic significance of discarding in the European *Crangon* fisheries

Species	Losses to spawning stock biomass (%)	Estimated lost annual landings (tonnes)	Average value of lost landings (Million EURO)
Plaice	6 B 16	7,300 B 18,800	17.9
Sole	0.4 B 2	150 B 1,350	3.9
Cod	0.5 B 2	1,000 B 3,200	1.9
Whiting	0.6 B 2	900 B 2,400	1.2

The research showed that the introduction of currently available selective devices into the North Sea *Crangon* fisheries of Denmark, Germany, the Netherlands, Belgium, France and the UK could recover in some cases more than 90% of the >lost= landings at no economic detriment to the fisheries. The recommendation was that the introduction of selective gears into these fisheries would have a net overall economic and biological benefit to EU fisheries as a whole. More work is now being undertaken to find the best ways of doing this.

4.3.4. Discards of non-commercial species

The cost of capture and subsequent discard of non-target species of little or no commercial value can be measured by considering the price of labour, machinery operation and other inputs required to catch, sort and discard. It may be also be argued that processing time is lost as a result of dealing with non-target species.

4.4. Assessment of the impact of discarding

4.4.1. Defining the discard problem

Before policy options for the discards problem can be explored, there is a need to identify those fisheries areas and métiers where the practice of discarding presents a risk of significant impact. That is, there is a need to define the problem. Many studies, based on field research in a wide range of fisheries, report the nature and extent of discarding. The consultants have reviewed the results of 67 such studies. These need to be reconciled and compared in an objective manner in order that the most severe discard situations can be identified.

A discard impact index was therefore developed by the consultants, to represent the severity of the discard problem in any particular fishery. This index takes into account the following factors:

sensitivity of the discard species to fishing exploitation
mortality resulting from discarding
discard rate
overall quantities discarded

relative market price of the discarded species.

The discard impact index is a tool designed to assist policy making by providing a numerical representation of the nature and extent of the problem of fisheries discards in different EU fisheries. The index attempts to resolve, in an objective manner, the disparities in the presentation of results of different studies.

4.4.2. Development of the discard impact index

The discard impact index comprises four components.

The first component ranks each discard species in terms of its sensitivity to fishing mortality. A value of 1 indicates a low sensitivity (for example small pelagic fish) whilst 3 indicates high sensitivity (for example slow growing demersal fish). Sensitivity to fishing mortality has been defined, based on a combination of the ICES classification of stock status indicating proximity to safe biological limits, and the species= life history characteristics.

The second component ranks discard rates, where rates less than 15% are given a value of 1, those between 15 and 45% a value of 2, and greater than 45% a value of 3.
The third component represents the annual discard volumes of studied fisheries. These ranked with a value of 1 if less than 1,000 tonnes, 2 if less than 10,000 tonnes and 3 if greater than 10,000 tonnes. The fourth component of the index incorporates a rating, dependent on market prices, to indicate the commercial importance of the species being discarded. Discards with a 1998 weighted average market price of less than _1,000/tonne landed were assigned a value of 1, between _1,000 and 2,500/tonne a value of 2 and greater than _2,500/tonne a value of 3.

Expert advice and opinion were used to assign values to each component according to the above rating scales. The values assigned to the four components were then averaged for each entry into the table to give an overall index for each fishery/métier which represents its discard impact. The index could be refined by assigning weights to individual components of the impact index depending on their relative importance. However it was not felt appropriate to refine the index along these lines any further in the context of this study. In the next section the results of this exercise are presented in summary form for the fisheries and métiers which have the highest impact score.

4.4.3. Table of impact indices for EU waters

	Target Fishery			Discards				Comments
Area	**Fishing method**	**Species**	**Average Annual catch**	**Species**	**Average discard ratio**	**Estimated annual quantity**	**Discard Impact index**	
IV bc	Beam Trawl	Sole, dab, turbot, brill, plaice	120,000t	Plaice/Dab/ Gurnard/ Invertebrates	Fish 83%	1976-90 study: 100,000t fish, 170,000t invertebrates/ debris	2.5	Discarding in sole fishery (80mm c much greater than in plaice fishery. species overlap. Plaice is discarded undersize. Dab is also discarded if r conditions are poor. Gurnard is disc to very poor market conditions and exists for inedible invertebrates.
IV	Demersal Trawl	Haddock/ Cod/Whiting	80,000t Haddock, 40,000t Whiting, 100,000t Cod	Haddock/ Whiting	Haddock 76% Whiting 80%	1993 study: total 131,000t: Haddock 61,000t Whiting 32,000t	2.4	Different discard patterns for twin r rig, pair trawls. Haddock fishery pa reliant on incoming year class. Had discarded if below MLS. Some whi also discarded above MLS due to p conditions.
VII/VIII	Demersal Trawl	Hake/ megrim /monk	15,000t Megrim 40,000t Hake	Hake/Megrim	Megrim: 40% by number 20% by weight Hake: 20% by number 5% by weight	1998 study: Megrim 3,000t Hake 2,000t	2.5	Discards include fish above MLS. A discard rate has declined from mucl levels in recent years, discarding of hake in the Bay of Biscay is still hig
VII/VI /IV	Demersal Trawl	Nephrops	50,000t *Nephrops*	*Nephrops*/ Cod/Whiting/Dab Hake in Area VII	1996 study: *Nephrops 27%* 1990-96 study: *Nephrops*, Whiting, Dab 20-48%	*Nephrops* 13,500t	2.5	Discard rate varies widely between Marketable *Nephrops* can be discar processing pressures. Introduction c mesh panels has reduced discards o which are below MLS.

Ivbc	Beam Trawl/ Shrimp Trawl	Crangon	14,000t	*Crangon/* Plaice / Sole/ Cod / Whiting	1996 study of potential lost annual landings: between 9,350t and 25,750t marketable fish	Total potential economic cost of discards to other vessels estimated at _25m per annum.	2.9	Elimination of discards or closure would allow Plaice quota increase c12,000 tonnes. Discard ratio varie between areas. Majority of discard to undersize, though some whiting discarded above MLS due to poor conditions.
VII Celtic Sea	Gill net	Hake	300t	Catch of protected harbour porpoise	N/a	6% of local population pa, 100,000 in harbour waters but populations highly localised		Effort has halved since 1994. Rese underway to evaluate use of Acous Avoidance Devices. Public percep acceptability and lack of markets c discards.
NE Atlantic	Bottom trawl	Roundnose grenadier	13,352t in 1996	50 species	90%	11,921 t	2.6	Deepwater fishery, 60 trawlers De productivity low, ecosystem partic sensitive. On average, 24% by we target species is discarded due to s Most of the other 50 discarded spe not marketable.
NE Atlantic	Bottom trawl	Nephrops and shrimp	5,543t in 1996	Torpedo ray, dogfish, conger eel, boar fish, hake	1996-97 study: 83%	35,000t in 1996	2.4	Deepwater fishery, south coast of I Discard species have no value (boa dogfish, torpedo ray) or are of sma (hake, conger eel).
Greece	Otter trawl	Hake, sea breams, flatfish, shrimp	20,000t	Hake, red pandora, shrimp	1996-97 study: 40-50%	8,000-10,000t	2.4	Discarded hake are mainly of smal damaged. Most other discards are no value.
Ionian Sea	Bottom trawl	Demersal species	No data	29 species unmarketable, 35 discarded when undersized	1992-93 study: 45-47%		2.2	Essentially no difference in discard between small inshore and larger d trawlers. Discards due to mixture undersize and lack of market.

The entries represent those EU fisheries at most risk from current discarding practices and levels. The impact index table focuses mainly on the direct impact in terms of discarding of target species, and it should be noted that other impacts (such as on the marine ecosystem) are not easy to quantify and are not reflected in the impact index.

4.5. Needs and priorities for intervention

Interventions should obviously only be contemplated where the ecological and economic impact of discards is particularly evident. They should be specific and aimed at reducing the economic motivations for discarding in specific cases. The nature of suitable discard policies is discussed in more detail in section 8.2.

From the data given in the table above, it is evident that trawls are the most significant gear for discarding. In particular, bottom trawling for *Nephrops* (Dublin bay prawn, or scampi) and beam trawling are implicated in rates of discarding with a significant impact. The latter also has the biggest impact on the bottom conditions. On the other hand, there appears to be no need for new policies for some types of gear, such as gill nets and trammel nets.

Pelagic trawling and purse seining can on occasions result in considerable discards and, although the impact of these may be relatively low, some intervention may be desirable.

5. Current research into the discard problem

5.1. Present research themes

5.1.1. Gear selectivity

Much recent research has concentrated on means of making fishing gears more selective i.e. allowing a greater proportion of undersized or unwanted species to avoid, or pass through, the fishing gear. A report funded by the EU under the FAIR programme[10] summarised the work undertaken in the EU on improving the selectivity of towed gear. Research work on square mesh panels, sorting grids and cod-end construction throughout the EU was summarised. Research since then has continued, funded both by the EU and national governments/ research organisations.

5.1.2. Cetacean Acoustic Avoidance Devices (AAD)

Following concerns that gillnet fisheries in both the North and Celtic Seas were responsible for an unacceptable number of deaths of harbour porpoises, fishermen have been testing a number of different devices. All work by alerting porpoises to the presence of a gill net anchored to the seabed before they make physical contact with it. AADs, commonly known as >pingers= from the sound that they emit, are currently being evaluated in a number of trials funded under the FAIR programme.

5.1.3. Modelling

Modelling of discarding can be used to improve survey precision and sampling strategies, to predict discard quantities and composition, to gain insight into factors governing discarding practices, and to evaluate the impact at the species and ecosystem level. To date, few models of discarding have been developed. This is mainly due to the fact that in most cases there is a lack of data for model building and because the data requirements are substantial.

5.1.4. Research into survey techniques for measuring discards

Currently, survey techniques for measuring discards are almost entirely based on the use of observers/technicians on board commercial fishing vessels. The major limitations of this methodology are:

Cost of trained observers for data collection
Often inadequate coverage in space and time

Non-random sampling of the fleet
Inadequate sample sizes
Biased estimates of landings and discards

This pencil and paper approach to data collection means that there is often a significant time lag between actual data collection and the use of the information for practical purposes (such as decision making with regards to TACs or area closures).

Stock assessment would benefit considerably from a computerised data collection and analysis system. Although the use of such systems for fisheries management has increased world-wide in recent years, to date there are no specific applications for by-catch and discarding practices. However there is some interesting research and development (such as the FISHCAM project), which use computer-based data logging systems linked to a Global Positioning System (GPS) and a Geographic Information System (GIS).

With such a system, vessel-based data capture can be matched to digital maps along with other relevant data bases (e.g. depth, temperature, bottom type). The proposed system would include vessel-based data collection and a laboratory-based computer database. This will permit finer tuning of conservation measures such as effort restrictions and TACs, and the identification of critical areas such as nursery zones where discarding of juveniles may be important. Useful outputs could include contour maps of discard amounts. This type of real-time fisheries data collection and analysis would greatly improve management decision making, enabling the rapid identification of high discard areas at an early stage, permitting appropriate and timely decisions to be taken. This is a pre-requisite for the effective implementation of a temporary closed area policy. The further development of the FISHCAM system is contingent on approval of a proposal submitted to DG XIV of the European Commission in 1998.

5.1.5. Discard Survival

Several projects have investigated the survival of fish that are either discarded at sea, or pass through the fishing gear. Using divers and large underwater cages, it has been found that the critical factor for fish survival appears to be the size. The smallest fish appear unable to recover from the stresses of being herded into the net and then passing through the mesh. However, above a size of 15cm survival rates are good, approaching 90% in some cases.

5.1.6. Economic Modeling of Discarding

Research reported in Section 4.3.3, modelled survival rates of juvenile fish in North

Sea trawl fishery for *Crangon*, and attempted to quantify the future potential economic gains to other demersal fisheries that would be obtained by the mandatory introduction of technical measures. Other economic modelling research has been of a more theoretical nature, and has involved the development of economic-behavioural models of the fishing activity and the discarding process. Theoretical models of by-catch, discarding and economically optimal discarding levels have been created and proposals are being considered for funding by DG XIV of a project to test these models with real data from the industry. A precursor to all fisheries economic research is the existence of good financial and economic data sets. Modelling of possible discard alleviation policies, including analysis of economic incentives, is a pre-requisite to achieving optimal discard levels.

5.2. Funding of research into discards in the EU

The European Commission currently operates two major research programs which cover work in the areas of discards including by-catch, gear selectivity and multi-species interaction: the FAIR Programme and the Biological Studies Programme.

The EU FAIR Programme of Research and Technological Development (1994-98) has a total budget of _12.3 billion of which _130 million is available for fisheries research. A review of the Project Synopses Volume VI: Fisheries and Aquaculture (FAIR: 1994-98) shows that of the 106 projects listed, seven projects aimed to study discards related issues directly, and had a total budget of _7.0 million. A further seven projects research discards related issues whilst having an alternative objective. The total budget cost for these studies is _11.2 million.

The Biological Studies Programme (1994-98) has funded approximately 200 studies covering research into fisheries biology, economics and technical issues. Over this period around 50 of these studies have been aimed at or related to the issues of discards, by-catch and selectivity. Some of these studies have involved collaboration between a number of EU Member States, and have attempted to gain a quantitative and qualitative view of discards in entire fisheries, rather than the vessels of one particular member state.

5.3. Research policy

There is no continuous EU-wide research programme on discards in operation. DGXIV=s most recent overview of the results of discards related research was in 1992. Most of the research to date has focused on the quantification and the origin of discards rather than the reasons for them occurring. Some of the main gaps in knowledge are:

there are many fisheries for which there are no reliable data on discarding. This is often due to the fact that the fisheries involve a number of nations and/or métiers; research can at best only be partial.

there is little understanding of the fate of discards: survivorship, consumption by sea birds, consumption in the water column, and consumption on the bottom.

behavioural aspects of discarding and discard reporting by fishermen are little understood and are at the heart of the discard problem

there is little data on the economic impact of discarding, and the corresponding incentives needed to reduce discards and fishing effort

The ecosystem effect of fishing is a major research priority for DG XIV over the next few years (e.g. the 5th Framework).

6. Present approaches to the problem of discards

International, regional and national agencies have adopted a number of measures to prevent discarding, often operating in conjunction with each other. Most regulations attempting to reduce discards approach the problem from two angles; i) to persuade fishermen to avoid fishing in areas where discards will be highest and/or ii) to reduce capture of discards in areas where they do fish. Some of the most frequently applied approaches are discussed in this section.

6.1. Minimum Landing Size

The majority of managed fisheries include within their regulations a minimum landing size (MLS). Below this size fish may not be landed for sale. With some notable exceptions (such as Norway, which is discussed later) in most countries such undersized fish must be returned to the sea. This approach aims to discourage fishermen from targeting concentrations of juvenile fish and from using small mesh nets. In theory an enforced MLS will encourage fishermen to concentrate their effort on adult populations of the target species.

However simple it is in theory to match a desired MLS to mesh size regulations, there are major problems with MLS as an effective management tool. There are both technical problems in linking gear selectivity to the MLS, and there is also an economic dimension. In the Irish Sea *Nephrops* fishery, for example, the MLS has been demonstrated to have little effect on fishermen=s behaviour mainly due to the MLS being below the optimum size favoured by the market with the result that the smallest sizes of *Nephrops* are only retained when catches are poor.

Although few commentators or fishermen question the need for enforced MLS, their use can also generate anomalies and difficulties in selecting the correct mesh size. Setting the mesh size that would allow 75% of fish below a biologically desirable MLS to escape for example, would also allow a significant proportion of marketable fish above MLS to escape. However necessary for conservation, few fishermen would be happy letting this happen. Raising the MLS without also introducing technical regulations that prevent nets from capturing fish below this size will serve only to increase the number of discards, and further alienate fishermen.

Mixed fisheries are even more complex. A reduction in the MLS of larger species caught may serve to reduce discards, but can also be counter productive. In addition to sending out the wrong signals about reduction of effort on juveniles there may well be no market for these fish, or it may allow fishermen to target effort where concentrations of juveniles exist. The move to reduce the MLS of

plaice to coincide with the selectivity of the nets used in this fishery, in which there is also a significant catch of sole, a smaller species, has caused an outcry amongst some fishermen, however sensible the measure appears to be to fisheries managers.

6.2. Technical Measures

Technical measures aim to allow fish that would have been discarded to avoid capture, or prevent capture of non-target species or damage to the seabed. Measures may involve the banning or restriction of certain types of gear, a minimum mesh size (MMS) or the mandatory use of some sort of escape device so that non-target species can avoid the gear. Some of these are described in the remainder of this section.

6.2.1. Minimum Mesh Size

This is the most basic form of technical measure, stipulating a minimum mesh size that may be used for nets in a particular area or fishery, thus permitting smaller fish to pass through the net. This may have no effect on the by-catch rate of non-target species. On its own an MMS policy may have little overall effect on the mortality of juvenile fish. Evidence exists that below a certain size fish passing through a trawl will die anyhow from scale loss and exhaustion. It is also possible for fishermen to adjust the tension of the net to reduce the effective mesh size, negating any regulation. The material used, shape of the mesh, length of the net, circumference of the cod-end and a host of other factors will all affect the effective mesh size of a trawl. Further regulations stipulating additional factors are often issued in an attempt to make the measures more effective, although they frequently do little more than provide additional measures to be circumvented.

6.2.2. Square Mesh Panels

It has long been recognised that the diamond mesh used in most trawls closes up under strain. In the UK both the Scottish Office and the Sea Fish Industry Authority have undertaken extensive research into the use of square mesh panels, much of it funded through the EU. Square mesh panels inserted in the top of the net have been shown to allow smaller fish to pass through, where otherwise they would have been trapped in the cod end. Survival of these fish in the mixed demersal fishery in Scotland have been as high as 90%, and a study on chartered vessels in the Scottish *Nephrops* fishery showed that up to 63% of undersized whiting and haddock were released, with little negative impact on the landings of *Nephrops* themselves, although some marketable whiting were lost. Square mesh panels, do however, have several problems. They are harder for fishermen to insert and repair, and their

effectiveness depends on their position in the net, seabed visibility and light levels. The EU has brought in regulations requiring square mesh panels for the *Nephrops* fishery, but not for any other fishery, apparently because of resistance by fisherman of various countries.

6.2.3. Separator Trawls

It has long been known that different species of fish will behave differently within a trawl. Fish tend to swim in the mouth of the net, until they drop back, exhausted, into the tunnel and cod end. Certain species tend to rise as they turn back, whilst others will turn downwards. These behavioural differences can be exploited by separator trawls which divide the rear of the net into two sections, with different mesh sizes suited to the separate species.

Along with square mesh panels, separator trawls require fishermen to learn to make, mend and fish with them. There will, instinctively, be a feeling that they may cause the loss of marketable fish, as well as create extra work. Research on separator trawls is not as advanced as it is on square meshed panels.

6.2.4. Sorting Grids

Sorting grids are rigid panels of spaced bars. The grid is deployed in conjunction with a trawl net. In some cases, principally shrimp fisheries, the grid is set in the tunnel of the net in front of the cod end. Large fish can escape, and only small fish and shrimp passing through the grid are caught. In other arrangements the grid is located before and beneath the cod end, so that only the larger fish which cannot pass through the grid will enter the cod-end.

Sorting grids are mandatory in certain fisheries, and are in widespread use in others. In most fisheries that have seen the introduction of grids, fishermen have initially complained that they are unwieldy, unpractical and cause the loss of commercial species. However, the use of the grids has subsequently become a marked success. In some shrimp fisheries which were threatened with closure due to excessive levels of discarding, the introduction of grids has allowed these fisheries to stay open.

Experience from Norway, where this approach has been employed successfully, suggests that it takes a matter of a few weeks or months to master the new techniques (depending on the competence of the skipper and crew). A recurrent theme (especially in shrimp fisheries) is that once these technical difficulties have been mastered fisherman often use the grids out of choice. Used correctly, grids reduce the amount of discards to the point that sorting and cleaning the catch on deck becomes considerably easier. In one fishery (in New South Wales, Australia)

the level of discarding dropped by 90%, allowing skippers to fish with one crew member less.

6.3. Closed Areas

Closed areas of many types have been tried around the world in a bid to reduce discards by restricting fishing in areas where catches of juvenile fish may be high.

The selective closure of areas to certain fishing methods more liable to cause discarding can encourage more sensitive methods of fishing, as it creates a positive incentive to fishermen to change their fishing methods. In Norway, for instance, opposition to the introduction of sorting grids within the shrimp fisheries was overcome by at first restricting access to certain lucrative shrimp fishing grounds to those vessels which installed grids. The more open minded fishermen who changed gears were soon able to recoup the expense of learning to fish with the new gear by being given access to grounds that would otherwise have been closed to all shrimp fishing activity. Others followed, and a change to more selective gear occurred relatively painlessly.

6.3.1. Temporary Closed areas B the EU experience

There are several closed areas within EU waters, including the ANorway Pout Box@ and the APlaice Box@. The Norway Pout Box is a defined area in the Northern North Sea, east of Shetland. Retention of Norway Pout on board a vessel inside the Box (exceeding a 5% by-catch level) is considered to be an offence. This regulation is to prevent the capture of juvenile haddock (which are abundant within the Box) by vessels that use 16mm nets, which are allowed for Norway Pout elsewhere.

The Plaice Box, an area stretching from the Dutch to the Danish coasts, was established in 1989. It closes a nursery area for plaice to all vessels over 8 metres in length, although a large number of derogations allow in a fixed number of vessels up to 24 meters in length, with an engine power below 221 KW. The aim of the box is to protect concentrations of juvenile plaice. However, the move has been deeply unpopular with the Dutch fishermen, who have a tradition of catching small plaice and sole in the area, and they have recently been requesting further derogations to allow in more large vessels. The ICES working group, which recommended initially that the Box be created, suggested that the benefits to the stock of a complete closure have been significantly reduced because of the derogations. A recurrent theme in the EU has been the weakening of conservation policy for particular national social and economic interests, and the Plaice Box is a good example of this.

Areas may also be closed to particular types of fishing activity even if other types of fishing that target the same species are allowed. An example of this in EU waters is the AMackerel Box@, to the south west of England. The area contains a high proportion of juvenile mackerel, often mixed in with adult stock. The creation of the Box, has in theory at least, reduced discarding by forcing the purse seiners to operate away from the concentrations of juveniles. Handliners, which also target the stock, are allowed to fish within the Box. This derogation was given on social and economic grounds, but it is true to say that handlining is a much more selective method than purse seining of fishing mixed stocks of juvenile and adult mackerel.

6.3.2. Temporary Closed Areas- the Norwegian Experience.

Norway operates a policy of closures that is designed to prevent the capture of juvenile fish. When captures of undersized fish reach more than 15% by number Norwegian fishermen are obliged to inform the Authorities who will then close the area. Fishermen must steam at least 5 miles before recommencing fishing activity, and if they again encounter this proportion of undersized fish they must repeat the exercise. Onboard observers on some vessels, and random checks by the Coastguard also help ensure that closures above this threshold take place rapidly.

Norwegian authorities are able to introduce such closures quickly and efficiently. Radio broadcasts are made over VHF and terrestrial radio, and closures are enforced within 24 hours. During the fact finding trip made to Norway for this study it became apparent that such closures have the support of the bulk of the fishing industry, and it is not uncommon for fishermen to volunteer information about excessive by-catch rates to the Coastguard. The measure has perhaps caused more problems to non-Norwegian operators because lower MLS in the EU (e.g. for cod) leads them to arrive at the 15% threshold earlier than Norwegian fishermen, and in addition notification of closures can be received late.

Norway is fortunate in some respects, in that many of the nursery areas found within its waters are far from areas with large inshore fleets. It is obviously much easier for large vessels to steam 20 or 30 miles to avoid juvenile fish than it is for a small inshore vessel. The inshore vessels also have a tradition of gill netting and jigging, which are inherently selective methods that preclude the capture of small fish. It is quite possible for these vessels to fish in areas of high concentration of juveniles without their exceeding the 15% threshold. In certain areas closure encompasses all types of fishing. However, it is more common for an area to be closed to a certain type of fishing, allowing the more selective vessels to carry on.

The sizes of area that are closed in Norway can vary from several hundred km^2 in

the case of some shrimp fisheries, to small fjords that cover only 1 or 2 km5.

6.4. Discards in pelagic fisheries

Fisheries for small pelagic species of fish can be regarded as a special case due to the large and relatively homogenous nature of the catches. One discard ban currently in place in the EU is a ban on discarding from pelagic freezer trawlers facilitated by the use of grading machines (although they can still discard manually). These vessels concentrate on a few species such as mackerel and herring, and can undertake >high grading= if the catch consists of too many small fish. Pelagic freezers have the capability of mechanically grading fish on board, making it easy for them to discard the portion of the catch that is not worth the costs of processing and landing. To prevent this, EU regulations stipulate that *>automatic sorting equipment must be installed in such a way that the catch resulting from grading Y cannot be easily thrown back into the sea=*. Other pelagic fishing vessels are prohibited from carrying grading machines at all.

The Norwegian approach to this problem is different. Under pressure from the Norwegian Fishermen=s Federation, legislation was passed forcing fishermen to land a fixed percentage of smaller grades of pelagic species. If a vessel lands only the largest sizes of fish his quota is automatically docked for the percentage of smaller fish that he is deemed to have caught and discarded or slipped. This regulation removes the economic incentive to discard the lower value portion of the catch.

6.5. Discard Bans B The Norwegian Experience

Norway also operates a ban on discards of all important commercial species within its waters, a policy that is at the opposite end of the spectrum from the thinking within the EU, where it is possession of over-quota or undersized fish that is the offence. There are a number of logistical problems associated with such a ban, but before they can be considered it is perhaps wiser to put the discard ban into context, as the ban was the culmination of a number of measures put in place in Norway in order to reduce discarding to a minimum.

The aim of the discard policy in Norwegian fisheries management is the avoidance of the capture of unwanted or juvenile fish. The first measures enacted within the framework of this policy were the rules on selective gear. Norway has fisheries that are in the main single species, making it much easier to introduce the optimal mesh sizes. The Arctic cod fishery, for example, has a minimum mesh size of 140mm. Such a size would also be optimal for cod in EU waters, but the fishery there relies additionally on whiting and haddock, catches of which would disappear if 140mm mesh was made mandatory.

Closed areas as a means to reduce capture of undersized fish were only introduced after technical gear measures had taken effect, increasing the momentum towards selective gear, and further reducing the numbers of discards. By the time the discard ban was introduced the most important problem, which was eliminating the capture of fish that would be discarded, had already been largely tackled.

Now in Norway, regulations require fish which would have been discarded to be brought to shore. Evidence from Norwegian fishermen suggests that, unlike the other regulations, the discard ban is flouted to some extent, although this is not considered to be widespread. On the whole therefore, the policy is considered to be successful in achieving its objective of reducing mortality of juvenile fish.

Wherever possible the landed fish is utilised for human consumption. Norwegian fishermen market all their fish through a national sales organisation, and this includes the low value fish as well. Fishermen are compensated for their time and for the packing costs concerned, but are not paid the market value of the fish. Receipts from sales are used to defray the running costs of the organisation. Fish unsuitable for consumption are sent for fishmeal.

It is hard to quantify the conservation benefits that may accrue from the discard ban. In part this is due to the fact that it is not an isolated measure: it is the totality of the regulations, where the main thrust is in the prevention of capture of unwanted fish, that require appraisal. Undoubtedly, a great success of the Norwegian ethos has been the support of the industry for measures that would be politically impossible to introduce inside the EU. Although many Norwegian fish stocks are still under pressure, the conservation regime in place is widely credited by fishermen with having played a major role in stock recovery.

7. Problems in the implementation of EU legislation

7.1. Present policy towards discards

Since the adoption of quotas within the framework of the Common Fisheries Policy, at first on an *ad hoc* basis, and since 1983, enshrined in the principle of Relative Stability, the entire ethos of EU fisheries conservation legislation has been to discourage fishermen from catching over-quota or juvenile fish by forcing them to be discarded. The basic fisheries offence is defined as *retention onboard of fish which does not comply with the regulations*.

7.2. Development of regulations

As and when discard problems have become apparent additional regulations have been introduced aimed at altering fishermen=s behaviour. The theory behind this has been that if it is an offence to retain on board fish that cannot be legally sold for profit, fishermen will alter their catching patterns and cease to catch, and discard, fish that they are not allowed to sell.

In practice this has spawned a plethora of ever more complicated regulations, designed to prevent fishermen from exploiting the loopholes in the regulations that they are adept at finding. Recognising this, a range of secondary instruments to prevent the capture of fish that will subsequently be discarded have been introduced by the Council. These include the use of closed areas, technical regulations, and, indirectly, fleet restructuring measures.

7.3. Present situation

Council Regulation 850/98 represents current thinking of the Council with regard to fisheries conservation. Due to come into force on 1st January 2000, it stipulates provisions for the carriage and use of nets, as well as defining closed areas, minimum mesh and landing sizes and the permitted catch composition that can be taken with different nets. Many of these regulations have been opposed by the European Union=s fishermen, who have also proved adept at circumventing similar regulations currently in force.

Regulation 850/98 stipulates catch composition targets for nets of different mesh sizes. It is, for instance, illegal to land more than 30% of cod and haddock (or in fact any species not named in Annex 1 of the regulation) when fishing with nets below a mesh size of 100mm. The catch composition regulation is designed to prevent fishermen from targeting concentrations of small fish of certain species, on

the pretext that they are fishing for other species. Whilst the theory is admirable, the practice is a little less clear cut.

The regulation has been updated from initial proposals, and requires catch compositions to be recorded on a daily basis in the standard EU logbook. This is to prevent a vessel deliberately targeting species with a smaller mesh net than is permitted, then moving elsewhere to concentrate on a permitted species. However, in seeking to prevent deliberate abuse of the catch composition regulations, it could be argued that in some cases this clause could create as many discards as it prevents. A vessel, for instance, that inadvertently catches a large proportion of cod whilst fishing for sole with 80mm cod ends, will have at most 24 hours in which to catch enough permitted 80mm >target species= before it is required to discard cod above the by-catch percentage.

7.4. Implementation of EU regulations and practical problems

Although in theory some aspects of the catch composition regulations have been introduced to reduce discards, their effect has been to create a further tier of regulation, with little evidence that they will have an effect on discard rates. At present regulations are still being drafted relating to the carriage of nets of different mesh size. Currently it is possible to land any combination of fish, and to claim that the correct proportions of fish were caught with the different nets. Attempts to plug this loophole, by insisting, for example that only one mesh size may be carried, have met with fierce opposition from fishermen in the past, leading to the need for derogations for many types of fishing, that weaken the possibility of the regulations having any effect.

Regulation 850/98 also altered the MLS of some species, in an attempt to reduce discards. For example the Plaice MLS was reduced from 27cm to 22cm. The idea behind this was that large numbers of plaice between 22 and 27cm were being discarded in the Southern North Sea by vessels fishing close to the Plaice Box, landing a mixture of plaice and sole. Reduction of the MLS aimed to prevent this, increasing the proportion of fish retained for human consumption. Again, this change to the regulation was met with incredulity by many, who consider this to be active encouragement by the Commission for vessels to target concentrations of smaller fish. The Commission argued in turn that the permitted mesh size controls meant that large numbers of small plaice would be caught when sole (a smaller species) were being targeted, and that lowering the landing size was a more preferable option to increasing the minimum mesh size, which would effectively close down the sole fishery.

A second example of the difficulties of the implementation of EU regulations is the use of French Dredges. French dredges are large steel dredges that scour the seabed

for shellfish, principally scallops, although they have proved to be a very profitable way of catching demersal species such as turbot and monkfish. Dredges create a large proportion of discards, both of target species and invertebrates. Regulation 850/98, which stipulate that dredges can be used only for shellfish, updates and replaces previous rules in regulation 3094/86. Under 3094/86 a 10% by-catch limit of *protected* (i.e. quota) species was allowed. This lead to fishermen deliberately keeping on board worthless >trash= species for several trips before discarding them, allowing the target species of turbot and monkfish to remain below the 10% threshold. Under the updated regulations only 5% by weight of all fish may be landed, in theory preventing fishermen from targeting high value fish species, and discarding a large proportion of damaged and undersized fish. The reality is that when 850/98 comes into force some fishermen will be likely to retain less valuable shellfish on board for several trips, targeting and landing only the more valuable Aby-catch@ fish species.

Again this illustrates the difficulty both of framing legislation to prevent discarding, and of enforcing the ever more complicated regulations that need to be developed when approaching the problem from this direction. Similar problems exist with the enforcement of technical regulations, that can be circumvented by fishermen quickly and easily, with little chance of the offence being detected. Regulation 850/98 continues the thread from previous legislation, outlining specified maximum sizes for cod end twine, minimum cod-end circumference and similar technical specifications.

These changes are all in response to perceived moves by fishermen to evade the previous set of regulations. The end result is a cumbersome set of rules that confuse and alienate fishermen, that are extremely hard to prosecute and in many cases simply fail to prevent fishermen from targeting the fish they choose, whether or not they have quota or the correct gear. There is a clear need for a re-assessment of the policy options available.

8. Policy options for consideration by the European Parliament

8.1. Scope for improved policy

Discussions with senior scientists covering North Sea stock management suggested that given >*appropriate*= discard reduction policies, a 5% reduction in fishing mortality may be achievable. Appropriate policies are considered to include technical conservation measures, real time closed areas and certain mixed-species and multi-annual TACs.

Present recommendations in Council Decision 97/413/EC, outlining development of the Multi-annual Guidance Programme (the main instrument used to direct fisheries effort reduction) indicate that cuts in fishing mortality of up to 30% need to be made in order to safeguard stocks. The principal measure for achieving a more sustainable exploitation of fisheries resources is obviously to reduce fishing capacities to bring them in line with available and accessible fishing potentials. Whilst a suitable discard policy will therefore not overcome the economic and ecological problems in EU fisheries, it does have a role to play, within a broader policy framework for effort reduction.

8.2. Nature of discards policies

To be workable, the policy options should focus on managing rather than eliminating discards. They should be concise, specific and suitable for implementation within a reasonable time and cost frame.

Furthermore, the present EU Regulations aiming at reducing discards are extremely complex; the average fisherman has difficulties in coping with them and future interventions should therefore, as far as possible, aim at simplifying and rationalising the regulatory framework.

The consultants have considered a range of policy measures and have identified a number of policy options which could be applied to specific fisheries where the impact of discarding is particularly great. These will be described in Section 8.3 and 8.4.

8.3. Discard bans in EU waters

Given the generally positive experience in adjacent Norwegian waters, it is worthwhile to consider the possibility of a discard ban policy within EU waters.

A discard ban would make illegal the practice of discarding any of the catch at sea.

This would reverse existing policy which prohibits the holding on board of certain species and sizes of fish which must be discarded if they are caught. Discard bans may be total (applying to all catches in all areas), selective (in that they prohibit discarding of certain species, whilst permitting that of others) or partial (in that they may apply in certain areas and times, and not in others). Discard bans work not only to reduce discards *per se*, but also to remove the incentive for unwanted by-catch, by raising the cost to the fisherman of this component, thus causing cessation of fishing at a lower by-catch rate.

The Norwegian experience shows that such a policy can have a substantial effect in reducing the level of discards. If adhered to, it also ensures that fisheries managers are presented with the opportunity to access almost perfect information on the nature and quantity of actual catches. In some fisheries however, where the level of unwanted catch is high, substantial costs arise to vessel operators in storing and transporting material on board, for which there is little or no return. This has the effect of forcing operators to stop fishing when by-catch rates start to rise beyond those which can be sustained by the average value of landed material.

In general, the Norwegian experience shows that a discard ban is workable where there is good access from the fishery area to shore-based marketing and processing infrastructure. For fishermen to comply with a discard ban, it must be relatively easy for them to do so, and a pre-condition of such a ban will therefore be that other (for example technical) measures are in place which have already reduced discarding to a minimum. Also, given the ease with which such a ban can be avoided, there needs be a culture of compliance within the fishery, evidenced by good compliance rates with other fisheries management measures.

At present within the EU, several economic and logistical factors mitigate against the immediate introduction of a discard ban. EU fisheries areas are rather geographically dispersed in relation to shore infrastructure (such as processing facilities for human consumption or fishmeal). For example, the cost of landing by-catch from the Bay of Biscay hake fishery would be prohibitive. Similarly, even where land may be close by, as in the North Sea demersal trawl fisheries, concentration of processing facilities in a few locations would mean that low value fish would have to be transported long distances, again with severe economic limitations. In some EU fisheries, for example for *Nephrops* or *Crangon*, the level of discarding is several times higher than landings of target species, and mandatory landings would render the whole fishery uneconomic. As a result there are strong economic limitations to the EU fisheries in which a discard ban policy could be successfully implemented.

The North Sea, which would be one of the main areas of focus for new policies in discard reduction, is characterised by mixed demersal fisheries, that have an

inherently higher proportion of discards. Furthermore the condition of most EU fisheries, (the bulk of which were classed by the Commission in 1997 as >depleted= or >overexploited=) means that juveniles constitute a much higher proportion of the fish population, and therefore catches. Finally, a lack of a compliance culture within the present management system would be a further barrier.

A general discards ban without first addressing the issue of over-capacity, although in theory a policy option, is not considered to be workable in the present environment. Although a general discard ban could be announced as a target for the future, much more remains to be done with other management tools before it can be realistically considered as a policy option.

Selective discard bans could however be considered as options within a much shorter time scale. If other fishery management measures such as closed areas and more selective fishing gear show positive results (as they have in Norway), the introduction of discard bans for defined areas or fisheries could then be considered on a selective basis.

8.4. Fishery management measures

8.4.1. Temporary Closed Areas

The measure of temporary closed areas (in which fishing is restricted) is already widely used in EU fishery management, as described previously for the Plaice Box and Norway Pout Box. However, one option which has not been fully utilised is the possibility of developing a system to enable such closures to be applied more flexibly and rapidly, in order to prevent fishing when and where by-catches and discards reach certain defined characteristics in terms of quantity and character.

An area closure could be absolute (i.e. no fishing whatsoever) or partial (to permit access for certain gear types). In this way, preferential access could be provided to vessels which adopt technical measures for discard reduction, thus providing an incentive to their adoption. Other access conditions could be imposed, such as reporting requirements or landing of by-catch. On the other hand, there is the view that such exceptions provide a means for entry to the closed area and that the conditions can subsequently be avoided, thus reducing the impact of the policy. Some proponents of such zones therefore argue that they should be absolute, and present opinion of ICES appears to be that derogations considerably water down the positive effects of conservation measures. Policy implementation would therefore have to be robust, with limited derogations and effective enforcement, in order to have any material benefits. Enforcement would be considerably easier in the case of total closure.

Two major pre-conditions for the effective operation of this policy are the timely reporting of by-catches, and more decentralised decision making at national or regional level. Both would require better monitoring of by-catch and communication with decision-makers and enforcement agencies than presently exist.

Establishing the real-time discard rate at a cost commensurate with the value of he fishery would present practical difficulties. Options might include random checks from patrol vessels, on-board observers, experimental fishing or by an obligation on the skipper to report on discards. All have advantages and disadvantages in terms of cost and data quality. New communication technologies, perhaps using the internet, may overcome some of the technical difficulties in this area. Moreover, the ongoing introduction of satellite vessel monitoring systems provides, for the first time, good opportunities for effective monitoring and enforcement of closed areas on a real-time basis.

Clear conditions would need to be specified to trigger the closure of the area, and for its subsequent re-opening to general access. Threshold conditions for closure would be related to discard rate and/or composition. For timely implementation, closed area decision taking would have to be decentralised, which would involve delegation of fisheries management authority from the Commission to other organisations, necessarily including closer involvement with fishermen=s organisations than presently exists. For a particular area, these conditions could be established centrally, with monitoring and decision-making delegated to a committee of stake-holders, thus enhancing subsidiarity in fisheries management.

In practice, temporary closure could be applied to areas in which there were unacceptable levels of discards of juveniles of target species or of other ecologically sensitive species. However, to be effective they would have to be in areas where there was a substantial variation in discard rates, either in space or time. Ideal candidates for temporary closure would include well defined areas identifiable as nursery grounds at certain times of year when they suffer from high discard rates. However where discards are an almost permanent feature of a widely dispersed fishery, there are few opportunities for applying flexible temporary closure. In such fisheries, the effect of the closure would only be proportional to the area it encompassed. For example, for the protection of North Sea cod, closing one quarter of the area of the fishery would not be sufficient to protect nursery areas.

With temporary closed areas, there is a further option of extending this instrument to permanent and complete closure of established nursery areas. The concept of such marine reserves is gaining in popularity, since as well as reduction of by-catch and target species, the measure also effectively conserves habitat.

8.4.2. More flexible quota allocations

Although there is no strong evidence that Aquota discards@ are a significant factor in the overall discard problem, they do undoubtedly occur. Furthermore, if present regulations were followed, the present illegally landed fish (so-called Ablack fish@) would be discarded. The pressure to discard or land illegally could be reduced by making it easier to comply with quotas over time by operating more flexible TAC management and quota allocations. This policy would permit above-quota catches to be landed by the assignment of mixed-species and/or multi-annual quotas, with the overall total TAC of each quota species within a given time period being the same. Thus a quota would be allocated for one or more species over say a two-year period, permitting the legal landing of fish which would become either discards or Ablack fish@ under the present arrangements. In practice, over-quota landings would be held Aon-account@, against the next year's quota. Such a system is already applied to some non-depleted listed stocks in EU waters. For example Council Regulation 847/96 contains provisions for >banking and borrowing= of up to 10% of the TAC.

The advantage of this policy option is that it would provide a legal means of landing and utilising fish which would otherwise be discarded, thus decriminalising an action considered by fishermen to be a just right. By permitting greater landings of otherwise prohibited catches, better information would be available for fisheries scientists, although in areas where the policy could be applied (such as the North Sea demersal fisheries) this is unlikely to significantly improve the already good understanding of discard rates.

The disadvantage of this policy is that fishermen given the permission to operate flexible quotas, may exploit that flexibility, by targeting some fish stocks at certain times which under the present regime would be illegal to land. Also, the problem would still arise, albeit of a different extent and nature, when fishermen reach the limit of their more flexible quota allocations, and are then still faced again with the option of discarding or landing Ablack fish@.

Under present policy, the allocation of quotas by the Council is to member states, with each fishing nation then deciding whether and how to allocate the quota to individual Producer Organisations or vessels. For multi-species or multi-annual quotas to operate within the present management system, the Council would either have to specify the quota allocation system within member states (a backward step for subsidiarity), or provide flexibility for member states to modify Council quota allocations over species or time, providing that certain overall technical conditions were met. Safeguards would have to be put in place so that the quota system was not undermined.

This policy could only operate where quotas are allocated to individual vessels for the fisheries concerned**.** At present this would focus mainly on the North Sea fishing nations. In this area the role of Producer Organisations would have to be reinforced to manage a more flexible allocation of quotas according to the more complex formulae. The policy could not operate where quotas are for all appropriately licensed vessels as a group (for example in Portugal) or in the Mediterranean where the quota system does not form the basis of fisheries management. Were it to be applied this option would require a more detailed and focused scientific assessment, with the objective of preparing proposals for mixed species and multi-annual TACs that provide equivalence with existing limits without undermining the relative stability principle.

The consultants have identified some fisheries in which this option could be applied (see Section 8.6).

8.4.3. Mitigation of the effect of minimum landing sizes

The measure of specifying the Minimum Landing Size (MLS) is a well-established management tool designed to protect juvenile fish. The measure appears to contribute to the discard problem by forcing the disposal at sea of undersized fish caught accidentally or as part of a mixed catch.

One policy option would therefore be to modify the MLS measures to permit the retention on board of smaller fish. The modification could be a reduction of the MLS, or the elimination of MLS requirement, or permitting the retention of a percentage of sub-MLS fish. All would have the effect of permitting the landing of smaller fish. As with other fisheries management measures, the policy could be applied selectively, in terms of species, time and location.

The policy would operate to reduce discards by enabling fishermen to bring to shore smaller fish when they considered that they could find a market, rather than being forced to discard those fish. The policy therefore operates to mitigate the effect of MLS-induced discards. In fact some aspects of such a policy are already operational, in that present MLS regulations permit retention on board of certain percentages of fish below the MLS, when these are caught incidentally.

The policy option has the advantage of appreciating the commercial reality of the pressures to land fish for which there is a market, irrespective of MLS. The disadvantage is that if the markets were sufficiently profitable, or even made a contribution to overheads, then the policy would actively encourage the targeting of concentrations of smaller fish, especially in locations where they could be caught easily and in larger quantities.

For the policy to operate effectively, a pre-condition is that there must exist a market for smaller sized fish, otherwise they will be discarded irrespective of the regulatory MLS. In many fisheries the markets for smaller specimens are not developed (e.g. with whiting in the North Sea) and it is unlikely that reduction in MLS alone would have any impact on discard rates. This reflects the reality that most discard practices appear to be motivated by economic conditions rather than regulatory measures. Adjustment of MLS should therefore only be considered as an option where there is a clear consumer demand for the smaller sizes of fish (e.g. hake in Spain or horse mackerel in Portugal).

A significant variant policy option which relates to the operation of the MLS regulations is one which permits a fishing vessel to land up to a specified percentage of target species fish below the MLS. To reduce the likelihood that discards may still occur for economic reasons, the specified percentage is counted against the catch quota for that vessel, whether or not it is landed. Thus an economic incentive is created to land the sub-MLS fish which would otherwise be discarded.

This policy option is successfully implemented in Norwegian small pelagic fisheries to overcome the problems of Ahigh grading@ and Aslipping@ which result in discards of juvenile fish.

To be effective, such a policy can only operate at times and in locations where it is impossible to avoid catching sub-MLS fish as part of normal fishing operations. Otherwise the measure could be considered to be unfair, since its effect would be a reduction of quota. Another pre-condition is that there is sufficient demand for the smaller sized fish to provide recovery of additional cost of retention on board; where the smaller sizes have zero value on shore, it will still be economically advantageous to discard and save the cost of labour, handling and ice.

8.4.4. Technical gear regulations

Technical regulation of fishing gear presents a means of controlling the mechanical effects of the fishing process and therefore presents a range of options to fisheries managers. The option operates by modifying the way in which fish are caught, improving the selectivity of the gear by taking advantage of differences in character (whether morphological or behavioural) of different species or sizes which occupy the same space in the marine environment.

This policy option for discard reduction would focus on the development and introduction of methods of fishing in which non-target fish (juveniles or non-target species) have a greater chance of avoiding or escaping the gear. The policy will

necessarily involve the scientific investigation of fish behaviour and habitat, the development of technical specifications of fishing gear which has the desired effect, the introduction of technical regulations and the creation of a framework of incentives for the adoption of the measures.

The advantages of the option are that with properly designed technical measures, effective regulation and support for introduction, the measures can be very effective in reducing discard rates at modest cost. There are several examples of positive experiences.

One disadvantage is that in practice it is difficult to find measures which are universally effective throughout a fishery pursued by different fleets. Small differences in techniques and behaviour of fishermen within a fleet can make significant differences to both fishing effectiveness and efficiency, and technical measures can therefore be unpopular. Whilst their installation on vessels is easy to enforce, their use is a different matter. Fishermen can rig and operate their fishing gear in a way that renders the technical regulation ineffective, often in ways that would be difficult to detect.

These disadvantages provide barriers to the introduction of technical measures, which require users to learn how to modify traditional practices, so that they can maintain their catch rates of target species when using the new measure. Accompanying measures are therefore required to facilitate and incentivise the introduction of new technical gear regulations. These can include an initial period of voluntary introduction, preferential access to restricted areas, financial incentives, temporary derogations for certain vessels, training and demonstrations. This latter option is in any case useful, since small differences in the way in which technical measures are applied can make a significant difference to discard rates.

The policy of introduction of technical gear regulations to reduce discard rates is already operational within the EU, for example the mesh size regulations. However, in recent years there has been much research and development of several effective techniques, the introduction of which could now receive further policy support. Examples that may be considered include:

- square mesh panels
- separator trawls
- sorting grids
- acoustic avoidance devices

In particular, clear benefits have been derived in many fisheries by the introduction of sorting grids and square mesh panels. In Section 8.6 some EU fisheries are identified in which the introduction of such devices might be expected to bring

considerable benefits.

To be effective such policies should also provide for economic incentives for the installation and use of new gear. Possible options for consideration are by direct grant or preferential access to resources or both.

8.4.5. Bans on fishing gear

In an extreme form, a technical gear policy may operate to ban certain gear types which are considered to be too damaging in terms of discards. Such a policy has already been applied to EU drift net fishing for tuna, tuna-like species and swordfish. The advantage of gear bans are that they are easy to enforce by shore-based inspection, with 100% compliance being a realistic target. The disadvantage is that they involve the substantial cost of eliminating that fishing capacity altogether, or re-directing it to other fisheries.

8.5. Research and Development Options

Research is an important aspect of the policy framework, since it provides information on which to base better policies in the future. A policy decision to address the problem of discards with a combination of realistic interventions in the future, will need underpinning with more and better data relating to the extent and nature of discards, with particular emphasis on the development of by-catch models for short and medium-term forecasting. This will be particularly important for the policy option of temporarily closing fishing grounds.

New policy options are presented by technological opportunities for better management of the discard problem. In particular, computerised data acquisition systems for timely reporting of by-catches and discards (as well as other fisheries management parameters), would permit improved and more rapid decision making by fisheries managers.

A decision to promote technical gear regulations will need continuous support for research into interactions between fish and fishing gears, particularly in relation to non-target species and juveniles, as well as support for technological development of new or modified gears which take advantage of the results of this work.

Finally, all policy measures for discard reduction will depend on fishermen for their successful implementation. This study has shown that a better documented understanding of the economic and other behavioural motivations of fishermen in relation to discards is required to ensure that the measures introduced have the desired effect.

8.6. Policy Options for specific fisheries

Section 3.3 identified the EU fisheries in which the problem of discards was particularly evident. It is appropriate now to consider how the general policy options described earlier in this section might be applied in practice in the specific problem fisheries. These options are not recommendations, but presented in order to illustrate how the above policies might be applied with effect.

8.6.1. Beam trawling for flatfish

In this fishery in Area IVbc discards of plaice are very high, particularly when sole is the target species. Most of the discards are due to small (sub-MLS) plaice. Policy options include a variety of measures, either taken individually or in combination.

A ban on beam trawling for sole in the North Sea would be an effective discard reduction measure, but its cost to the industry or the tax-payer would be several hundred million Euro. The option of multi-species quotas including plaice, whilst an option, would not be an effective discard reduction measure, since the quota for plaice has not been fully taken up in most years since 1990.

However the option of closure of selected areas to beam trawling could also be expected to be an effective discard reduction measure. This is already implemented in the Plaice Box, in which, to protect juvenile plaice from the sole fishery, access for larger vessels is prohibited. However, recent scientific evidence[11] suggests that, as scavengers, juvenile plaice grow faster on ground disturbed by beam trawls, and are now migrating to the edge of the box, thus indicating the difficulty of achieving the expected outcome from any given policy option.

For the extension of flexible closure of areas to the sole and plaice fisheries, threshold levels (possibly progressive over time) would have to be established for discard rates, which would vary depending on the region and the target species. Since this fishing operation has a high benthic by-catch, only discards of non-target commercial species should be taken into account in this threshold. This option is likely to be effective only if the decision for closure is made and controlled at local decentralized level, e.g. by the respective Producer Organisations.

8.6.2. Demersal trawl for ground fish

This concerns mainly the haddock, cod and whiting fishery in Area IV (North Sea) and the hake, megrim, monk fishery in Area VII (West Ireland) and VIII (Biscay).

Temporary area closures would seem to offer some flexible options. Threshold levels will vary depending on season and the fishery and will need research to establish a reasonable level. Substantial research would be required to design the system. Decentralized decision-making would be required, but would be complicated by the multinational nature of the fishery.

Technical measures could also be expected to have significant impact in these areas. Suitable candidates might be square mesh panels and/or separator trawls. Technical measures may be introduced on a voluntary basis, and mandatory requirements could be phased in over a few years. Financial incentives for adoption could be provided, e.g. subsidies on the installation cost, and support also provided for demonstration and training activities. A further incentive could be provided by the provision of preferential access to the closed areas for vessels with more selective gear types. This would require either declaration of gear type (selective or not) before a trip starts, or random gear checks in the closed area.

For the haddock, cod and whiting fishery in Area IV the additional option of multi-annual quotas for haddock and whiting could be contemplated, whereby annual quotas may be exceeded by up to, say, 20% and accounted for in the next year=s quota. Regulation 847/96 already allows a quota excess of 10% to be transferred to the following year. For the hake and megrim fishery in Areas VII and VIII, new regulations could permit all fish above the MLS to be landed, with the provision that above-quota catch (20% is suggested by some proponents) will be accounted for in next year=s quota. However, more study is required to develop specific options at the fishery level, along with a better understanding of the motives for existing discarding practices.

8.6.3. Demersal trawl for Nephrops:

Present measures in Regulation 894/97 require *Nephrops* nets to have square mesh panels by the beginning of 2000. Some national regulations (eg.UK) already require this. Sorting grid research is continuing and is expected to provide additional options for improved selectivity. Area access incentives could also be created for initial voluntary adoption of proven effective measures.

8.6.4. Demersal/beam trawl for Crangon shrimp:

The main option would be the mandatory introduction of sorting grids, along the same lines as given for the *Nephrops* fishery. The possibility of seasonal closed areas, at times and places of highest discards, may also be considered. The Commission is in the process of drafting regulations on the structure of gears to be used in these fisheries.

8.6.5. Pelagic trawl

Impact of discards in these pelagic trawl fisheries is regarded as relatively limited. It might nevertheless be appropriate to reduce the practice of Aslipping@ and Ahigh grading@ by establishing a fixed percentage of smaller sized fish which has to be landed, with the provision that if fishermen choose not to bring this quantity to shore it would still count against their quota. This has proven to be successful in Norway. Although EU demand for small-sized small pelagic fish is not strong, some markets may be found of sufficient value to justify the introduction of the measure. More work would be required to assess the feasibility of this option.

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[5.] High grading may also include the discard of a marketable species in order to retain another species of higher value and the retention of only those species or individuals within a mixed catch having the greatest market value, less valuable species or individuals being discarded.

[6.] Producer Organisations (POs) are bodies which represent the vast majority of EU catching capacity, and are run by fishermen with EU funding to manage and market their own fish. In some EU countries, POs also have responsibilities of quota management and allocation to individual vessels.

[7.] International Council for the Exploration of the Seas

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