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Worse things happen at sea: **the welfare of wild-caught fish**

“One of the sayings of the Holy Prophet Muhammad(s) tells us:
‘If you must kill, kill without torture’” (Animals in Islam, 2010)

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Alison Mood
fishcount.org.uk

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Executive Summary

1 Introduction

There is increasing scientific acceptance that fish are able to feel fear, pain and distress. There is correspondingly a growing concern for the welfare of these animals, largely focused on the rapidly developing area of fish farming. This report looks at the welfare of fish in commercial fishing.

Considerable suffering is caused to wild-caught fish during capture, landing and subsequent processing. Fish are likely to experience fear, pain and distress as they are, for example:

- pursued to exhaustion by nets
- crushed under the weight of other fish in trawl nets
- raised from deep water and suffer decompression effects e.g. burst swim bladders
- snared in gill nets
- confined in constricted seine nets
- spiked with hooks (gaffed) to bring them aboard
- caught on hooks, often for hours or days
- thrown live to tuna as bait
- impaled live on hooks as bait

In many types of fishing the duration of capture can be very long, lasting hours or even days. Fish often die, or are fatally injured, during this process.

Once landed, most fish are either left to asphyxiate, or die during further processing which may include gutting, filleting and/or freezing while alive and conscious. Some fish may be slaughtered by "spiking" the brain or by a blow to the head, potentially humane methods of killing fish, but these are the exception rather than the rule.

Perhaps the most inhumane practice of all is the use of small bait fish that are impaled alive on hooks, as bait for fish such as tuna.

The number of animals affected is very high. It is estimated that in the order of 1 trillion fish are caught each year.

The combination of the severity of suffering, its duration and the huge numbers of animals involved, make commercial fishing a major animal welfare issue that needs to be addressed urgently. This report proposes measures and strategies for reducing the suffering in fisheries.

Key welfare issues in commercial fishing

Suffering is caused to wild-caught fish throughout the process of capture until death, which may be considered as three parts: capture, landing and the treatment they receive between landing and death. The welfare impact of some major fishing methods is briefly discussed below. What happens to fish once they have been landed is discussed subsequently.

2 Major fish capture methods and their impact on animal welfare

Trawling

Fish caught by trawling are chased to exhaustion by a bag-shaped net towed through the water. Once exhausted, the fish become overrun and swallowed by the net. Then they will start to panic and thrash their tails in attempts to escape. Collisions with the sides of the net and with other fish may cause scale damage. As the fish collect in the narrow end of the net (cod end), they may be suffocated in the crush of other fish, or die from circulatory failure. Fish may experience decompression injuries, such as a burst swim bladder, when raised from deep water. The trawl tow may last for many hours.

Trawling, especially shrimp trawling, results in high levels of bycatch. Trawls towed along the sea bottom can be highly damaging to the seabed, destroying fish habitat.

Purse seining

In purse seining a school of fish is gradually surrounded by a long wall of netting, hanging in the water and towed into a circle. Once the loop is complete, the net is drawn together like a draw-string bag, constraining the fish. Fish are likely to experience fear during this encirclement. The eventual crowding and confinement has been shown to be very stressful. Panicking fish are liable to incur injury and scale loss from collisions with other fish and with the net walls. Fish released at this stage (sometimes deliberately to avoid excess catch) often die, probably as a result of these injuries. Fish can also receive further injury as they are transferred to the fishing vessel. The duration of the whole fishing operation is probably generally shorter than in trawling.

Setting nets around dolphin pods can harm these cetaceans. The dolphin-friendly method of setting nets on fish aggregating devices (FADs) results in high numbers of bycatch animals such as sea turtles, sharks and juvenile fish.

Gill nets, tangle nets and trammel nets

A gill net is a wall of netting, hanging in the sea, which is invisible to fish. Fish of a certain size, swimming into a gill net, will pass through it only as far as their head and become snared by the gills as they try to reverse. As the fish struggles to free itself, it may become yet more entangled, and is likely to experience fear and panic. Constriction of the gills by the netting can stop the fish being able to breathe properly. Struggling results in cuts to the skin and scales. Sometimes snared fish are attacked by predators, such as seals, leaving them wounded. Fish sometimes remain like this for many hours or even days, and some die before they are landed. Further injury can be caused during landing e.g. when fish are gaffed (i.e. their bodies spiked with a hand held hook) to bring them on board.

Sometimes marine turtles, birds, and mammals are tangled in gill nets and drown. Lost gill nets may continue to catch fish ("ghost fishing") for several months or even years.

Rod & line fishing and trolling

In hand line and "rod and line" fishing, the fish is caught individually with a hook and line. In trolling, lines bearing baited hooks or lures are towed through the water by a slow moving vessel. Hooking is stressful to fish and causes an alarm response in which they will struggle to become free. This can lead to severe exhaustion. Hooking fish causes injury which is sometimes severe, especially when fish become hooked through the gills. Live fish are sometimes impaled on hooks as bait in all forms of hook and line fishing. Sometimes fish are gaffed to bring them aboard.

Pole & line fishing

In "pole and line" fishing, the fishers create a feeding frenzy in a school of fish by scattering bait fish such as anchovies and sardine, usually alive, over the side of the vessel (a practice called "chumming"). In this feeding frenzy, the fish snap at barbless hooks attached to the fishers' rod and lines. When a fish becomes hooked the fisher swings the rod, bringing the fish flying onto the deck behind and disengaging it from the lure. Sometimes live fish are impaled on hooks as bait. From the point of view of the target fish (as opposed to the bait fish) this may be one of the most humane methods of catching fish on account of the short duration of capture. The use of live bait fish greatly adds to the welfare cost of this fishing method.

Long line fishing

Long line fishing, or long lining, is a commercial fishing method that uses hundreds or even thousands of baited hooks hanging from a single line which may be 50-100km long. Unlike the other hook and line fishing methods discussed, which catch fish quickly, fish caught on long lines are landed hours or days later when the gear is hauled up. In this method of fishing, it is common for live fish to be impaled on hooks as bait. The target fish, once hooked, may themselves be subsequently attacked by predators. Many sharks that are caught on ling lines are "finned". Their fins are cut off and they are thrown back into the sea, often still alive.

Long lines kill sea birds, sea turtles, sharks and other non target fish, which are attracted by the bait.

Use of live bait fish in fish capture

The use of live fish as bait is likely to cause considerable suffering over and above that caused to the fish caught for food. These bait fish will have suffered fear and distress caused by capture and confinement, possibly for days or weeks, before they are impaled on hooks or scattered live amongst shoals of tuna. The suffering caused during fish capture could be greatly reduced by avoiding the use of live bait fish, preferably using artificial baits or fish off-cuts instead.

Summary of measures to reduce suffering during capture

The following measures, combined with humane slaughter as soon as the fish is landed, would improve the welfare of fish in commercial fishing.

I. Avoid the use of live fish as bait, especially when impaled on hooks

The use of live fish as bait should be seen as contrary to any norms of civilised animal treatment and avoided, preferably using artificial baits or off-cuts instead.

II. Reduce the duration of capture

This could be achieved by, for example, reducing the time period between setting and retrieving nets and lines.

III. Reduce injury and stress during capture

Very little research has directly addressed the welfare of wild-caught fish. However, there have been some studies into how stress and injury could be reduced during capture. This research has been carried out for reasons of improving the survival of fish released as bycatch (for conservation of fish stocks) and improving eating quality, but is also relevant to welfare.

The stress and injury caused to fish during capture, and the potential for these to be minimised, will greatly depend on the fishing method. For example, fast hook and line methods have more potential in this respect than trawling. In rod and line fishing, it is possible to catch and land fish quickly, handle carefully, and despatch humanely with a percussive stun or by spiking (see "3 Processing of wild-caught fish alive on landing"). In trawling, the capture duration is inevitably much greater, as are stress and injury from collisions with the net and crushing in the cod end.

Within a given fishing method, the type of gear used can also make a difference. One study compared the death rates in Chinook salmon that were caught in gill nets and subsequently released as bycatch. Tangle nets (which entangle rather than snare the fish) killed proportionately fewer of these fish than conventional gill nets. In another study of gill net fishing, multifilament nets killed fewer fish than monofilament ones. In hook and line fishing, circle hooks can cause less injury than j-shaped hooks.

Modifying fishing practice, including careful handling of the fish, can help reduce the harm caused. For fish caught by hook and line, the means by which the hook is removed is important. Injury and death rates are lower if the hook is carefully removed by hand, rather than by machines that tear it out. The conditions in which fishing is carried out can have an impact. Fishing at greater depths can result in decompression injuries, and fishing at higher temperatures can be more stressful for fish.

IV. Develop methods of landing fish that reduce stress and injury

This would include careful handling and avoiding gaffing. Pumping systems which minimise stress and damage have been devised for farmed fish.

These systems could potentially be adapted for use on fishing boats. Wild Salmon Direct, which claims to be the only wild salmon producer using humane slaughter technology, uses a pump specifically designed to pump live fish.

V. Reduce bycatch

Bycatch is the unintended capture of fish (and other animals) of the wrong species or size. Fishing should be avoided in conditions where bycatch levels are particularly high, by fishery closures. Some fishing practices result in high levels of bycatch and should also be avoided, such as fishing on FADs. Unintended capture of fish also happens when lost gears continue to fish ("ghost" fishing). Changes to fishing practice that reduce the incidence of lost or discarded gill nets are required. Initiatives that can help prevent gear loss include zoning fishing activities to prevent loss of nets caused by trawlers towing through gill nets.

Bycatch can also be reduced by modifying the fishing gear to make it more "selective". In trawling, increasing the mesh size can allow smaller fish to escape but the main drawback is that the conventional diamond mesh of nets may close under tension. Trawl nets can be fitted with bycatch reduction devices (BRDs) that enable non target species to escape through a hole in the net. These devices exploit the differences in size or swimming behaviour between the target and non target species. For example, BRDs can enable fish to escape from shrimp trawl nets. Gear is only truly "selective" when these escapees can escape sufficiently unharmed to survive. Fish escaping from fishing gears may die immediately, or sometime later, from physical injury, exhaustion or increased vulnerability to disease or predation. For example, a study of survival rates for herring escaping trawl nets observed death rates ranging from 77-100% for escapee fish.

BRDs of a different kind can be used in gill netting. Acoustic BRDs called "pingers" reduce mammal and bird bycatch by alerting them to the presence of the gill net. Constructing gill nets from biodegradable materials that deteriorate more quickly can help reduce "ghost" fishing. In hook and line fishing, bycatch can be affected by the size of hook and type of bait.

3 Processing of wild-caught fish alive on landing

Most commercially-caught wild fish that are alive when landed are not slaughtered but die either from being left to suffocate in air or by a combination of suffocation and live gutting. Sometimes fish are put onto ice as they suffocate, or into iced water, which may both increase and prolong their suffering.

According to a Dutch study, during observation of fisheries at sea, the majority of most fish species caught were still alive and conscious when landed. The time taken to lose consciousness was measured for several species of fish (herring, cod, whiting, sole, dab and plaice). Those left to asphyxiate took 55-250 minutes to become insensible. Those which were gutted first remained sensible for 25-65 minutes.

Introducing humane slaughter

To obtain any clear welfare benefit from reducing the injury and stress caused during capture, fish must be swiftly and humanely slaughtered on landing. Humane methods of killing animals are ones that cause immediate loss of consciousness which lasts until death (or if not immediate, where the method of inducing unconsciousness does not cause suffering). There are two traditional methods for killing fish that have the potential to be humane, namely percussive stunning and spiking. These methods kill fish individually, and so may not be practical for larger fishing operations with large numbers of smaller fish. For these cases, humane slaughter technology used on fish farms needs to be adapted for use on fishing vessels. More humane capture and killing are likely to result in improved eating quality.

Percussive stunning involves a blow to the head with a club or "priest". This must be performed accurately and with sufficient force to be humane. Automatic percussive stunning devices have been developed for some species in fish farming. They are used by Wild Salmon Direct on wild-caught salmon. To ensure that percussive stunning does kill humanely, it should be followed immediately by bleeding. In spiking (also called “ike jime”) a fish is killed by inserting a spike into the brain. If this is performed accurately, the fish can become unconscious immediately. Spiking has not yet been automated for fish farming.

Electrical stunning systems have been developed for en mass humane slaughter in fish farming. As with some automated percussive stunning, the fish are killed without taking them out of water. A current is passed though the water containing the fish. The fish are stunned immediately, and die without regaining consciousness, if the voltage and duration of the current are sufficient. It is believed by some animal welfare professionals that electrical stunning technology in fish farming has the potential to be adapted for use on wild-caught fish at sea. An important step for this will be the development of electrical stunning systems for salt water farmed species. Electrical stunning of salt-water species is technically more challenging than for fresh water species, owing to the greater conductivity of salt water.

Other methods for the humane slaughter of farmed fish may also present the possibility of being adapted for use in some commercial fishing. One other method is the use of food grade anaesthetics added to the water. AQUI-S is the brand name of one such fish anaesthetic licensed for use on fish farms in New Zealand, though not in Europe or the USA. AQUI-S is used for “rested harvest” in which anaesthetised fish are then slaughtered by percussive stunning or spiking. Quality benefits are also obtained from this low-stress slaughter method.

4 Reducing suffering by reducing numbers of fish caught

Even the most humane method of catching fish is likely to be stressful. Another approach for reducing suffering in commercial fishing would be to reduce the numbers of fish caught each year. This could be achieved by some or all of the measures summarized below.

Reducing numbers of fish caught wastefully or illegally

Many fish are caught wastefully. Wasteful deaths include the fish caught unintentionally as bycatch (wrong species or size) and then thrown back into the sea, dead or dying. In addition, an uncalculated number of fish die following escape from trawl nets and when caught by lost or discarded fishing gear (“ghost fishing”).

Modifications to fishing practice and to fishing gears can help reduce the numbers of fish killed wastefully (see “2 Major fish capture methods and their impact on animal welfare” above). Better enforcement of fishing regulations is required to address the global problem of illegal and unregulated fishing.

Catching fewer fish and letting fish grow larger

If fish are allowed to grow larger before they are caught, then fewer fish are caught for the same amount of food. There are other good reasons for pursuing such a strategy besides those of animal welfare.

Overfishing is a serious problem in world fisheries. Overfishing reduces abundance of individuals in a fish stock, by removing fish faster than they can be replaced by breeding. If continued, it can lead to a collapse of the fishery, as happened with Newfoundland cod. Too many fish are being caught and they are being caught too young.

The means by which fishing can be made more “selective” in terms of reducing the numbers of under-sized fish, and non target species, caught as bycatch are discussed above in “2 Major fish capture methods and their impact on animal welfare”. The numbers of these bycatch fish that survive following release can also be improved by measures that reduce stress and injury during capture. Selective fishing gear is a means of catching only those fish within the optimum size range in order to reduce overfishing. For a sustainable management of fisheries, reductions in fishing effort (e.g. by limits on catch and the number of days at sea fishing) and "no take" marine protected areas (MPAs) are also needed.

People in developed countries have been encouraged in recent years to increase their consumption of fish, despite the fact that current levels of fish consumption are unsustainable. According to a paper published in the Canadian Medical Association Journal, levels fish consumption in developed countries are having a harmful effect on people in developing ones. Rather than advising people to eat more fish, alternative non-fish sources of omega-3 should be developed and evaluated.

Reducing numbers of fish not directly caught for food

A large reduction in the suffering of wild-caught fish would be achieved by reducing the levels of fishing for feed. It is estimated that in the order of 1 trillion fish are caught each year. A substantial proportion of these are caught for feed and other non food uses, either whole or (mostly) as fishmeal and fish oil.

Increasingly this fishmeal and fish oil is being used to feed farmed fish such as salmon. It takes 3-4kg of wild fish to produce 1kg of salmon. This means that each of these feed fish, which are usually small fish such as anchovy, suffers a stressful death to produce a miniscule amount of food. For example, a Peruvian anchovy, weighing 20g, is killed inhumanely to produce approximately 6g of salmon flesh. This amount of animal suffering for so little human gain seems totally disproportionate.

An uncalculated number of fish are also caught for use as bait, either dead or alive. Great suffering could be reduced by avoiding the use of live fish as bait. Instead, fish off-cuts could be used in chumming for tuna and artificial baits, or off-cuts, used in hook and line fishing.

5 Towards more humane commercial fishing

Various stakeholders (animal welfare scientists, animal protection NGO's, environmental NGO's, government and intergovernmental bodies, supermarkets and retailers, animal welfare certification schemes) have worked to address the welfare of farmed fish. A similar approach is needed to address the welfare of wild-caught fish.

Action to address this problem is now required in the EU since the EU Treaty recognises animals as sentient beings and states that full regard should be given to their welfare needs in fisheries.

Animal welfare groups can achieve much by persuading the public that this issue matters and by lobbying governments and intergovernmental agencies to develop and require levels and methods of fishing which minimise animal suffering.

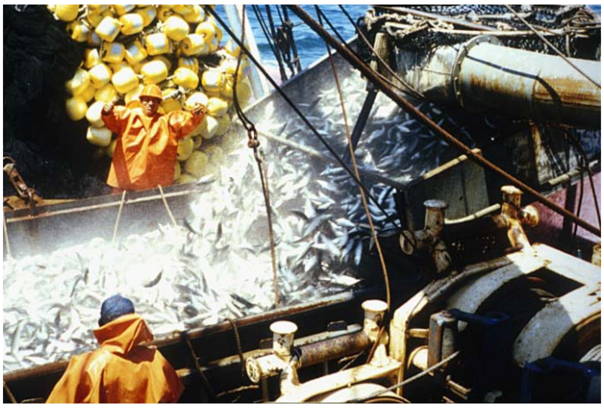
Environmental groups could widen their support base by acknowledging that fish are sentient beings and that fish welfare matters. Many of the steps required to promote welfare would also help conservation.

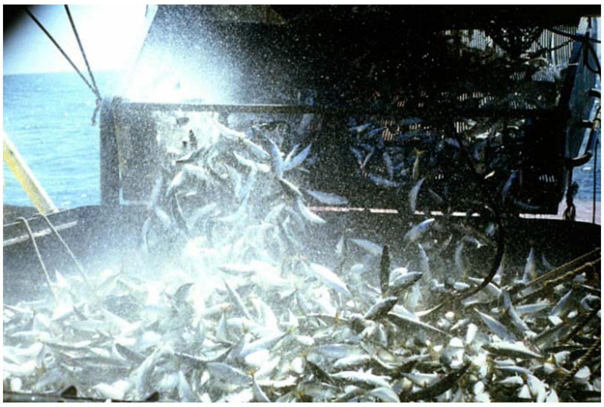
Retailers need to incorporate wild-fish welfare into their Corporate Social Responsibility policies and support more ethical fishing practices which aim to be humane as well as sustainable.

Animal welfare scientists will play a key role in establishing fish welfare science, developing humane practices and educating the next generation.

Better things could be happening at sea.

1 Introduction





Chub mackerel being loaded on a boat

Rather than being slaughtered, most wild-caught fish die in the process of capture, storage and processing which includes gutting, filleting, chilling and freezing. This report argues the case for the humane treatment of fish caught for food, feed or oil.

Credit: National Oceanic and Atmospheric Administration/ Department of Commerce. Photographer: Teobaldo Dioses

It is widely accepted that animals killed for food should be slaughtered humanely. A definition of humane slaughter for fish is given by the Humane Slaughter Association as follows (HSA, 2008):

> *"As with mammals, a humane slaughter is one that results in an immediate loss of consciousness, or if slow acting, induces unconsciousness without discomfort or pain. This unconsciousness should persist until death intervenes."*

There is increasing concern for the welfare of farmed fish during rearing, transport and slaughter, and in the last few years some progress has been made here. This report argues that the welfare of commercially-caught wild fish during capture and slaughter also needs to be addressed.

The killing of wild animals for food is a welfare problem if suffering is caused in the process of capture or killing. The magnitude of the suffering, and hence of the welfare problem may be quantified with the equation (WSPA, 2003):

> Magnitude of welfare problem =
> Severity x Duration x Numbers.

Wild-caught fish are captured and killed in a manner entirely inconsistent with the concepts of humane treatment and slaughter, and the severity and duration of suffering are likely to be high. The capture of wild-caught fish may last for several hours or even days. Most are likely to die from being crushed in nets, from suffocation in air or from live dissection. They may be rapidly chilled as they suffocate, a process which may both increase and prolong their distress. In fact, the vast majority of wild-caught fish are not "slaughtered" as such, but die in the process of being caught, stored and processed into food or fishmeal and oil. In the EU and many other countries, the slaughter of farmed land animals is subject to animal welfare regulation. The methods by which wild fish are killed would be illegal for land animals in many countries.

Table 1. Numbers of animals killed for food globally each year, by species type

Species	Numbers killed for food worldwide each year (millions)
Farmed Animals	
Chickens	52,887
Ducks	2,556
Turkeys	669
Total birds	56,769
Pigs	1,313
Sheep	527
Goats	398
Cattle	298
Total mammals	2,572
Fish (estimated)[1]	6,400-110,000* (31 ,927, 813 tonnes)
Wild Fish (estimated)[1]	
Peruvian anchovy	300,000-870,000
Atlantic herring	3,600-22,000
Bombay duck	2,600-38,000
European pilchard	8,300-15,000
Atlantic mackerel	1,400-1,700
Total wild fish	970,000-2,700,000 (77,388,322 tonnes)

* Rough estimate assuming an average weight between 280g and 5kg.

Source: Farmed animals - FAOSTAT data for 2008, website accessed 25 February 2010.
Farmed fish - FAO Global Aquaculture Production (online query). Data for 2007. Website accessed 25 February 2010.
Wild fish - Average annual numbers 1999-2007, current author (see chapter 19 and Appendix A).

The number of wild catch fish is also very high compared with other species slaughtered for food. The current author has estimated that the number of wild fish killed annually is in the order of 1 trillion i.e. 1,000 billion (see chapter 19). This compares with 3 billion mammals, 57 billion birds and, at a rough estimate, 10-100 billion farmed fish slaughtered annually (see Table 1).

In 1980, the UK RSPCA's Medway report concluded that fish can feel pain and fear. Since then, animal welfare science has become a field in its own right, and the evidence that fish can suffer has grown. As Professor Donald Broom of the University of Cambridge states (1999a):

> *"…at least some aspects of pain as we know it must be felt by fish."*

The suffering of fish in commercial fishing is therefore a major animal welfare issue.

[1] To 2 significant figures

2 Scope of this report

The purpose of this report is to raise awareness of the suffering caused to fish in commercial fishing. It makes the case that this is both a huge and neglected area of animal welfare concern that needs to be addressed. It also proposes measures and strategies for reducing the suffering in fisheries.

The report describes some major fishing methods and how suffering is caused during the capture, landing and subsequent processing of these animals. For each fishing method, a brief description of the environmental impact is also given. Environmental problems in fishing are usually, if not always, animal welfare problems too. This particularly applies to issues of fish, birds, mammals and other animals caught in fishing gears as unintended bycatch. Addressing these environmental problems will be an essential part of developing a more humane and sustainable fishing practice. However, a detailed description of environmental problems is beyond the scope of this document.

The report examines some studies giving evidence of the welfare impact of fishing methods and how welfare could be improved. Two key references concerning the welfare of fish during capture and landing are the Dutch study “Killing of fishes: literature study and practice-observations (field research) report” (V.d. Vis and Kestin, 1996) and a chapter in “Animal welfare and meat science” (Gregory, 1998). Two other key references are the review “Methods Used to Kill Fish: Field Observations and Literature Reviewed” (Robb and Kestin, 2002) and the welfare standards set by Fair-fish (Fair-fish, 2007a), a unique example of a welfare certification scheme for wild-caught fish.

Very little research has directly addressed the welfare of wild-caught fish. However, scientists have studied measures to reduce stress during capture and killing for reasons of fish conservation and food quality. Findings of a number of such studies are considered in this report, for which a key reference used is “Mortality of fish escaping trawl gears” (Suuronen, 2005) published by the FAO. For each fishing method described in this report, there is a section on reducing fish bycatch and bycatch death rates (i.e. improving survival of discards). Throwing dead and dying fish back into the sea is not only potentially unsustainable and a clear waste of resources. It is also a matter of unnecessary suffering.

This report proposes measures by which the severity and duration of suffering could be reduced in each method by modifications to fishing practice. Methods of humane slaughter for landed fish, and the need to adapt humane slaughter technology from fish farming for use on boats, are also discussed.

It is not just the severity and duration of suffering of individual wild-caught fish that causes welfare concern, but also the huge scale of the numbers involved. Though individual suffering can be reduced, it probably cannot be eliminated. Nor can bycatch be completely avoided. Possible ways of limiting the numbers of fish caught must therefore also be considered. The report discusses how the numbers of fish caught each year could be reduced by a more sustainable management of fisheries.

As discussed in chapter 19, it has been estimated by the current author that in the order of 1 trillion fish are caught every year, a substantial proportion of which are used to feed to farm animals, either whole or as fishmeal and fish oil. A detailed explanation of this estimate is beyond the scope of this report and readers are referred to separate documentation for this. This report questions the ethics of industrial fishing for feed or oil, in which many billions of fish suffer a stressful death for a minimal benefit to humans e.g. to provide feed to produce a few grams of farmed fish.

As well as developing practical measures for reducing suffering, it is necessary to persuade industry to adopt more humane practice. The potential commercial benefits of lower levels of fishing and humanely slaughtered fish are discussed. The question of how change can be brought about is tackled by considering the ways in which animal welfare professionals, industry and governments have worked to improve the welfare of fish in other areas, particularly that of farmed fish, in recent years. Proposals are made for a strategy to reduce the suffering of wild-caught fish in commercial fishing, and how these stakeholders could all play a role.

3 Fish are sentient beings

Pain and fear in fish

"Anatomical, pharmacological and behavioural data suggest that affective states of pain, fear and stress are likely to be experienced by fish in similar ways as in tetrapods [amphibians, reptiles, birds and mammals]" (Chandroo et al, 2004a)

Credit: National Oceanic and Atmospheric Administration/Department of Commerce. Photographer: Mr. Mohammed Al Momany, Aqaba, Jordan

Professor John Webster, of the University of Bristol, defines sentience with (2009):

> *"A sentient animal is one for whom feelings matter".*

Sentience is about the inner life of an animal, and a sentient animal has capacity to suffer fear, pain or distress as well as a sense of well-being. Evidence that fish are sentient has been sufficient to achieve international recognition that their welfare matters. The policy statement of the World Organisation for Animal Health (OIE) states (OIE, 2008b):

> *"The use of fish carries with it an ethical responsibility to ensure the welfare of such animals to the greatest extent practicable."*

In the European Union, a scientific panel commissioned by the EU Commission adopted its "General approach to fish welfare and to the concept of sentience in fish" in 2009 (AHAW, 2009). Having examined the research carried out for some species of fish (a relatively small number of species have been studied), this panel concludes:

> *"The balance of the evidence indicates that some fish species have the capacity to experience pain"*

and that

> *"Responses of fish, of some species and under certain situations, suggest that they are able to experience fear".*

Fish sentience is central to the case for more humane treatment of fish in commercial fishing, and is therefore discussed in this chapter.

The Medway Report

1980 saw the publication of the "Medway report" (Medway, 1980) commissioned by the RSPCA to enquire whether practices related to shooting and angling in the UK involved cruelty (defined as "unnecessary suffering"). As part of its investigation, the panel of inquiry considered the evidence that fish feel pain. They point out that ability to feel pain is generally useful to an animal, helping to prevent injury and unhelpful movement during recovery. They quote the report of the Committee on Cruelty to Wild Animals, 1951:

> *"Pain is of the utmost biological value to animals because, in general, what is painful is also harmful, and consequently animals tend to avoid anything which gives them the sensation of pain. Pain is the "conditioning" stimulus which teaches an animal to avoid anything which is physically harmful to it, and this end could hardly be achieved unless the pain felt*

by an animal were painful in the ordinary sense. Pain is therefore a sensation of clear-cut biological usefulness..."

The Medway Report discusses the neurological and pharmacological evidence that fish can feel pain. The pain receptors present in the skin of man, called "**nociceptors**", have been found in other vertebrates including fish. So too has "substance P", a chemical "*apparently important in the transmission of pain*". The Medway report published data on levels of **substance P** and **enkephalin** found in the trout brain, which were "*of the same order as in a mammal*". Enkephalins are endogenous opiates, i.e. pain killers similar to morphine in their effect, produced in the body and "*it has been suggested to us that they may play a role in the process of learning through gratification*". The report also refers to benzodiazepines, which "*apparently play a role in the pharmacology of anxiety in man*" and which have also been found in a range of other vertebrates including 3 bony fish (cod, plaice and eel).

The Medway Report concluded that:

"In the light of evidence reviewed … it is recommended that, where considerations of welfare are involved, all vertebrate animals (i.e., mammals, birds, reptiles, amphibians and fish) should be regarded as equally capable of suffering to some degree or another, without distinction between 'warm-blooded' and 'cold blooded' members."

Researching fish sentience

In the last 20 years, animal welfare science has developed into a scientific field in its own right, and the evidence for fish sentience has grown.

Because animal consciousness cannot be measured directly, animal welfare scientists look for anatomical, physiological and behavioural evidence as indicators of sentience or suffering. Fish intelligence has also been studied and, for example, it is known (FSBI, 2002) that some fish species:

"form mental representations of their environment and use these for quite complex feats of navigation"

and a collection of articles on fish learning was published in a special edition of "Fish and fisheries" (Laland et al, 2003) in which the introductory chapter states that fish are:

"steeped in social intelligence, pursuing Machiavellian strategies of manipulation, punishment and reconciliation, exhibiting stable cultural traditions, and co-operating to inspect predators and catch food".

The BBC news website reported this (BBC News, 2003b) saying that, according to scientists, fish

"do not deserve their reputation as the dim-wits of the animal kingdom".

Also reported in the news (Mail Online, 2008), have been the learning achievements of a goldfish called "Comet". Comet has been trained

Social intelligence in fish

Fish are "steeped in social intelligence, pursuing Machiavellian strategies of manipulation, punishment and reconciliation, exhibiting stable cultural traditions, and co-operating to inspect predators and catch food" (Laland et al, 2003).

Credit: National Oceanic and Atmospheric Administration/Department of Commerce. Photographer: Farb Monitor Expedition by his owner Dr Dean Pomerleau to perform a number of tricks for food rewards, and a video clip of this can be viewed on the internet at fishcount.org.uk/fish-sentience. The video shows, for example, Comet fetch hoops *"just like dogs do"*.

Of key importance in animal welfare is the capacity to experience pain, fear and distress. Professor Donald Broom, of the University of Cambridge, sums up the case for fish feeling pain (1999a):

> *"There are some differences in sensory functioning between fish and mammals because fish live in water but the pain system of fish is very similar to that of birds and mammals. Fish have pain receptor cells, nociceptive neuronal pathways, specialized transmitter substances, electrophysiological responses to cuts, bruises and electric shocks, behavioural avoidance, learned avoidance of places where they had unpleasant experiences and processing systems in the brain which parallel those in birds and mammals. Hence at least some aspects of pain as we know it must be felt by fish."*

Following a request from the European Commission, the AHAW Panel was asked to deliver a Scientific Opinion on the animal welfare aspects of fish farming. The AHAW panel reviewed the current evidence for pain and fear in fish, which it presented in the above-mentioned "General approach to fish welfare and to the concept of sentience in fish" (AHAW, 2009). This evidence is outlined below following a brief discussion of the arguments made against fish sentience.

Critics of fish sentience

Some people argue that fish are not sentient and take a Cartesian view of fish. Descartes (1596-1650) dissected conscious dogs without anaesthetic, after nailing them to boards, in order to demonstrate the circulation of blood (Magnotti, 2006). This is perhaps not so dissimilar to the way fish are treated in commercial fishing (for example, when they are dissected while conscious or impaled on hooks as live bait). Descartes argued that dogs, and other animals, do not feel pain or have feelings and are just machines. The dog's screams were just a mechanical response devoid of any feeling.

Fish feel pain

"at least some aspects of pain as we know it must be felt by fish" (Broom, 1999a)

Herring caught in the crush

Credit (above left): Courtesy of United Nations Food and Agriculture Organization. Photographer: Danilo Cedrone. National Oceanic and Atmospheric Administration/Department of Commerce.

Credit (above): National Oceanic and Atmospheric Administration/ Department of Commerce. Photographer: J. M. Olson.

For some people, this Cartesian view is largely based on an emotional response to their own perceptions of fish. For others this view is more considered, and is presented as a scientific argument.

While many people respect the welfare of these animals, it is also true that many people empathise less with fish than they do with mammals or birds. Fish have a particular "public relations" problem in that their physiological and behavioural responses to painful or distressing events are not always obvious to human observers. Fish lack the ability to make facial expressions and their vocalizations are more limited (Yue, 2008).

People may be inclined to believe that fish have less ability to feel pain because they may consider them to be less intelligent than birds or mammals. Broom argues that there is no logical reason to assume that greater cognitive ability makes pain feel worse (Broom, 2001):

> *"Pain might be a greater problem in animals with less cognitive ability".*

Is it not the case in humans, that young children seem all the more sensitive to pain, fear and distress despite, or perhaps because, of the fact that they have less developed cognitive ability? As Professor John Webster of the University of Bristol said (2005a)

> *"you don't have to be clever to suffer".*

Some scientists have argued that fish cannot suffer. In 2002, Rose published a paper, conducted at the behest of the American Fisheries Society, arguing that fish do not feel pain because they do not have a neocortex and that their behaviours are reflexes without feeling (Yue, 2008).

The evidence that fish do in fact have brain structures capable of feeling pain and fear is discussed below. The evidence that fish have a pain system which is

- similar to that of other vertebrates (e.g. mammals and birds), and that
- involves these animals *feeling* pain,

is discussed subsequently.

Fish have brain structures capable of feeling fear and pain

AHAW (2009) discusses the similarities in brain structure between fish and other vertebrates and begins by saying that:

> *"As vertebrates, fish, birds and mammals share a similar general brain structure".*

Like that of other vertebrates, the fish brain consists of the forebrain (i.e. telencephalon and diencephalon), midbrain and hindbrain. The fish brain is not identical to the mammalian brain. It is smaller and fish do not have the extensive cerebral cortex seen in the forebrain of mammals. This is a laminated structure which covers the telencephalon.

It has sometimes been argued that because fish do not possess this laminated structure (a "neocortex"), they must therefore be incapable of experiencing pain. However, there is good reason to believe that fish do experience pain and fear without this particular structure.

AHAW (2009) argues it is known that the same brain function can be served by different brain structures in different groups of animals, e.g. cognitive functions in birds and mammals (visual stimuli are processed by part of the cerebral cortex in mammals but by the midbrain optic tectum in birds (FSBI, 2002)). Another example, cited elsewhere, is that seen in dolphins, highly intelligent animals whose brain is organized in a fundamentally different way to that of primates (Marino 2002, cited in Chandroo et al, 2004b). It is also a matter of some debate whether human consciousness is a function of the neocortex

Convergent evolution

The brains of sentient animals can perform similar functions, without necessarily following the same design.

An example of convergent evolution is seen in the dolphin brain, which is organised in a "fundamentally different pattern" to those of primates. Yet these animals have great cognitive abilities, seen elsewhere only in humans and great apes (Marino 2002, cited in Chandroo et al, 2004b).

Credit: OAR/National Undersea Research Program (NURP).
Photographer: M. Herko. National Oceanic and Atmospheric Administration/ Department of Commerce.

alone, or restricted to any single area of the brain (Chandroo et al, 2004b).

As AHAW (2009) states, there is evidence that the fish forebrain contains within it several brain structures that perform similar functions to those associated with pain and fear in higher vertebrates. These are known to be active after a noxious stimulus, such as pin-prick stimuli in trout or goldfish. For example, the dorsomedial (Dm) and dorsolateral (Dl) telencephalon are thought to perform the same functions as the amygdala and hippocampus respectively in mammals. The amygdala is important in arousal and emotions, particularly fear responses, while the hippocampus is involved in memory and learning of spatial relationships. Damage to the Dm area in fish has been observed to impair the fear response without affecting spatial learning, and vice versa for damage to the Dl area.

Critics of fish sentience focus on the structural differences between the brain of fish and that of humans. Through convergent evolution, different species can develop the same function through anatomical structures that may be quite different. For example, there is good evidence that some invertebrates, such as decapod crustaceans (e.g. crabs and lobsters), have the capacity for pain and fear, despite the lack a vertebrate pain system (Elwood et al, 2009; Broom, 2007). The invertebrates with the most complex brains are the cephalopods (including octopus and squid), which can solve maze puzzles and remember the solutions (Håstein et al, 2005). These authors also state that cephalopods appear to show strong emotions that are signalled by profound changes in colour. In 1993, the UK legislation governing the use of animals in scientific research was amended to include the common octopus (Elwood et al, 2009).

AHAW (2009) concludes its discussion on brain structure by saying:

> *"There is scientific evidence to support the assumption that some fish species have brain structures potentially capable of experiencing pain and fear".*

As Professor John Webster argues, since all or nearly all the evidence points in the direction of fish feeling pain (Webster, 2005b):

> *"The claim that fish 'do not have the right sort of brain' to feel pain can no longer be called scientific. It is just obstinate"*

and that (John Webster, personal communication, 2009)

> *"to say that a fish cannot feel pain because it doesn't have a neocortex is like saying it cannot breathe because it doesn't have lungs".*

Fish probably experience pain, fear and stress in a similar way to other vertebrates

Fish have a pain system similar to that of other vertebrates. As stated by Chandroo et al (2004a):

> *"Anatomical, pharmacological and behavioural data suggest that affective states of pain, fear and stress are likely to be experienced by fish in similar ways as in tetrapods [amphibians, reptiles, birds and mammals]".*

Fish have nociceptors (pain receptors) to detect harmful stimuli such as high temperatures or harmful chemicals. These pain receptors connect, via sensory pathways, to the brain. Activity in the brain has been measured when nociception (detection of harmful stimuli) occurs. The fact that the brain is involved during nociception "*demonstrates the potential for pain perception in lower vertebrates [fish]*" (Dunlop and Laming, 2005).

Painkillers, such as morphine work on fish. Fish, like other vertebrates, produce their own natural painkillers in the brain called "endogenous opioids". The presence and action of painkillers in fish is further evidence that fish feel pain, or why would they need them?

Fish can learn to avoid noxious or threatening stimuli. For example paradise fish learned to operate an escape hatch to avoid electric shocks. Avoidance learning further suggests the behaviour is more than just a reflex. While reflexes occur quickly, the detection of noxious stimuli in fish can cause profound and prolonged changes to the animal's behaviour, lasting several hours. Fish can also learn to avoid threatening, but not painful, stimuli suggesting they also feel fear.

The evidence that fish can feel pain and fear is given in more detail in 3.1 and 3.2 below. Animal suffering is wider than pain and fear. AHAW (2009) reports that the stress physiology in fish is *"directly comparable to that of higher vertebrates"* and manifested as primary, secondary and tertiary stress responses. The primary response includes the release of hormones e.g. cortisol.

In a number of studies referred to in this report, the measurement of physiological variables (such as cortisol) and adverse behaviour have shown that fish suffer stress when caught (for example in gill nets (see 8.1 of chapter 8) and purse seine nets (see 7.1 of chapter 7), in fish traps and by hooks (see 13.1 of chapter 13)) and when subjected to live chilling (see chapter 17) and removal from water (see chapter 17).

Implications of the evidence for fish sentience

Fish are sentient beings

The sentience of fish has huge ethical implications for the way they are caught and killed in fisheries

Credit: OAR/National Undersea Research Program (NURP); University of North Carolina at Wilmington. Photographer: A. Hulbert. National Oceanic and Atmospheric Administration/Department of Commerce

Most of what is known about human pain is from self-reporting (Broom, 2001) and because a fish cannot report to us what it is feeling, it may be that scientific method cannot prove, in an absolute sense, that fish feel pain. Just as it cannot be totally proven that babies, or even you and I, can feel pain. The balance of evidence, together with what is understood about evolution and the biological purpose of pain, indicate that fish do feel pain and, for humane reasons, the benefit of any doubt should be given to avoiding suffering.

As this report goes to press, Dr. Victoria Braithwaite's book "Do fish feel pain?" brings the science behind the debate around pain in fish into the open. She describes the many different pieces of evidence that together build up a picture of fish as animals that, she concludes, *"have the mental capacity to feel pain".* She argues, on the basis of the evidence, that *"I see no logical reason why we should not extend to fish the same welfare considerations that we currently extend to birds and mammals".*

The sentience of fish has huge implications for the way they are treated in fisheries and elsewhere. Dr. Braithwaite identifies the welfare of fish caught in commercial fishing as a major fish welfare concern:

> *"In terms of sheer numbers of fish, the real business is ocean-going trawlers scooping fish from the sea. Fish, netted by the tens of thousands, are pulled to the surface through such rapid changes in pressure that their swim bladders overinflate, causing the body to become severely distended. On reaching the surface fish are dropped onto open decks where they then flap around as they suffocate. We tend not to think too hard about the way we capture fish at sea – it isn't very pretty. We wouldn't accept killing chickens by throwing them into a tank of water and waiting for them to drown, so why don't we object to fish suffocating on trawler decks?"*

Fish are also likely to suffer considerably when chased to exhaustion and buried in the crush of trawl nets; when snared in gill nets; when thrown to tuna, or impaled on hooks, for use as live bait; and when gutted or frozen while still conscious.

Taking into account the great numbers of animals involved, this is a huge animal welfare problem. Action to address this problem is now required in the EU since the EU Treaty recognises animals as sentient beings and states that full regard should be given to their welfare needs in fisheries[2]:

> *"In formulating and implementing the Union's agriculture, fisheries, transport, internal market, research and technological development and space policies, the Union and the Member States shall, since animals are sentient beings, pay full regard to the welfare requirements of animals, while respecting the legislative or administrative provisions and customs of the Member States relating in particular to religious rites, cultural traditions and regional heritage."*

3.1 The evidence that fish feel pain in more detail

The AHAW (2009) report lists some of the criteria used to indicate whether an animal, including fish, might be capable of experiencing pain as follows. It goes on to give some examples of evidence supporting each of these in fish species:

(i) the existence of functional nociceptors
(ii) the presence and action of endogenous opioids and opioid receptors,
(iii) the activation of brain structures involved in pain processing,
(iv) the existence of pathways leading to higher brain structures,
(v) the action of analgesics in reducing nociceptive responses,
(vi) the occurrence of avoidance learning,
(vii) the suspension of normal behaviour associated with a noxious stimulus.

All of the above show a pain system in fish that is similar to that of mammals.

(i) the existence of functional nociceptors (pain receptors)

Fish have pain receptors. Pain receptors are called "nociceptors" because they detect noxious, i.e. harmful, things such as high temperatures or

[2] The EU Treaty as amended by the Lisbon Treaty, Title II: Article 13 (CONSILIUM, 2008)

harmful chemicals. AHAW (2009) defines "nociception" as follows:

> *"Nociception is the detection of a noxious stimulus and is usually accompanied by a reflex withdrawal response away from that stimulus immediately upon detection. Noxious stimuli are those that can or potentially could cause tissue damage so stimuli such as high mechanical pressure, extremes of temperature and chemicals, such as acids, venoms, prostaglandins and so on, excite nociceptive nerve fibres".*

As AHAW (2009) states, Sneddon and her team found nociceptors on the face of rainbow trout. Elsewhere, Broom makes a more general point (Broom, 2001) that:

> *"most vertebrate animals which have been investigated seem to have very similar pain receptors and associated central nervous pathways".*

As Broom explains, lampreys are one of the most primitive vertebrates and modern teleosts (most species of fish alive today) have more in common with humans than they do with lampreys. Primitive as they are, lampreys too possess nociceptors. Recordings were made from sensory neurones in the skin and mouth of lamprey during heavy pressure, puncture, pinching and burning and the output was "*like that which would be recorded in a mammalian pain receptor*".

(ii) the presence and action of endogenous opioids and opioid receptors

Endogenous opioids are substances produced in the brain in order to reduce pain. In mammals, these natural pain killers work through three distinct types of opioid receptor, and these have also been identified in zebrafish. Other evidence that fish produce these substances is given by the fact that (AHAW, 2009):

> *"When goldfish are subjected to stressful conditions, there is an elevation of pro-opiomelanocortin, the precursor of the enkephalins and endorphins, just as there would be in humans"*

Fish have endogenous opioids

Endogenous opioids are substances produced in the brain in order to reduce pain. "*One has to ask why they are needed in fish if these animals do not experience pain*" (FSBI, 2002).

Credit: FreePixels.com

and that (Ibid.):

> *"The distribution of enkephalins in the fish brain shows a similar pattern to that seen in higher vertebrates".*

FSBI (2002) reports the response of goldfish to analgesics (pain killers) is *"similar to that of a rat"* and says of these endogenous pain killers:

> "*one has to ask why they are needed in fish if these animals do not experience pain*".

(iii) the activation of brain structures involved in pain processing

The processing of pain in fish involves the brain. AHAW (2009) cites research by Dunlop and Laming which measured electrical activity in the forebrain of trout and goldfish. Measurements in goldfish subjected to something noxious (e.g. heated prods) differed from those for harmless stimulation (e.g. being stoked with a paint brush) (Dunlop and Laming, 2005). Dunlop and Laming argue that this research "*demonstrates the* *potential for pain perception in lower vertebrates [fish]*'.

(iv) the existence of pathways leading to higher brain structures

The pain receptors of fish connect, via sensory pathways, to the brain.

AHAW (2009) reports that in fish, as in other vertebrates, information received by nociceptors in the skin is relayed to the brain via two major routes. Information from the head is sent via the trigeminal tract, while information from the rest of the body is sent via the spinothalamic tract. In fish, the trigeminal tract has been shown to project to the thalamus (part of the diencephalon in the forebrain (FSBI, 2002)) as it does in other vertebrates.

(v) the action of analgesics in reducing nociceptive responses

Analgesics (i.e. pain killers) work on fish, which gives further evidence of a fish pain system similar to that of other vertebrates such as mammals. Analgesics reduce the adverse behaviour seen in response to noxious stimuli, and this indicates that a feeling of pain is involved.

Some of the research by Sneddon et al into pain perception in rainbow trout is discussed in (vii) below. Rainbow trout that had been injected in the lips with acetic acid (a noxious substance) showed adverse behaviour. They were observed rubbing their lips on the substrate of the tank and displayed a rocking behaviour, as well as a faster breathing rate. In a separate study, Sneddon et al showed that when morphine was administered to the fish, these effects were reduced.

AHAW (2009) goes on to cite research in which goldfish subjected to electric shocks show agitated swimming, but if injected with morphine, the threshold for this response increased.

(vi) the occurrence of avoidance learning

There is evidence that fish can learn to avoid noxious stimuli, such as common carp and pike avoiding hooks in angling trials and goldfish that have learnt to avoid electric shocks.

Broom (2001) describes experiments in which paradise fish were given an electric shock when they entered a black compartment. They subsequently avoided the black compartment and learned to activate an escape hatch to avoid further shocks. Avoidance learning has also been documented for rainbow trout, as discussed in 3.2.

(vii) the suspension of normal behaviour associated with a noxious stimulus

It is sometimes argued by critics of fish sentience that, although fish can detect noxious (harmful) stimuli through nociceptors (pain receptors), that their response is a reflex behaviour without feeling. AHAW (2009) argues that where a noxious stimulus has adverse effects on an animal's normal behaviour beyond a simple reflex, then this may indicate that the animal is perceiving pain, stating that:

> *"Reflex responses occur instantaneously and within a few seconds but some of the responses of fish may be prolonged to 3 to 6 hours (Sneddon, 2006)".*

AHAW (2009) goes on to describe research by Sneddon et al to investigate the behavioural response of rainbow trout to noxious substances (acetic acid and bee venom) injected into their lips. Changes in behaviour over a prolonged period of time appeared to result from experiencing pain:

> *"These fish showed an enhanced respiration rate for approximately 3 hours, did not feed within this period, and showed anomalous behaviours such as rubbing of the affected area on the aquarium substratum and glass and rocking from side to side on either pectoral fin (Sneddon et al., 2003a; Sneddon et al., 2003b)".*

In this research, fish injected with acid also failed to show their normal fear response to a novel challenge. As Yue (2008) explains, rainbow trout are fearful of novel objects and try to keep a distance from them, at least for a period of time. The failure of these fish to avoid new objects indicates that the painful stimulus dominated their attention.

A later study published after the AHAW panel's report, found that goldfish subjected to an aversive, but non-harmful, heat, were displaying signs of fear 2 hours later (Nordgreen et al, 2009). For the experiment, each fish was fitted with a miniature jacket containing a tiny heater with an upper limit of 50°C to prevent harm. The fish showed an escape response when the temperature was raised to a certain level, at which point the heat was turned off to prevent suffering. Half the fish were given morphine prior to the heat tests. The Telegraph online (Dobson, 2009) reported this, quoting one of the researchers Dr. James Garner of Purdue University, Indiana:

> *"Morphine had some effect on their behaviour in the test, but the major effect was this response two hours later. That was really key…Those fish not given morphine showed hovering behaviour and were less active. These are defence and fear behaviours.*
>
> *"We believe this hovering and inactivity are indicators of a general increase in fearfulness, wariness, and a generalisation of a bad experience. It is extremely difficult to explain this two hours later as a reflex".*

3.2 The evidence that fish feel fear

As discussed by AHAW (2009), fear, like pain, serves a function that is fundamental to survival in protecting animals against dangerous environmental threats.

Behavioural responses to potentially threatening stimuli that have been described for fish include escape responses, such as fast starts or erratic movement, freezing and sinking in the water. In a number of studies these behaviours were shown in response to conditioning, i.e. learnt. Learned avoidance studies, as discussed in 3.1 above, provide evidence that the displayed behaviour is not merely a reflex response.

AHAW (2009) refers to a study of avoidance learning in rainbow trout. This study (Yue et al, 2004) showed that these fish can learn to avoid threatening stimuli, indicating that they experience fear. Rainbow trout were placed individually into a tank comprising two chambers connected by a doorway. When subjected to the frightening stimulus of a plunging dip net in the chamber containing the fish, the fish escaped through the doorway to the other chamber. Each fish was then presented with a neutral stimulus of a light that went on 10 s before the net plunged into the water. Over a 5-day period, all fish learned to avoid the plunging net by swimming through the doorway when the light was illuminated. All fish showed evidence of longer-term memory by performing this response on the first occasion they were tested after 7 days of no testing.

Learning is thought to involve receptors in the brain that are activated by a substance called NMDA. Chemicals that block these NMDA receptors (antagonists of NMDA receptors) have been shown to impair learning and fear conditioning in mammals. Experiments have shown that administering an NMDA receptor antagonist into the brain of a goldfish likewise impairs the fishes' fear conditioning.

4 Summary of key welfare issues in commercial fishing

The Food and Agriculture Organisation of the United Nations (FAO) states that (Suuronen, 2005):

> *"All major fishing gear types involve some degree of injury to fish through internal and external wounding, crushing, scale loss and hydrostatic effects, with the severity of the injury depending on the gear type and its operation."*

In commercial "Danish seining", which uses trawls, purse seines and hooks (Håstein et al, 2005):

> *"death may typically take one hour (trawls), from one to four hours (seines), and from four to six hours (hooks), depending on the species, while nets may take up to 24 hours".*

Suffering is caused to fish throughout the process of capture until death, which may be considered as three parts:

- the process of capture, which may last many hours or even days for some fishing methods
- the process of removing the fish from nets and hooks and landing them
- the process of killing the fish or, more usually, leaving them to die from suffocation, live gutting or freezing.

The welfare implications for the first and second of the above for some major fishing methods are discussed in chapters 5 to 16. What happens to fish once they have been landed is discussed in chapter 17.

5 Introduction to animal welfare aspects of fish capture

This section discusses some major methods of fish capture and their impact on the welfare of fish caught. As discussed in chapter 2, the environmental problems caused by each fishing method, such as bycatch, are also briefly discussed since these are almost always a welfare problem too.

Bycatch is a major problem in world fisheries. As discussed later in 20.1 of chapter 20, large numbers of bycatch fish are thrown back into the sea, often dead or dying. The selectivity of a fishing method is the extent to which the unintended capture of animals, i.e. bycatch, is avoided. Bycatch cannot be completely eliminated, but it can be reduced and certain measures can improve the survival chances of bycatch fish after release. For each fishing method discussed, factors affecting the selectivity and survival of released bycatch fish are discussed. This is relevant for two reasons. Firstly, reducing wasted deaths is an obvious way to reduce suffering. Secondly, measures that promote the survival of released fish, such as shorter capture periods or hooks that cause less injury, could potentially reduce the suffering of both retained and released fish.

A number of studies researching “live capture, selective harvest”, i.e. how fish can be caught alive so that bycatch can be released with a better chance of survival, are examined. Such research involving measurements of stress, exhaustion, injury and mortality gives evidence of the welfare impact of fishing methods.

For each fishing method, a list of suggested measures for improving welfare during capture and landing is given as a summary. These lists are fairly general and are not meant to be exhaustive or detailed. The aim is to show that for a given capture method, there are possible steps that can reduce suffering.

Chapter 16 summarises the possible ways for reducing suffering during capture into general principles applicable to any fishing method. This summary also considers whether some methods of fishing are potentially more humane than others.

6 Trawling

Cod end of a trawl net full of catch

Credit (above and below): Alaska Fisheries Science Center, Marine Observer Program. National Oceanic and Atmospheric Administration/Department of Commerce

Catch being emptied from the cod end of trawl net

Above credit: © Greenpeace / Kate Davison

Fish caught in a trawl showing signs of decompression

Fish caught in trawls are forced towards the "cod end" at the back of the net. Here they are likely to be compressed and effectively buried under a mass of other fish. Trawls may last for several hours and a proportion of the fish die before landing as a result of crushing, suffocation or circulatory failure. According to one study, on average 29% of fish died before landing following a 2-hour trawl. The mortality rate rose to 61% on average following a trawl which lasted 4 hours (Gregory, 1998 based on Hattula et al, 1995). Deep-caught fish can suffer decompression as they are raised through the water table. The sudden change in pressure can cause parts of the gut to be forced out through the mouth and anus, eyes to bulge from their orbits and the swim bladder to burst.

Those which survive capture and landing will usually die of suffocation or during the course of processing.

Fish caught by trawling are chased to exhaustion by a net towed through the water, as described by Gregory (1998). The trawl net is funnel-shaped, with a wide open mouth and a narrow closed end, called the cod end, where the captured fish collect. Wings extend from the mouth of the net, increasing the area swept by it, and they guide the fish towards this opening. Once exhausted, the fish become overrun and swallowed by the net, ending up in the cod end. The tow duration may last several hours, after which the net is hauled on deck.

The time taken to exhaust and overrun a fish will depend on its stamina, and this will vary with species. For example, when the towing speed is 3 knots, haddock swim for no more than 2.5 minutes whereas pollack will continue trying to out-swim the net for about 15 minutes (Gregory, 1998).

Trawling may be categorised as follows:

- “Bottom” or “demersal” trawling is where the net is towed along the seabed. Chains may be attached to bottom trawls in order to disturb fish in the path of the trawl and cause them to rise above the seabed into the oncoming net (FishOnline, 2008a). Large heavy wheels, or rockhoppers, may be attached to the trawl gear to enable it to travel over rocky terrain.
- “Mid-water” or “pelagic” trawling is where the net is towed in the water column between the seabed and the surface.

Methods of trawling include the following:

- In pair trawling, the horizontal spread of the net is provided by two boats, each towing one side.
- In otter trawling, otter boards, or doors, are attached to the wings of the net. These wings are held open by the outward force acting on the otter boards as they are towed through the water. Opposing floats and weights keep the mouth of the bag open.
- In the beam trawl (bottom trawling), the mouth of the net is kept open by a beam which is mounted at each end on guides or skids which travel along the seabed.

6.1 Animal welfare impact on captured fish

Fish are likely to experience fear and distress as they are chased to exhaustion and overrun by the net, and as they subsequently move down into the much narrower cone-shaped part of it where they become confined and start to panic. This process is described by Gregory (1998). As they thrash their tails in attempts to escape, they will incur scale damage from collisions with the net and each other. Eventually they pass to the end of the net, the cod end, which is yet narrower. As the number of fish in the cod end increases, the fish will experience compression under the crush. This may prevent some of them being able to move their gills in order to breathe, resulting in suffocation. It may also stop the blood supply, resulting in death from circulatory failure.

Many will still be alive when landed and will then be subjected to continued distress by, for example, leaving them to suffocate in air or gutting them alive (see chapter 17). The trawl tow may last for many hours and studies have shown that longer towing periods increase the proportion of fish that are dead on landing (e.g. Hattula et al, 1995; Neilson et al, 1989). Fish may have suffered fear, exhaustion, injury, and compression for some considerable time by the time they are landed.

Gregory (1998) describes the decompression injuries caused to species that have closed swim bladders when landed from some depth. The sudden change in pressure, caused by bringing these fish to the surface, can cause the swim bladder to overinflate:

> *“In extreme cases, the build up of pressure within the abdomen causes a prolapse; parts of the gut are forced out of the mouth and anus, the eyes may be forced from the orbits and there can be distortion of the scales and flesh.”*

Such decompression effects are common in fish raised from depths of 20-30m or more (Gregory 1998 and 2005).

6.2 Environmental impacts

Trawl nets catch everything in their path which is not small enough to escape through the holes in the mesh, resulting in bycatch (see 20.1 of chapter 20 for an explanation of bycatch and discards). Shrimp trawl fisheries in particular can have very high levels of bycatch because they require a small mesh size. Trawling and tropical shrimp trawling account for respectively 55% and 27% of global discarded (i.e. thrown overboard) bycatch (Kelleher, 2005). Trawlers can reduce bycatch by adding turtle-exclusion devices and with other modifications to the gear.

Bottom trawls are considered particularly destructive by environmentalists. Dragging nets along the sea floor can damage or destroy the seabed structure, the corals, sponges, worm tubes and rocky reefs etc. which create habitat for fish. This damage can be reduced by avoiding rocky or coral habitats and ceasing the use of rockhoppers (Monterey Bay Aquarium, 2008). These are large heavy wheels attached to the trawl gear that enable it to travel over rocky terrain.

Bycatch from bottom trawl gear for orange roughy in the Tasman Sea

Most of the fish and invertebrates landed in this trawl were bycatch. The environmental group Greenpeace, supported by more than a thousand scientists, has argued for a moratorium on bottom trawling in international waters to reduce damage to marine life caused by this fishing method (Greenpeace, 2004).

Credit: © Greenpeace / Roger Grace

Turtle caught by a shrimp trawl

Trawl nets catch and kill other animals besides the target species, such as this loggerhead turtle. Turtle exclusion devices (TEDs) are metal grids fitted to shrimp trawl nets that allow up to 97% of marine turtles to escape with only minimal reduction in catch (WWF, 2008). TEDs are mandatory in some countries, including the US.

In 1989, the US passed a law banning the import of commercially-caught shrimps from countries where TEDs are not mandatory. This ban became a subject of an initially successful WTO challenge in 1998, by Malaysia, Thailand, Pakistan and India, and counter-challenge. This was finally resolved in 2001 when the WTO, recognising the greater assistance the US had since provided in this technology transfer, declared the import ban legal (Stevenson, 2002).

Credit: National Oceanic and Atmospheric Administration/Department of Commerce. Photographer: Bob Williams.

Overfishing and its effects on the marine environment and animal welfare are discussed in 20.2 of chapter 20.

6.3 Reducing fish bycatch numbers and death rates

Fish escaping from trawl nets, and fish thrown back into the sea after landing because they have been identified as bycatch, often die as a result.

Left: bringing the net aboard a shrimp trawler

Right: bycatch from a shrimp trawl

Below: separating shrimp from bycatch

Credits: National Oceanic and Atmospheric Administration/ Department of Commerce.

Shrimp trawl bycatch

Shrimp trawls catch large numbers of fish as bycatch, partly because they require a small mesh size. Tropical shrimp trawling accounts for 27% of global discards (i.e. bycatch thrown overboard) (Kelleher, 2005).

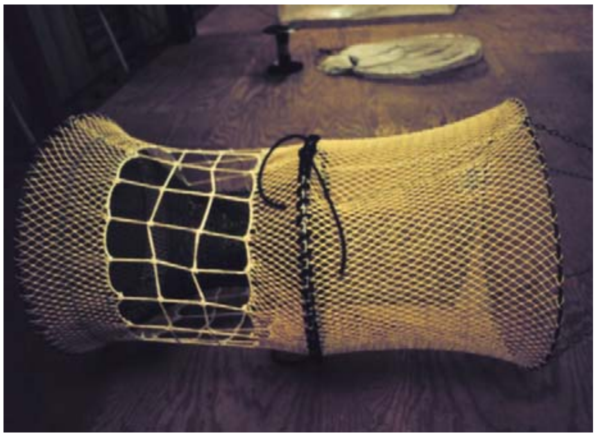
Bycatch can be reduced by modifications to the net called bycatch reduction devices. These work by allowing unwanted species to escape though holes in the net while retaining the target species. They exploit differences in size and swimming behaviour of target and unwanted species.

However, fish can still be killed escaping from trawl nets. Some research has looked at how the survival chances of fish escaping trawls nets, and of fish caught and discarded as bycatch, could be improved.

These measures would work by reducing stress and injury during capture. They could therefore also help reduce the suffering of target fish, provided these are humanely slaughtered on landing.

Trawl gear may theoretically be made selective by modifications and these are summarized by Cook (2001). The basic principle is to provide larger holes for unwanted creatures in the catch to escape. The most obvious way to do this is to increase the mesh size but the main drawback is that the conventional diamond mesh of nets may close under tension. Alternatives to mesh size increases are the insertion of panels with square mesh. Such panels are less susceptible to mesh closure and may be effective for roundfish if located appropriately in the net. They are less effective for flatfish due to the shape of the mesh opening.

Bycatch reduction devices for trawl gears



A combination turtle excluder device/bycatch reduction device

Fish escape by swimming forward and out of the large holes in the net. Shrimp are swept into the bag at the end of the net and cannot swim out.

Turtle excluder device (TED)

The oval metal ring and bars deflect the turtles. The cut in the netting is where the trap door will be placed. The bars force a turtle to the trap door which will open allowing the turtle to go free.

Credits: National Oceanic and Atmospheric Administration/Department of Commerce. Photographer: William B. Folsom, NMFS

Another bycatch reduction modification is the rigid grid device, which is placed somewhere in the cod end of a trawl and acts as a sorting device. It allows either the small organisms to be retained while larger ones escape, or vice versa. These devices are used in some shrimp fisheries to allow fish to escape. The same principle is applied in turtle exclusion devices used in USA shrimp fisheries.

Grids offer a partial means of separating species based primarily on size. It is also possible to sort species by exploiting their particular behaviour. This is done in separator trawls, where a horizontal panel in the net divides those species that try to escape by swimming upwards from those that try to escape by swimming downwards. This device can be used to separate haddock from cod. By having separate cod ends for each part of the catch, it is possible to use different mesh sizes that best suit each species.

By combining designs of bycatch reduction devices that entail size or behavioural separation in the same gear, it is possible to allow a range of different species and sizes to escape from trawls (Broadhurst, 2000).

All these modifications work by allowing fish of the wrong species or size, e.g. those too small, to escape the net rather than preventing their capture in the first place. Gear is only truly “selective” when these escapees have a good chance of survival. The FAO reports that it has largely been assumed most escapees survive, but that this assumption may be wrong, leading to large numbers of unaccounted fish deaths. A study of survival rates for herring escaping trawl nets observed death rates ranging from 77-100% for escapee fish (Suuronen et al, 1996).

Another method of bycatch reduction is to reduce fishing effort, e.g. by closing a fishery at a particular time and place when bycatch levels are particularly high. An example of this is in the saithe purse seine fishery in western and northern Norway. This fishery, like many, has minimum legal landing sizes so that the fish are allowed to breed before being caught. If a high proportion of under-sized fish continues to be found in catches, the Directorate of Fisheries normally closes the area concerned for fishing until the situation improves (Misund and Beltestad, 2000).

Some research has investigated how the numbers of bycatch fish (escapees and discards), killed as a result of coming into contact with fishing gear, could be reduced. This is reviewed by Suuronen (2005). The survival chances of fish caught in trawl nets and subsequently thrown back as discards may be increased for some species by reducing the stress i.e. the “capture stresses” inflicted on fish by the trawl process. Fish that are alive when landed, and are then discarded, may die shortly after from injury, or from being too exhausted or stressed to adequately evade predators. This is also true of fish that escape from trawl nets. The effects of scale damage can also cause delayed fatality some days, or perhaps weeks, later. Some fish that escape from trawl nets without dying immediately may have their growth and reproductive capacity impaired, thereby having a negative impact on conservation of the species.

For species that do not have gas bladders that inflate after capture, survival chances of discards can be increased by better handling of the fish on deck (in particular reduced manual handling and reducing time spent out of water). Survival chances are also likely to be increased with shorter time spans between putting the net out and landing the fish. For many species however, it is difficult to reduce discard deaths by improving handling processes, and selective fishing gear seems a more feasible means to reducing numbers of fish killed (Suuronen, 2005).

It is likely that the towing speed has an effect on a fish’s swimming capacity within the trawl and during escape from it, and thereby on escapee death rates (Suuronen, 2005). Presumably, a slower towing speed gives those species desired to escape the net more time to find an exit before entering the cod end where they are more likely to become injured, compressed or suffocated. Water temperature can also affect the survival chances of escaping and discarded fish. Higher water temperatures can increase the stress on captured fish (see 8.3 of chapter 8 and 9.3 of chapter 9) while low water temperatures can impair swimming ability, leading to greater injury (Suuronen, 2005). Further research in this area may suggest other modifications to fishing practice for reducing unwanted deaths and injuries to fish.

6.4 Possible ways to improve welfare

The following summarises measures that, combined with humane slaughter immediately the fish is landed, would improve the welfare of fish captured by trawls:

Reduce the duration of capture

- reduce the duration of the trawl tow.

Reduce the numbers of bycatch animals

- use modifications to trawl gear that reduce bycatch, without killing the escaping fish
- close fisheries as and when necessary to reduce high levels of bycatch.

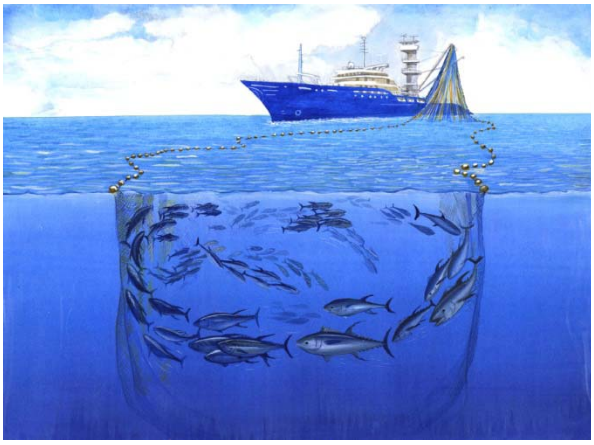
Reduce stress and injury during landing

- develop methods of landing fish which reduce stress and injury and minimise time out of water
- handle fish carefully, and with minimal time out of water, prior to humane slaughter (or release as bycatch)
- avoid fishing from depths greater than 20m (for fish with swim bladders).

Reduce harm to other non-target animals

- avoid gears that are more damaging to fish habitat.

7 Purse seining



Artist's conception of purse seining operations

In purse seining, a vertical wall of netting is towed in a circle surrounding a school of fish. Once the circle is complete, the net is pulled tight, containing the fish in a shrinking space of water at the side of the vessel.

Credit: National Oceanic and Atmospheric Administration/Department of Commerce

In purse seining a school of fish is gradually surrounded by a long wall of netting, hanging in the water and towed into a circle. Once the loop is complete, the net is drawn together like a draw-string bag, constraining the fish. The fish are then hauled aboard within the net; pumped to the deck, or scooped into smaller brail nets and lifted aboard.

A large purse seine can be as long as 1 kilometre and 200 metres deep (ECBC, 2008). In purse seining the fish are herded by a net at relatively slow speed so as not to alarm them. The vessel then speeds up to 2-3 knots to outpace the fish as the circle is completed (Gregory, 1998).

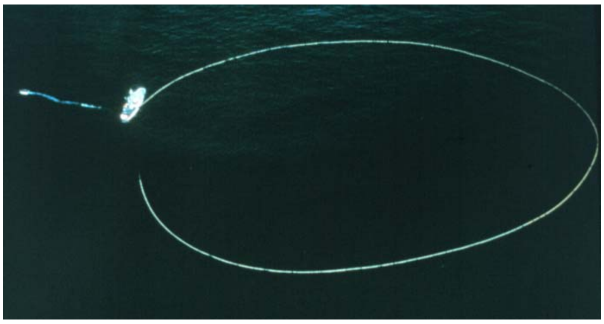
The duration of the whole fishing operation is probably generally shorter than in trawling, and the duration of the phases that are the most stressful to fish, i.e. during tightening of the net and transferring the fish aboard, are shorter still. In a study of the sardine purse seine fishery in northern Portugal (Marçalo et al, 2006), the fishing operation took between 90-160 minutes and usually about 2 hours. The phase in which most of the net is hauled in to tighten the portion containing the fish usually took around 1 hour. The time taken to transfer the fish aboard after hauling varied according to catch size but took on average 36 minutes. According to Lockwood et al (1983), for mackerel purse seines the time taken between starting to set the net and the net tightening phase is about 40-50 minutes. Fish quality of seined whitefish species tends to be better than trawled fish due to shorter periods of time in the net (Anon, 2008). This is a potential welfare advantage purse seining has over trawling.

7.1 Animal welfare impact on captured fish

Fish are likely to experience fear as they try to out-swim the net moving towards them, and as they are finally encircled. Sometimes fish are deliberately scared by high speed chase boats, cherry bomb fireworks and flashing lamps to herd the fish and prevent them leaving the enclosure while the net is closed (Sainsbury, 1996a).

Once the circle is complete, most of the net is hauled in so that the remainder of it forms a purse, constraining the fish ready for landing them. As this hauling process ensues, the trapped fish are confined in a shrinking space of water and become increasingly crowded. This is likely to be very stressful and fish are liable to incur injury and scale loss, as discussed below.

Sometimes part of the catch is deliberately released at this stage, in a process called "slipping". This would happen if, for example, the skipper had decided that the quantity of fish in



1. Arial view of a purse seine fishing operation

The larger vessel on the circle is the purse seiner. The smaller tug boat, which has pulled the net into a circle, is on the far left. The net will be tightened and pulled up against the purse seiner for landing the catch.

2. Tuna agitating the surface as the net is drawing closed

3. Tuna captured in a purse seine net

The fish become increasingly crowded as the net is tightened ready for landing.

the net was too large for the legal quota. In the 1970's, large numbers of dead mackerel, but not other species, were reported in UK bottom trawl catches, arousing the suspicion that these dead fish had died following slipping from purse seine nets. This concern stimulated research into the stress and death caused to fish caught during purse seine operations (Lockwood et al., 1983). This research gives evidence of the welfare impact of this fishing method in terms of the suffering of caught fish and wasted deaths.

Lockwood et al (1983) investigated the effects of crowding mackerel in purse seines. This study describes the effect on these fish of hauling in the net to shrink the portion of net containing them. Mackerel continue to swim as a shoal inside the net until there is no longer enough space to allow this when they instead move as individuals. At this point they are most vulnerable to damage.

Lockwood's team estimated that, at this stage of a mackerel purse seine operation, there are probably 1000 fish or more per cubic metre of water, or just 1 litre of water per fish. They held mackerel in experimental keep nets at stocking densities and durations comparable to those in a purse seine operation prior to "slipping". High death rates of up to 90% in the first 48 hours following release, were observed. The researchers concluded that the fish probably died as a result of skin and scale damage incurred from collisions with other fish and with the net walls.

Another study (Misund and Beltestad, 2000) describes the panic reaction of mackerel confined in a tightened purse seine net:

> *"most of these fish swam around at burst speed and leapt frequently out of the water and up along the net wall to such an extent that the catch seemed to 'boil'."*

Photo credits this page.

1. Credit: Courtesy of South Pacific Commission (SPC). National Oceanic and Atmospheric Administration/Dept. of Commerce.

2. Credit: National Oceanic and Atmospheric Administration/ Department of Commerce. Photographer: Joel Prado.

3. Credit: National Oceanic and Atmospheric Administration/ Department of Commerce.

Chilean jack mackerel caught in a purse seine net

Chilean jack mackerel is caught mainly for processing into fishmeal (Shepherd et al, 2005). Studies in other species (see text) have shown that fish caught in purse seines experience high levels of stress.

Credit: National Oceanic and Atmospheric Administration/ Department of Commerce. Photographer: C. Ortiz Rojas

In a study into slipping in purse seining for sardine off northern Portugal (Stratoudakis and Marçalo, 2002), the authors observed during net slipping:

> *"large concentrations of scales in the water and many fish show evidence of stress (disorientated swimming, gulping for air, etc.)".*

A later study by Marçalo et al (2006) also found that purse seining caused significant stress in this species. Stress levels were measured by sampling fish during the phase of net-tightening and of transferring the fish aboard. Stress levels recorded at the end of the fishing operation were similar to peak values reported elsewhere after acute distress. The researchers found that stress (as evidenced by cortisol and other physiological stress variables) continued to increase with the time spent in the net.

Depending on how the fish are transferred to the deck, they may receive further injury. In brailing, fish are scooped from the seine net by a smaller net, the bottom of which is opened and closed by a drawstring rope, and then dropped on the vessel. Many fish transferred this way will presumably suffer some scale abrasion from contact with the brail net and some compression under the weight of their shoal mates, as well as the stress of removal from water.

Fish pumps are used to transfer fish that are to be turned into fishmeal, sometimes described as "trash" species by the industry, in which case a length of hose is lowered over the side of the boat to the bottom and extent of the seine net (Sainsbury, 1996b). Damage to the fish caused by pumping has less impact on their value when they are destined for processing into fishmeal and fish oil. An operation in which menhaden are pumped aboard a purse seiner is described in the photo library of the National Oceanic and Atmospheric Administration of the United States. As the crowding in the net continues, increasing numbers of fish will float to the surface as they become injured or die. As more fish float to the surface, they become easier to pump (NOAA, 2008a).

Fish pumps are also sometimes used to pump fish destined for human consumption. It is claimed that these pump fish without damaging more than a small percentage (World Fishing, 1977 cited in Gabriel et al, 2005)) but it is not clear how stressful this process is to the fish. According to Gregory (1998), vacuum and turbine pumps

Landing fish using a brail net (NOAA, 2008b)

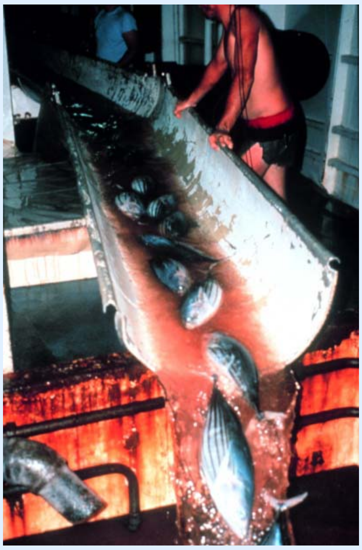
Using a brail net can reduce damage to fish compared with ramping (where the seine net, with the entire catch, is hauled on deck). In the sequence shown above, the fish are immediately frozen. Chilling is a highly aversive experience for fish (Skjervold et al, 2001; HSA, 2005 cited in Stevenson, 2007).

Suffering during capture and landing could be reduced by a well-designed humane handling and slaughter system similar to that used for some farmed species.

1 *The brail net is dipped repeatedly in the seine net, lifting out the fish*

2 *The brail net is then placed directly over the hole in the foreground*

3 *The fish will drop down the chute*



4 *The chute leads directly to the freezer compartments*

5 *Alternative system where fish are transferred directly to a container on deck*

Credits: National Oceanic and Atmospheric Administration/ Dept. of Commerce. Photographers: 1,4 Joel Prado; 2,3,5 Jose Cort

Landing menhaden using a pump (NOAA, 2008a)

Menhaden are caught to make fishmeal and oil. Most of this will be fed to farmed fish, pigs and poultry. Damage to the fish caused by pumping has less impact on their value when they are destined for processing into fish meal and oil. Pumping systems which minimise stress and damage have been devised for farmed fish. These systems could potentially be adapted for use on fishing boats, in combination with humane slaughter technology, to reduce fish suffering.

1 *The menhaden are captured in a two-boat purse-seining operation*

2 *The hose of the pump is lowered inside the seine net*

3 *The net is drawn tighter, crowding the fish closer together*

4 *The increasing compression of the school within the net produces its first casualties. Killed or injured fish float to the surface*

5 *As the net draws tighter, increasing numbers of fish are killed. The floating fish will be easier to pump aboard*

6 *The pump lifts the fish aboard*

7 *The fish are dumped into the hold of the vessel, ready for transportation to the fishmeal plant*

Credits: National Oceanic and Atmospheric Administration/Department of Commerce. Photographer: Bob Williams

Wasted casualties of purse seining

Fish entangled in the seine net are ripped apart as the net is winched in (NOAA, 2008c).

Credit: National Oceanic and Atmospheric Administration/ Department of Commerce. Photographer: Joel Prado

cause more broken fins than brailing, but brailing and turbine pumps cause more skin abrasions than vacuum pumps.

Sometimes the net is hauled on board. If the catch is very large, the entire stern end of the boat can tilt down and the fish are "ramped" up into the boat. This is called ramping and it can be very stressful to the fish, often crushing them (Gallaugher, 2007). A Canadian study found that coho salmon released from purse seines were severely exhausted when landed, but that the "physiological disruption" was greater in fish transferred aboard by ramping compared to brailing (Farrell et al, 2000). The researchers in this study concluded that ramping was more stressful to salmon than brailing. A previous study had found higher death rates in all species of seine-caught salmon with ramping as compared to brailing (J. O. Thomas & Associates Ltd., 1997 cited by Farrell et al, 2000).

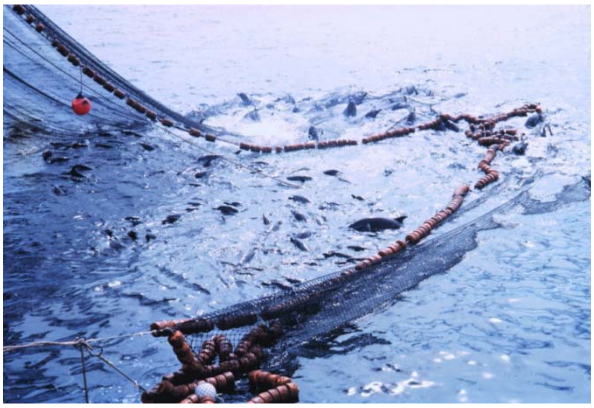
As with other types of fishing, fish caught in purse seines can be attacked by predators during capture (e.g. Mitchell et al, 2002).

7.2 Environmental impacts

Purse seine fishermen identify schools of tuna by keeping watch for associated white water or for dolphins at the surface as tuna often, for reasons unknown, travel with dolphins. Alternatively, fishermen may set out floating objects (logs or rafts, sometimes called fish aggregating devices (or fish attraction devices) or FADs), to attract fish in the open ocean. Again for reasons unknown, some species tend to congregate beneath floating objects and FADs exploit this behaviour. Different methods of locating schools of fish are known as "fishing on schools", "fishing on dolphins" and "fishing on logs".

In the 1980's public outcry was raised by the large numbers of dolphins killed by purse seine tuna fishermen targeting dolphin pods in the eastern Pacific. Historically, the dolphins were hauled on board with the tuna, and discarded, dead or dying, back into the water. As many as 7 million dolphins may have died in this way since the late 1950s (WWF, 2003).

Following a dolphin-friendly tuna certification scheme instituted by the environmental group



Dolphins caught in purse seine net

Dolphins and tuna often swim together, so fishermen deliberately set their nets on these cetaceans to catch tuna. In early tuna purse seining operations, dolphins were consequently often caught as bycatch and killed.

Alternative "dolphin-friendly" methods of catching tuna have been developed. Fish naturally congregate around floating objects and fish aggregating devices (called FADs or logs) are floated in the water to exploit this behaviour. Unfortunately, although this system catches fewer dolphins, FADs result in substantially higher levels of other bycatch animals including turtles, sharks and juvenile tuna which are also attracted to the FADs.

Credit: National Oceanic and Atmospheric Administration/ Department of Commerce

"Earth Island Institute" (EII), fishermen have tended to use FAD's instead. However, FADs attract a wide range of species and setting nets on FADs results in larger numbers of other animals caught as bycatch. Fishing on FADs typically incurs up to 10% bycatch, including dolphin fish, billfish, wahoo, triggerfish, rainbow runners, barracuda, sharks, rays and sea turtles as well as juvenile tunas (EJF, 2005).

Other environmental groups such as Greenpeace and WWF no longer support this dolphin-friendly scheme and endorse a cleaner method of fishing, monitored by an observer programme, which sets on dolphins but allows them to escape before the net is hauled in (Clover, 2005a). Greenpeace UK is currently running a campaign to persuade John West, the UK's largest seller of tinned tuna, to stop selling tuna caught using FADs because of the high levels of bycatch involved (Greenpeace UK, 2008).

The practice of releasing fish from fully tightened purse seine nets, called "slipping", discussed in 7.1 above, probably results in high numbers of unaccounted wasted deaths.

Overfishing and its effects on the marine environment and animal welfare are discussed in 20.2 of chapter 20.

7.3 Reducing fish bycatch numbers and death rates

As discussed earlier, sometimes the catch, or part of it, is deliberately released from a purse seine after the net has been pursed and while both net and fish are still in the water. This process is called "slipping" and may happen frequently e.g. in the sardine fishery off northern Portugal (Stratoudakis and Marçalo, 2002). Unlike the "discard" fish from trawls and gill nets, for example, these "slipped" fish will not have suffered the stress of being removed from the water. However, they will have experienced the process of capture and crowding in the pursed net, which is also stressful. Death rates for slipped fish can be high, as was found in the Lockwood et al study for mackerel discussed above in 7.1.

Some scientists have recommended that net design should allow the quick release of unwanted catch, in order to improve the survival chances for these released fish. The catch should be identified as marketable (to be retained) or not before the net is tightly constricted. The catch can then be released before the school begins regular and violent contact with the net, i.e. the panic escape reaction, where major scale loss can occur (Mitchell et al, 2002). Other scientists propose targeting smaller schools of fish, offering excess catch to other vessels and possibly smaller purse seine nets, as ways to reduce the practice of slipping fish where the quantity of catch exceeds the quota (Stratoudakis and Marçalo, 2002). The practice of slipping fish from tightened purse seine nets has been banned in Western Australia (Mitchell et al, 2002).

Sorting grids might be a possible way to make purse seining more selective, if survival of escapees can be demonstrated. A sorting grid is a rigid grid consisting of bars spaced a few centimetres apart such that fish below a certain size are able to swim through. The grid is positioned within a trawl or purse seine net so as to enable these smaller fish, but not larger ones, to escape the net.

One experimental study in Norway investigated the feasibility of using sorting grids to enable under-sized mackerel and saithe to escape purse seines (Misund and Beltestad, 2000). In Norwegian waters, purse seine catches normally consist of a single species but there are economic reasons for desiring to catch larger fish. Catching larger fish, for the same quota, also reduces suffering by reducing the numbers of fish caught, as discussed in 20.2 of chapter 20. In this study, field experiments were carried out to test the use of sorting grids on a chartered purse seiner. This research concluded that the selection grids were successful for saithe as the mortality of saithe in these experiments was "insignificant". For mackerel, however, a maximum of just 56% survived these experiments, and it was concluded that sorting grids for this species may cause too many deaths. The likely reason for so many mackerel dying after escaping the purse seine net is the greater panic reaction they showed (described in 7.1) when confined within the constricted net, as compared with saithe.

As discussed in 7.1, brailing fish aboard instead of ramping them is likely to reduce the numbers of bycatch fish that die following landing and release from purse seines.

7.4 Possible ways to improve welfare

The use of pumps to transfer farmed fish between cages can cause less stress and injury than other methods of transferring them (Ashley, 2006). In particular, they avoid removing the fish from water. The use and development of fish pumps for use on purse seine ships that involve minimal stress and injury to fish could, perhaps, greatly reduce the suffering during landing, especially if the fish are pumped into a tank of water (rather than air) for humane slaughter.

As discussed in chapter 21, the Wild Salmon Direct Company, which claims to be the only wild salmon producer using humane slaughter technology, uses a pump specifically designed to pump live fish.

The following summarises measures that, combined with humane slaughter immediately the fish is landed, would improve the welfare of fish captured by purse seines:

Reduce the duration of capture

- reduce the duration of the whole capture process
- reduce the time spent in the net once it has been pursed and constricted ready for, and during, landing when the fish are most crowded and vulnerable.

Reduce the numbers of bycatch animals

- avoid fishing on FADs
- use encirclement methods that avoid harm to cetaceans
- use gear modifications shown to reduce bycatch, e.g. sorting grids, without killing the escaping fish
- close fisheries as and when necessary to reduce high levels of bycatch.

Reduce stress and injury to bycatch fish

- reduce the practice of slipping
- for catch to be partially "slipped", do so before the net is tightened ready for landing
- use gears which enable quick release of fish during slipping.

Reduce stress and injury during landing

- avoid the practice of ramping to land fish
- develop and use methods of landing fish which reduce stress and injury, and minimise time out of water e.g. use and development of better pump designs may offer a potential solution
- handle fish carefully prior to humane slaughter (or release as bycatch).

8 Gill nets, tangle nets and trammel nets

Gill net catch being brought in

In some gill net fisheries, fish can remain snared in nets for many hours, or even days.

Credit: NOAA Restoration Center, Chris Doley. National Oceanic and Atmospheric Administration/Dept. of Commerce

A gill net is a wall of netting, hanging in the sea, which is invisible to fish. As fish swim into a gill net, they may be too large to pass completely through the mesh and then become trapped by the gills when they try to reverse out.

Fish may remain snared like this for many hours or even days depending on the "soak time" i.e. the time interval between setting and retrieving the net. Eventually the net is hauled in over roller guides. Snared fish are then pulled out by hand or removed by shaking the net.

Gill nets may be set at or below the surface, on the seabed, or at any depth in between. A number of variations of gill nets exist as follows:

- Tangle nets are similar to gill nets but are slacker, shorter and have less flotation. This results in a looser-hung net that entangles fish rather than snaring them.
- Trammel nets are a wall of net comprising an inner layer of fine mesh and one or two outer layers of a larger mesh. The inner net is looser than the outer ones, ensuring that the fish become entangled within it.
- A drift net is a gill net that is allowed to drift with prevailing currents. An EU wide ban on all drift nets was introduced from January 2002 because of high levels of mammal and other bycatch.

8.1 Animal welfare impact on captured fish

Fish of a certain size, swimming into a gill net, will pass through it only as far as their head and become ensnared as they try to reverse. As the fish struggles to free itself, it may become more entangled, and is likely to experience fear and panic. Constriction of the gills by the netting may also prevent the fish being able to breathe properly. Struggling may result in cuts to the skin and scales. The snared fish may then also suffer attack from predators, leaving it wounded. Fish may remain like this for many hours or even days and a proportion may die before they are landed.

A salmon caught in a gill net

The mesh has cut into the gills.

Credit: National Oceanic and Atmospheric Administration/ Department of Commerce

A juvenile codfish caught in a gill net

As the fish struggles to free itself, it may become more entangled. Constriction of the gills by the netting may prevent the fish being able to breathe properly

Credit: OAR/National Undersea Research Program (NURP). National Oceanic and Atmospheric Administration/Dept of Commerce

One study found high levels of stress (as measured by plasma cortisol levels) in sea bream captured by trammel net under experimental conditions (Chopin et al, 1996). Fish were caught in a trammel net for a period of between 10 minutes and 18 hours. The researchers found that the gill covers of the fish were often held closed by the net, preventing the fish from breathing. 28% of fish died in the net, with the numbers dying increasing with capture duration. The researchers believed that constriction of the gills was a primary factor in this high death rate. The fish were unable to lessen the constriction of the netting around the body either by struggling or by ceasing to struggle. Struggling sometimes caused the fish to re-enter the net mesh, increasing their entanglement. Nor did ceasing to struggle reduce the netting tension around the body because of the elasticity of the netting material (nylon monofilament). Stress levels continued to rise the longer the fish were in the net, even after 12 hours. Another 16% died in the hours or days following release, all of them having incurred open wounds.

This study shows that the suffering caused to fish caught in trammel nets increases with the duration of capture. Stress levels, as evidenced by cortisol levels, were generally higher the longer the period spent in the net. This is as one might reasonably expect and the same thing was found for sardines caught in purse seine nets (see 7.1 of chapter 7). Injury and death rates, too, increased with time in the net. Deep cuts were observed in the trammel-caught fish though not in the first hour of capture, and none of the fish that died did so before 3 hours of capture.

A Canadian study looked at physiological stress in coho salmon captured in commercial purse seine, troll and gill net fisheries. It found that all fish were severely exhausted when landed, regardless of the fishing method. However, the "physiological disruption" was found to be less for gill net fishing with a 30 minute soak time as compared to 60 minute soak times (Farrell et al, 2000).

Another Canadian study, discussed below in 8.3, compared the survival of spring chinook salmon released from gill nets and tangle nets in the Columbia River. Tangle nets have a smaller mesh size and catch fish by the snout rather than by gilling them, allowing the fish to continue respiring and reducing injury. Nearly all the adult chinook salmon caught in 8-inch gill nets had net marks around the body in front of the dorsal fin or around the gills. These tended to be severe and scales were lost. Nearly all the fish caught by tangle nets or the smaller (5.5-inch) mesh gill nets had net marks around the snout which were reportedly less severe as the snout does not have scales (Vander Haegen et al, 2004).

Although tangle nets resulted in lower levels of injury and death as compared with gill nets, damaged fins and seal wounds were found on fish caught in both types of net. There is evidence the fish had been attacked by seals while snared in these nets. As many as 12% of these fish had suffered attack from seals, showing seal wounds, ranging from scars to open wounds, in the 2002 trials. In these trials, seals were seen in the fishing area during half of the sets, and one third of the nets set had fish with seal wounds.

When the gill net is hauled in, the net containing snared fish passes over a roller guide. Some of these fish will still be alive and this may cause further injury to their skin and scales. Loosely attached fish may be gaffed (i.e. their bodies spiked with a hand held hook) to bring them on board (Gregory, 1998). Being impaled on a hook will cause additional pain and distress. Pulling the fish from the net is likely to cause further pain. Fish may also be removed from gill nets by shaking them free.

8.2 Environmental impacts

Sometimes marine turtles, birds, and mammals are tangled in gill nets and drown. Cetacean and bird bycatch can be reduced by use of acoustic devices ("pingers") to make the nets more acoustically "visible" to them. However, seals sometimes prey on fish caught in gill nets and these pingers can attract, rather than deter, seals like a "dinner bell" (Milius, 1999).

Habitat damage can be caused when gill nets anchored to the seafloor are hauled in and become entangled on structures such as coral and rocky bottoms (Monterey Bay Aquarium, 2008).

Overfishing and its effects on the marine environment and animal welfare are discussed in chapter 20.

8.3 Reducing fish bycatch numbers and death rates

The numbers of discard fish that die following release from gill nets will vary between species and fishery. It is likely to be high in some fisheries. Some studies have estimated how many such fish die immediately, or some days later, as a result of gill net capture. Vander Haegen et al (2004) cite estimates ranging from virtually no survival for sockeye salmon, to more than 97% survival in the first 24 hours for coho salmon released; held for a time in revival boxes and then held in net pens. However, the survival chances of fish held in net pens may not adequately represent their survival chances when set free, where they will need to be able to escape predators.

Increasing the mesh size can help reduce the numbers of bycatch fish caught, but larger mesh sizes can also increase the injury to fish actually caught, reducing the survival of released bycatch. This was found to be the case for gill nets compared to smaller meshed tangle nets in the Canadian study of spring chinook salmon by Vander Haegen et al (2004), discussed in 8.1 above and below.

Vander Haegen et al (2004) compared survival of spring chinook salmon released from gill and tangle nets in the Columbia River by tagging and releasing the fish into the wild. They then compared the proportions subsequently recaptured with a tagged and released control group of fish. The control fish had been previously caught by traps (trapping is discussed in chapter 13) and allowed to recover. All these fish were handled more carefully than is the norm for the fishery. Despite careful handling, the number of recaptured fish released from 8-inch and 5.5-inch gill nets was respectively only 51% and 57% that of the control group, suggesting survival chances of around just 51 and 57%. The study found that survival rates of spring chinook salmon was nearly twice as great for those captured in a 4.5-inch mesh tangle net than those caught in a conventional 8-inch mesh gill net, even though the tangle net was as effective at catching fish. The researchers suggested two reasons why tangle nets killed fewer chinook salmon than gill nets. Firstly, the level of injury caused was lower for tangle nets. Secondly, fish caught around the face (as tended to be the case for tangle nets) seemed to struggle less than those caught around the body. They were therefore less likely to be exhausted when released.

In this study, more careful handling of the fish had probably helped to reduce the numbers of released fish that died. More "careful handling" included not touching the gill area or holding fish by its caudal peduncle (tail end). Fishers were instructed to, as far as possible, look over the bow as the net was pulled up so that they could lift fish over the roller. Careful handling presumably also involved taking care not to damage the gills when removing fish from the mesh and not gaffing fish.

The material of the net is likely to have a substantial effect on the injury and subsequent survival of captured fish. Another study into the Kentucky Lake paddlefish gill net fishery in Tennessee found that the number of fish dying in the net was related to the water temperature and twine type, as well as increasing with soak time. Most of the paddlefish (71%) died in the net when the water temperature exceeded 17^{o}C and fish were more likely to die in monofilament nets than in multifilament ones. Because many of these paddlefish caught were bycatch (e.g. smaller than the legal landing size), the results of this research prompted the state regulatory authority to end the fishing season 8 days earlier to avoid warmer temperatures, although they failed to enact a ban on monofilament nets (Bettoli and Scholten, 2006).

Gill nets are frequently caught on the bottom and subsequently lost. Trawl gears also drag and cut the nets into pieces. Lost gill nets may continue to catch fish ("ghost fishing") for several months or even years before they gradually disintegrate (Suuronen, 2005). The problem can be partially addressed by constructing nets from biodegradable materials that deteriorate more quickly and by "retrieval surveys" in which vessels survey fishing grounds to retrieve lost nets (Allsopp et al, 2006). Brown et al (2005) discuss initiatives that can help prevent gear loss and ghost fishing. These include zoning fishing activities to prevent loss of nets caused by trawlers towing through gill nets, and limitations on gear use (e.g. restrictions on net size and soak time). They also include the fitting of acoustic detection devices to nets, which can help fishers locate gears they have lost.

8.4 Possible ways to improve welfare

The following summarises measures that, combined with humane slaughter immediately the fish is landed, would improve the welfare of fish captured by gill, trammel and tangle net fishing:

Reduce the duration of capture

- reduce the time between setting and retrieving the net (the Fair-fish certification scheme (see page 96) limits capture duration to 30 minutes).

Reduce the numbers of bycatch animals

- use gear modifications shown to reduce bycatch e.g. pingers to deter cetaceans
- close fisheries as and when necessary to reduce high levels of bycatch
- use gears and practices that reduce ghost fishing e.g. nets made from biodegradable materials
- survey fishing grounds for, and retrieve, lost and discarded gill nets.

Reduce stress and injury during capture

- use gears that entangle fish rather than gilling them e.g. tangle nets rather than gill nets
- use gear type variations that reduce injury e.g. knotless multifilament nets are preferable to monofilament nets.

Reduce stress and injury during landing

- avoid gaffing fish
- handle fish carefully when landing and removing from nets, prior to humane slaughter (or release as bycatch)
- minimise time spent out of water.

Reduce death rates for released bycatch fish

- avoid fishing in warm-water weather when fish are likely to be particularly stressed.

9 Rod & line and hand line fishing

In hand line and “rod and line” fishing, the fish is caught individually with a hook and line. Hand line fishers don’t use a rod but hold a line in their hand. On some boats, lines are hauled in mechanically. This type of fishing carried out from a moving boat is called trolling (see chapter 10).

9.1 Animal welfare impact on captured fish

As with any other hook and line fishing methods, fish are caught when they snap at baited hooks which then become embedded in the fish’s mouth or elsewhere. Hooking is stressful to fish and causes an alarm response in which they will struggle to become free. As discussed in 10.1 of chapter 10, this can lead to severe exhaustion. As with trolling, hooking fish causes injury which is sometimes severe and likely to cause additional suffering.

Webster (1994 and 2005c) describes experiments by Verheijen et al, at the University of Utrecht, to discover whether carp experience pain and fear when hooked and captured. The experiments involved either:

(1) hooking alone
(2) hooking and “playing” (applying tension to the line)
(3) electrical stimulation to the mouth of free-swimming fish
(4) triggering alarm responses by release of pheromones from damaged skin.

The fish responded rather similarly to all these stimuli, indicating that hooked fish experience fear and pain. When the hook was left in the mouth, but there was no tension on the line, the alarm responses diminished. When the line was pulled and the fish sensed that it was captured, the alarm response was the greatest.

When a fish first becomes hooked it will struggle to escape and will become increasingly stressed. The study into sea bream caught in experimental trammel nets, discussed in 8.1 of chapter 8, also examined the stress response for sea bream caught by hook and line in experimental conditions. This study showed that stress levels were high when measured after 1 hour of capture, and higher still after 3 hours. In contrast to the trammel-caught sea bream, after 3 hours these fish appeared to adapt to their predicament to some extent by ceasing to struggle. By doing so they were able to regain their normal swimming position. Stress levels remained high, but lower than they had been at 1 or 3 hours of capture. Multiplying the duration of capture multiplies the amount of distress, even where the severity remains constant. In long line fishing, discussed in chapter 12, fish remain caught on hooks for long periods of time.

With hand line, and rod and line fishing, fish are generally landed soon after capture. Keeping the time from when the fish is hooked until it is landed as short as possible, by continuous monitoring of the gear, will clearly reduce the suffering. Even with short durations, welfare during capture will be poor. According to Broom (1999b):

> *“Since the mouth of most fish is richly innervated with sensory receptor cells, fish have a very similar pain and adrenal system to those of birds and mammals (Matthews & Wickelgren 1978, Pickering 1981, 1989a,b) and fish will learn to avoid places where they have had unpleasant experiences including*

those in which they received tissue damage from hooks (Ingle 1968, Verheijen & Buwalda 1988) it is clear that fish welfare is poor when they are caught on hooks and when they are removed from water, even for a short period."

The duration of being reeled in is likely to be more stressful for the fish than when there is no tension in the line attached to hook. Sport fisherman often prolong this time by "playing" the fish to watch it struggle, and this is likely to cause additional fear, distress and exhaustion.

Live fish are sometimes used as bait in all forms of hook and line fishing. This hugely adds to the welfare cost of this method and is discussed in chapter 15.

Hand line and "rod and line" fishing has the potential to be relatively humane, so long as artificial baits (or fish off-cuts) are used for bait rather than purpose-caught bait fish. The capture duration is relatively short and the fish can be humanely killed with a priest on landing.

9.2 Environmental impacts

Conservation groups consider rod and line, or hand line, fishing to have low levels of bycatch relative to other major fishing methods e.g. WWF Canada (WWF-Canada, 2008). Although bycatch is relatively low and fish can be released quickly in this fishing method, some of those that are caught and released will die as a result of the experience, as discussed in 9.3 below.

Overfishing and its effects on the marine environment and animal welfare are discussed in chapter 20.

9.3 Reducing fish bycatch numbers and death rates

There has been some research to investigate survival rates for released bycatch in hook and line fishing, including recreational "catch and release" fishing. Estimates of death rates for fish caught by hook, and subsequently released, show wide variation. Death rates of less than 3% in the first 4 days following release were reported for esox sp. (pike) released by anglers (Schwalme and MacKay, 1985 cited by Chopin and Arimoto, 1995). Much higher death rates of 40-86% were estimated for released troll-caught chinook salmon (Parker et al, 1959 cited by Chopin and Arimoto, 1995).

The size and species caught in hook and line fishing is partly determined by the hook size and bait type**.** The injury and survival chances for a released fish are affected by the type and size of the hook and bait (Cooke and Sneddon, 2007). These affect where and how deep the hook penetrates.

Some scientists have recommended ways in which "catch and release" fishers can reduce stress in fish and so increase their survival chances. For example, the "Guide to ethical angling" (New Jersey Marine Sciences Consortium, 2004) recommends use of circle hooks (the name denotes the shape of hook which is more circular than the J-shaped hook), in which the point is turned inward, rather than j hooks so that the fish is more likely to be hooked around the mouth than in the stomach, throat or vital organs.

Cooke and Sneddon make several recommendations for improving the welfare and conservation of fish in catch and release angling (Cooke and Sneddon, 2007) and these are discussed briefly in 22.1 of chapter 22. They recommend the use of barbless hooks because they are easier to remove and suggest that barbless circle hooks may be a good alternative in "catch and release" fishing.

Further wounding may be caused during removal of the hook and so the method used for this is also important. Fish removed from hooks by hand in a way that tries to take the hook out the same way it went in, suffer less resulting injury than fish removed by automatic means that tear the hook out. In a study of Pacific halibut caught as bycatch in long lining (long line fishing is discussed in chapter 12), fish were more likely to suffer severe injury to the cheek, jaw and face if the hook was torn out automatically than if it was removed carefully by hand. Careful removal by hand more than doubled the survival chances for released fish. Of the fish for which the hook was torn out, those that did survive suffered decreased growth rates in the years following release, as compared to the carefully handled fish (Kaimmer, 1994). According to this study, the use of automatic hook strippers has been banned in the commercial fishery for halibut on the Pacific coast of the USA and Canada.

A study into the survival of under-sized Atlantic cod released from the Northwest Atlantic long line fishery similarly found that survival rates were greater when the hook was removed by hand rather than torn out automatically. This study found that depth and temperature also had an effect on survival (Pappalardo et al, 2006 reviewed in New England Fishery Management Council, 2008):

> "*Survival improved as depth and sea surface temperatures decreased*".

Many factors affect the ability of a fish to cope with being hooked. These include the species and size of the fish, the temperature and depth of the water, the type and size of the hook and bait and how the hook is removed (Suuronen, 2005). Fishing at warm temperatures and at greater depths (causing the fish to experience sudden changes in pressure) can increase the stress of capture and handling (Cooke and Sneddon, 2007). Smaller fish seem to cope less well (see 10.3 of chapter 10 on trolling).

9.4 Possible ways to improve welfare

This fishing method has the potential to be relatively humane because it is relatively fast. The following summarises measures that, combined with humane slaughter immediately the fish is landed, would improve the welfare of fish captured by rod and line, and hand line, fishing:

Reduce suffering of bait fish
- avoid the use of live fish as bait
- avoid the use of bait fish generally (use artificial baits or off-cuts instead).

Keep the duration of capture short
- monitor gear and land fish immediately they become hooked (the Fair-fish certification scheme (see page 96) limits capture duration to 5 minutes for fish caught by hook).

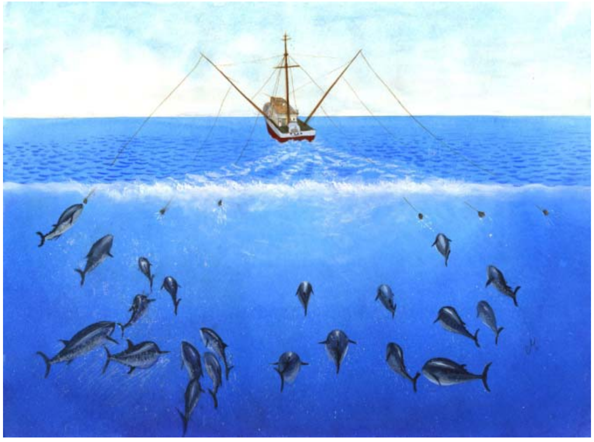
Reduce the numbers of bycatch animals
- use hooks and baits that reduce bycatch.

Reduce stress and injury during capture
- use hooks than cause less injury e.g. barbless circle hooks
- avoid fishing from depths greater than 20m (for fish with swim bladders).

Reduce stress and injury during landing
- handle fish carefully when landing prior to humane slaughter (or release as bycatch)
- minimise time spent out of water
- remove hooks after fish are humanely slaughtered or stunned, rather than before (as required by Fair-fish certification)
- carefully remove hooks from fish to be released
- avoid gaffing fish.

Reduce death rates for released bycatch fish
- avoid fishing in warm-water weather when fish are likely to be particularly stressed.

10 Trolling



Artist's conception of tuna trolling operation

In trolling, lines bearing baited hooks or lures are towed through the water by a slow moving vessel. Caught fish are landed quickly.

Sometimes fish are gaffed with a hook to land them. Live fish are sometimes used as bait. These practices increase the suffering caused.

Credit: National Oceanic and Atmospheric Administration/Department of Commerce

In trolling, lines bearing baited hooks or lures are towed through the water by a slow moving vessel. The fish are hauled in after becoming hooked.

10.1 Animal welfare impact on captured fish

Hooking is stressful to fish and invokes an alarm response as discussed in 9.1 of chapter 9. This can lead to severe exhaustion. Hooking also causes injury which is sometimes severe and likely to cause additional suffering. Sometimes fish are gaffed (i.e. impaled on a hook) to bring them aboard (Gregory, 1998).

As discussed in 8.1 of chapter 8 on gill nets, a Canadian study into the physiological stress in coho salmon captured in commercial fisheries found that troll-caught fish were severely exhausted when landed (Farrell et al, 2000). Fish can also be fatally injured by hooking. In a study discussed in 10.3 below, it was found that many troll-caught fish became hooked in locations other than the mouth, and that this increased the likelihood of fatal wounding, especially if the gills were damaged. 4% of the fish were hooked through the gills and 23% through the eye (Gregory, 1998 based on Wertheimer et al, 1989).

Because the capture duration is short, trolling has the potential to be relatively humane if the use of bait fish, especially live ones, is avoided and if the fish are killed by a priest or spiking as soon as they are landed.

10.2 Environmental impacts

As with rod and line fishing, conservation groups consider trolling to have low levels of bycatch relative to other major fishing methods e.g. WWF Canada (WWF-Canada, 2008). Although bycatch fish can be released quickly, some released fish will die as a result of the experience, as discussed below.

Overfishing and its effects on the marine environment and animal welfare are discussed in chapter 20.

10.3 Reducing fish bycatch numbers and death rates

As discussed for rod and line fishing, the size and species caught is partly determined by the type/size of hook and bait, which also affect the survival chances of released fish.

Wertheimer (1988) studied death rates for chinook salmon caught incidentally by commercial trolling in Alaska and subsequently released. This study refers to previous reviews of published and unpublished data proposing estimates of hooking mortality for this species at 30% (Wright, 1970), 38% (Horton and Wilson-Jacobs, 1985) and 50% (Ricker, 1976).

A later study of Alaskan trolled chinook salmon (Gregory, 1998 based on Wertheimer et al, 1989) found that a fish's chance of survival was affected by how it became hooked. Of the fish for which the hook penetrated the snout, corner of the mouth or maxillary (upper jaw), respectively 5%, 7% and 8% died within 6 days. Of the fish for which the hook penetrated the lower jaw, cheek, eye or isthmus (throat), this figure was respectively 12%, 16%, 21% and 35%. For fish hooked through the gills, 85% died.

Wertheimer et al (1989) found that smaller fish may cope less well with being hooked than those of legal capture size. They estimated the death rate for released troll-caught chinook salmon to be 18.5 – 26.4% for fish of legal capture size and 22.0-26.4% for smaller fish. The earlier study (Wertheimer, 1988) found that the hooking location seemed to be affected by the type of lure.

Using types of hook and bait that reduce the incidence of hooking injury would both serve fish conservation and help reduce suffering. The impact of hook type, method of hook removal, water depth and temperature on survival of fish released from hooks are discussed in 9.3 of chapter 9.

10.4 Possible ways to improve welfare

The following summarises measures that, combined with humane slaughter immediately the fish is landed, would improve the welfare of fish captured by trolling:

Reduce suffering of bait fish

- avoid the use of live fish as bait
- avoid the use of bait fish generally (use artificial baits or off-cuts instead).

Keep the duration of capture short

- monitor gear and land fish immediately they become hooked (the Fair-fish certification scheme (see page 96) limits capture duration to 5 minutes for fish caught by hook line).

Reduce the numbers of bycatch animals

- use hooks and baits that reduce bycatch.

Reduce stress and injury during capture

- use hooks that cause less injury e.g. barbless circle hooks.

Reduce stress and injury during landing

- handle fish carefully when landing prior to humane slaughter (or release as bycatch)
- minimise time spent out of water
- remove hooks after fish are humanely slaughtered or stunned, rather than before (as required by Fair-fish certification)
- carefully remove hooks by hand for fish to be released
- avoid gaffing fish.

Reduce death rates for released bycatch fish

- avoid fishing in warm-water weather when fish are likely to be particularly stressed.

11 Pole & line fishing

“Pole and line” fishing usually means a particular type of rod and line fishing in which fish, such as tuna, are attracted to the surface with bait fish. The fishers locate a school of fish and then create a feeding frenzy by scattering small bait fish (e.g. anchovies or sardines), usually alive, over the side of the vessel. In this feeding frenzy, the fish snap at barbless hooks attached to the fishers’ rod and lines. When a fish becomes hooked the fisher swings the rod, bringing the fish flying onto the deck behind and disengaging it from the lure.

11.1 Animal welfare impact on captured fish

Hooking is stressful to fish, invokes an alarm response and can result in exhaustion and fatal injury, as discussed chapters 9 and 10. In this fishing method, the fish is quickly landed by being swung onto the deck. The fish is likely to suffer further fear and pain by being pulled out of the water and thrown onto the deck, but the whole process of capture and landing is one of short duration.

The process of throwing bait fish overboard is called “chumming”, and it usually involves live bait fish. Occasionally minced bait, prepared from frozen sardines or similar fish in a hand mincer, is used in place of live bait for chumming (Sainsbury, 1996c). Normally bare hooks or jigs (artificial lures) are used on the lines, but hooks may be baited with live bait (Sainsbury, 1996d) to encourage fish to bite. The use of live bait fish, in this way and in chumming, hugely adds to the welfare cost of this fishing method, as discussed in chapter 15.

From the point of view of the target fish (as opposed to the bait fish) this may be one of the most humane methods of catching fish on account of the short duration of capture.

Artist's conception of pole and line fishing

In “pole and line” fishing, a feeding frenzy is created in a school of fish such as tuna by scattering bait fish, e.g. anchovies and sardine, usually alive, over the side of the vessel. In this feeding frenzy, the fish snap at barbless hooks attached to the fishers’ rod and lines. When one fish is hooked, the rest of the school may follow the hooked fish to the side of the fishing vessel (NOAA, 2008d).

This system is often considered relatively humane since the fish remain on the hook for a very short time and there is little bycatch. However, the bait fish are likely to suffer confinement of a long duration, and considerable fear and distress after release.

Credit: National Oceanic and Atmospheric Administration/Department of Commerce

Pole and line fishing

Chumming with bait fish (1 and 2)

1 Small bait fish, usually alive, are thrown overboard to create a feeding frenzy in a school of fish.

2 Water is sprayed to prevent the tuna from noticing the activity on deck.

Notice the gaff hook used to impale the caught tuna to bring them aboard.

Landing the fish (3 and 4)

3 Bigeye tuna caught by pole and line fishing.

The fish are quickly landed.

4 Gaffing. Sometimes fish are impaled on gaff hooks to bring them aboard.

Photo credits this page.

1. National Oceanic and Atmospheric Administration /Dept. of Commerce. Photographer: Jose Cort.
2. and 4. Courtesy of United Nations Food and Agriculture Organization. Photographer: Andrey Urcelayeta. National Oceanic and Atmospheric Administration/Department of Commerce.
3. National Oceanic and Atmospheric Administration/Department of Commerce. Photographer: Bernard Frink, BCF

11.2 Environmental impacts

Conservation groups consider pole and line fishing to have low levels of bycatch relative to other major fishing methods. The wildlife conservation organisation WildAid cites the Western Pacific pole and line fishery for tuna which limits bycatch to less than 1% total catch (WildAid, 2001). Overfishing and its effect on the environment and animal welfare are discussed in chapter 20.

11.3 Reducing fish bycatch numbers and death rates

As fish are landed soon after becoming hooked, unwanted catch can be released quickly.

Because bycatch is relatively low, less has been written about discard survival in pole and line fishing compared to other fishing methods. Survival chances of released fish are considered to be high due to the use of barbless hooks and the quick release from them (IUCN, 2008). It is not clear to what extent survival chances are affected by injury and stress caused by being thrown onto the deck.

11.4 Possible ways to improve welfare

The following summarises measures that, combined with humane slaughter immediately the fish is landed, would improve the welfare of fish captured in pole and line fishing:

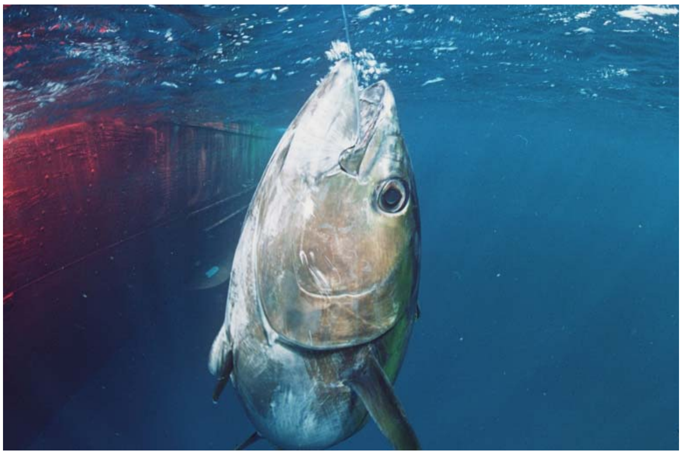
Reduce suffering of bait fish

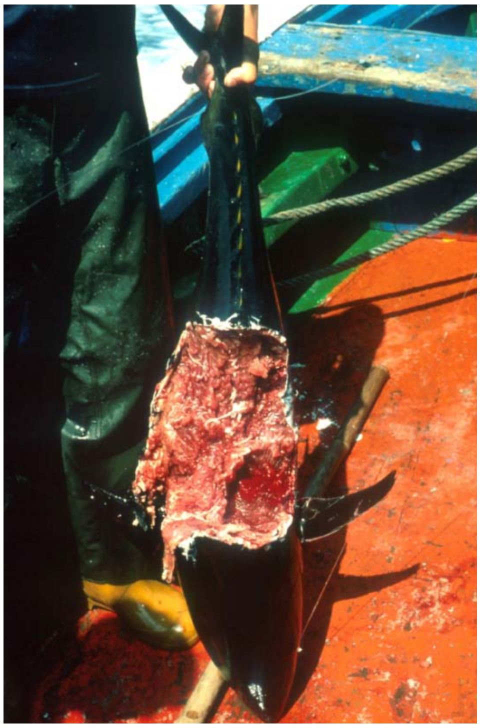
- avoid the use of live fish as bait
- avoid the use of bait fish generally (use fish off-cuts and artificial baits instead).

Reduce stress and injury after landing

- handle landed fish carefully prior to humane slaughter (or release as bycatch)
- avoid use of gaffs
- minimise time spent out of water.

12 Long line fishing





Above: A big-eye tuna caught on a long line

Unlike other hook and line methods which are fast, in long line fishing the fish may remain captured for many hours, or even days.

Credit : © Greenpeace / Jeremy Sutton-Hibbert

Above right: A bluefin tuna attacked by a shark while being landed

Fish caught in commercial fishing can effectively become live bait for predators while caught on lines or in nets. This tuna was attacked by a shark during capture. In this case, the fishing method was pole and line fishing carried out by scientists for tagging and release.

Credit: National Oceanic and Atmospheric Administration/ Department of Commerce. Photographer: Jose Cort.

Long line fishing, or long lining, is a commercial fishing method that uses hundreds or even thousands of baited hooks hanging from a single line. In this method of fishing, it is common for live fish to be used as bait. A semi-automatic machine impales the live fish on hooks as the line is played out (Gregory, 1998). Fish caught on long lines are landed hours, or days, later when the gear is hauled up.

A long line may be 50-100km in length (FishOnline, 2008a). Short lengths of line carrying baited hooks are attached at intervals. The lines may be set vertically in the water column, or horizontally along the bottom.

A study of the Northwest Atlantic long line fishery reported that this fishery does not soak the gear in the traditional sense and that the soak time is only as long as it takes to get the gear back after setting it. As such, the soak time is always “brief”, ranging from 1-4 hours (Pappalardo et al, 2006 reviewed in New England Fishery Management Council, 2008). It would therefore appear that shorter soak times of around an hour are possible in this type of fishing.

12.1 Animal welfare impact on captured fish

Hooking is stressful to fish, invokes an alarm response and can result in exhaustion and fatal injury, as discussed in chapters 9 and 10. Unlike other hook and line fishing methods discussed in this report, the duration of capture for long line fishing is very long, lasting many hours or even days. The use of live bait hugely adds to the welfare cost of this method (see chapter 15).

As with gill netting, the fish caught on long lines effectively become live bait themselves and may then be attacked by predators. Halibut hooked and tethered on long lines for long periods of time can be attacked and killed by small parasitic crustaceans commonly known as sand fleas (Trumble et al, 2000). Some fish, for example most skipjack tuna (Ward et al, 2004) will be landed dead.

The fate of many sharks, including those caught as bycatch on long lines, is to be "finned". Their fins are cut off and they are thrown back into the sea, often still alive (Wildaid, 2001).

12.2 Environmental impacts

Long lines kill sea birds, sea turtles and sharks, as well as other non target fish, which are attracted by the bait. Sea birds like albatross get hooked when the lines are near the surface. The birds are then dragged under water and drowned. Bird bycatch can be reduced by measures such as bird-scaring devices and weighting the lines to make them sink more quickly. US fishermen can avoid the migratory paths of sea turtles by sinking their long lines deeper (Monterey Bay Aquarium, 2008).

Long line fishing catches more sharks as bycatch than any other fishing method in international waters. In 1990 it was estimated that Japanese long liners in Tasmanian waters were catching 34,000 blue sharks a year, finning and discarding them. This practice of "finning" sharks (see 12.1 above, wastes 95-99% of the animal. Although banned in a number of fisheries, it is a common practice (Wildaid, 2001).

Overfishing and its effect on the marine environment and animal welfare are discussed in chapter 20.

Turtle caught by a Spanish long line

Long lines kill sea birds, sea turtles and sharks, as well as other non target fish, which are attracted by the bait.

Credit: © Greenpeace / Steve Morgan

A wandering albatross killed by a Japanese long line

Sea birds like albatross get hooked when the lines are near the surface. The birds are then dragged under water and drowned.

Credit: © Greenpeace / Dave Hansford

12.3 Reducing fish bycatch numbers and death rates

According to the Sea Turtle Restoration Project (2003) large numbers of bycatch fish are caught and thrown back dead:

> *"U.S. Atlantic longline fleet in 1993 caught 362,138 fish; nearly half, 174,819, were discarded because they were unmarketable. Most were already dead. This is typical of long line fishing worldwide."*

The impact of hook type, method of hook removal, water depth and temperature on survival of fish released from hooks are discussed in 9.3 of chapter 9. The impact of hooking location is discussed in 10.3 of chapter 10.

12.4 Possible ways to improve welfare

The following measures, combined with humane slaughter immediately the fish is landed, would improve the welfare of fish captured by long lines:

Reduce suffering of bait fish

- avoid the use of live fish as bait
- avoid the use of bait fish generally (use artificial baits or off-cuts instead).

Reduce the duration of capture

- reduce the time between setting and retrieving the lines (the Fair-fish scheme (see page 96) limits capture duration to 5 minutes for fish caught by hook).

Reduce the numbers of bycatch animals

- use practices shown to reduce bycatch e.g. bird-scaring devices
- use hooks and baits that reduce bycatch
- close fisheries as and when necessary to reduce high levels of bycatch.

Reduce stress and injury during capture

- use hooks that cause less injury e.g. circle hooks
- avoid fishing from depths greater than 20m (for fish with swim bladders).

Reduce stress and injury during landing

- avoid gaffing fish
- handle fish carefully when landing prior to humane slaughter (or release as bycatch)
- minimise time spent out of water
- remove hooks after fish are humanely slaughtered or stunned, rather than before (as required by Fair-fish certification)
- carefully remove hooks by hand for fish to be released.

Reduce death rates for released bycatch fish

- avoid fishing in warm-water weather when fish are likely to be particularly stressed.

13 Trapping

A wire fish trap

Fish traps include a variety of designs of cages. This wire fish trap has been set by marine scientists to collect reef fish.

Credit: OAR/National Undersea Research Program (NURP); Caribbean Marine Research Center. National Oceanic and Atmospheric Administration/Department of Commerce

Trapping is a fishing method in which fish may be trapped alive and uninjured as they swim into baited cages.

13.1 Animal welfare impact on captured fish

Although fish caught by traps can be caught without injury, confinement may be distressing to fish. Trapped fish are likely to be frightened when potential predators approach the trap, and are sometimes attacked by predators entering it.

A New Zealand study investigated the stress caused to blue cod by trapping, and how this might be reduced in order to improve flesh quality (Cole et al, 2003). When scuba observers approached the pots the fish often "*panicked and hurled themselves into the netting repeatedly*".

In this research, the baits used were pilchards and paua (edible sea snail) guts. Interestingly, the use of paua guts instead of pilchards for bait was found to decrease the bycatch. The welfare cost of this method is reduced the bait comes from waste rather than purpose killed animals.

Modifications to the traps enabled them to be hauled in within a bag, with the trap still surrounded by a reservoir of water. Fish caught in this way were constantly immersed in water during capture and landing, and killed by spiking (a humane method of killing if performed correctly (see chapter 18)) within 2.5-3.5 minutes of landing. However, these fish still suffered more fatigue (as indicated by pH, lactate and ATP levels in the white muscle[3]) than a control group of captive fish killed using a low-stress method involving careful handling and anaesthesia with AQUI-S (see chapter 18).

Green moray eel preys on other trapped fish

Fish traps aim to catch fish alive and uninjured. However, fish can be killed by trying to escape and by predators, such as this green moray eel, entering the trap. Distress, injury and death rates are likely to be reduced by shorter time intervals between setting and retrieving traps.

Credit: OAR/National Undersea Research Program (NURP); National Marine Fisheries Service-- Galveston Lab. Photographer: G. Gitschlag. National Oceanic and Atmospheric Administration/Department of Commerce.

[3] When teleost fish are severely stressed and exercised to exhaustion, they make extensive use of their 'white' muscle system (Medway, 1980).

13.2 Environmental impacts

Conservation groups consider trapping to have low levels of bycatch relative to other major fishing methods e.g. WWF Canada (WWF-Canada, 2008).

Marine mammals can become entangled in the lines connecting the traps to the buoys. Traps may damage the seabed when large ocean swells and tides bounce the gear around. Hauling in a row of traps may also drag the cages along the seafloor and cause damage (Monterey Bay Aquarium, 2008). Overfishing and its effect on the marine environment and animal welfare are discussed in chapter 20.

13.3 Reducing fish bycatch numbers and death rates

Traps catch fish live and so bycatch fish species can often be released uninjured if the traps are emptied frequently. However, it is reported that in many tropical or subtropical fisheries where there is a wide range in species and size, many fish are likely to become gilled as they try to escape from the trap (FishOnline, 2008a).

Bycatch fish caught in traps can become injured from attempting to escape the trap, from decompression as traps are lifted to the surface to land fish, from handling during landing and from predators, such as moray eels, that enter the trap and prey on fish before the traps are hauled in (Bohnsack et al, 1989).

Traps can become lost and can continue “ghost fishing”. They can be fitted with time release panels to stop them fishing after a period of time has elapsed (Suuronen, 2005). Bycatch can be reduced by choice of mesh size. Openings can be included in the traps to release undersized fish.

13.4 Possible ways to improve welfare

The following measures, combined with humane slaughter immediately the fish is landed, would improve the welfare of fish captured in traps:

Reduce suffering of bait fish

- avoid the use of fish as bait (use off-cuts instead).

Reduce the duration of capture

- reduce the time between setting and retrieving the trap (the Fair-fish certification scheme (see page 96) limits capture duration to 30 minutes.

Reduce the numbers of bycatch animals

- use baits and mesh sizes that reduce bycatch
- use gear modifications to allow under-sized animals to escape
- use gear modifications and practices that reduce ghost fishing e.g. time release panels.

Reduce stress and injury during capture

- use gear designs that cause less stress e.g. modifications to keep the trap enclosed by water as it is retrieved
- avoid fishing from depths greater than 20m (for fish with swim bladders).

Reduce stress and injury during landing

- handle fish carefully when landing prior to humane slaughter (or release as bycatch)
- minimise time spent out of water.

14 Harpooning

A harpoon is a barbed spear fired at a fish and this fishing method is used to catch large species such as swordfish. When the fish has been struck and the harpoon takes hold, the fish is allowed to swim until exhausted. Once exhausted, it is secured in a sling and hoisted aboard (Gregory, 1998).

14.1 Animal welfare impact on captured fish

Harpooned fish will suffer fear and pain from being harpooned. The fish will become exhausted as they try to escape.

14.2 Environmental impacts

As with whaling, harpooning fish raises serious welfare concerns but is considered to result in relatively low levels of bycatch since the fish are identified before the harpoon is fired.

Overfishing and its effect on the marine environment and animal welfare are discussed in chapter 20.

14.3 Possible ways to improve welfare

As with all other methods of fishing, welfare could be improved by landing fish quickly and followed immediately by humane slaughter.

15 Use of live bait fish in fish capture

Bait fish being transferred to a pole and line fishing vessel for use as live bait

Credit: National Oceanic and Atmospheric Administration/ Department of Commerce

Tank holding live bait on a tuna boat

Bait fish are held in a tank for days, or weeks, until they are fed live to tuna. Use of dead, rather than live, fish as bait in pole and line fishing is the exception rather than the rule (FishOnline, 2008a).

Credit: National Oceanic and Atmospheric Administration/ Department of Commerce. Photographer: Jose Cort.

Live fish are sometimes used as bait in all hook and line methods, commonly in longlining and nearly always in pole and line fishing. This is likely to cause considerable suffering over and above that caused to the fish caught for food.

These bait fish will have suffered fear and distress caused by capture and confinement, possibly for days or weeks, before they are impaled on hooks or scattered live amongst shoals of tuna. Death rates of bait fish held in tanks for pole and line fishing can be high before baiting even starts. Fatal shock and injury can be caused by handling and crowding (Hester, 1974).

Fish are likely to be frightened further when dropped into the open sea, an unfamiliar environment to those originally caught in shallow water or reefs, in the practice of "chumming" (see 11.1 of chapter 11 on Pole and line fishing). Gregory explains (1998):

> *"Typically the live bait remains motionless for several seconds upon hitting the water, and then it swims underneath the hull for protection…After the initial catch, the vessel is eased forward to flush out the live bait from under the hull and a second catch follows."*

Live fish that are impaled on hooks as bait, as is common in long line fishing, will then suffer pain and distress from tissue damage. They are likely to suffer fear from being immobilised and unable to escape predators.

Baiting a hook with a live fish

This fish is alive and being impaled on a hook to use as bait in pole and line fishing, a practice considered by many to be an abuse of sentient animals.

Credit: National Oceanic and Atmospheric Administration/ Dept. of Commerce. Photographer: Etienne Ithurria.

The animal protection group Animal Concern has described the use of live bait fish in recreational fishing (Robbins, 2006):

> *"What is not natural is attaching treble hooks on wire traces to the lip and back of live roach or small trout and casting them out to lure pike. Any angler who has used this fishing method, as I did as a child, will know that the first indication of a take is when the float is dragged at great speed by the terrified bait fish as it is chased by the pike. If not taken the bait fish will eventually die and be replaced by another."*

The suffering caused during fish capture could clearly be greatly reduced by avoiding the use of live bait, preferably using artificial baits or fish off-cuts instead. It is not normally considered acceptable practice to feed live animals to other animals as, for example, in zoos.

16 Summary of improving welfare during capture & landing

Methods of fishing that are potentially more humane are the ones most likely to land fish alive. This is only a clear advantage to the fish if they are swiftly and humanely slaughtered. Measures to reduce the suffering in capture may not improve welfare if death remains slow, especially if preceded by gutting, filleting or freezing. Humane slaughter is discussed in chapter 18.

The extent of suffering caused to fish will vary within and between different methods of fishing. For a relative measure of suffering both the severity and duration of suffering are considered, as discussed in chapter 1. To assess the welfare of wild fish during capture, the whole process must be examined including:

- the duration and severity of suffering during both capture and landing
- the welfare impact on bait fish
- the extent and impact on bycatch
- other unintended effects such as predator attack on caught fish and ghost fishing.

The key welfare problems and assessment of the welfare potential for each method are summarised in Table 2.

All types of fishing are stressful to fish but stress and injury can be reduced by shorter capture duration. The longer a fish remains captured, the longer the period of suffering. The severity of suffering is also likely to increase with capture time, as was found to be the case for sardines caught in seine nets (7.1 of chapter 7) and sea bream caught in experimental trammel nets (8.1 of chapter 8). The fastest capture methods are fast hook and line ones. However, where dead or alive bait fish are used, these methods can only be as humane as the treatment of these fish. Fast hook and line fishing methods which use artificial baits (or baits made from waste) seem to be among the potentially most humane methods. Trapping, which can catch fish without injury, may have a greater humane potential than fast hook and line methods if soak times are short.

The distress caused to fish caught in gill nets for periods of several hours may be greater than for fish caught on long lines for a similar duration. As discussed in chapter 8, one study compared the stress, injury and death rates experienced by sea bream caught in trammel nets (a variation of gill net) to those caught by hook and line under experimental conditions. While the fish caught on hooks were able to regain a normal swimming position by ceasing to struggle, for those caught in trammel nets neither struggling nor ceasing to struggle lessened the constriction of the netting. The fish caught in trammel nets suffered open wounds from the netting and many died in the net, apparently from suffocation caused by constriction of the gills. Injury and death rates, like stress, increased with time in the net, and deep cuts and mortality were not observed in the first hour of capture.

Methods that catch fish alive, with minimal injury and with capture durations in minutes rather than hours are potentially relatively humane (or at least relatively more humane). Gill net fishing (or variations of it such as fishing with tangle nets) with a short capture duration of no more than 1 hour may achieve this and is permitted in the Fair-fish welfare certification scheme (see page 96),

Table 2. Summary of the welfare impact of different fishing methods

	Key welfare problems:	Duration	Bycatch problems	Measures that would reduce suffering (when combined with humane slaughter)	Overall welfare potential with these measures (when combined with humane slaughter)
Trawling	*Chase to exhaustion; Fear caused by capture; Injury from collisions with net and other fish; Compression in mass of other fish; Decompression effects; Removal from water during landing.*	*Several hours.*	*High levels of bycatch.*	*Humane slaughter as soon as landed; Reduced trawl duration; Effective bycatch reduction devices and measures; Handle fish carefully prior to humane slaughter or release as bycatch; Avoid fishing from depths > 20m.*	*Suffering could be greatly reduced but injury and compression of fish will inevitably be caused. Some fish species caught from deep water will inevitably suffer decompression.*
Purse seining	*Fear caused by capture; Stress caused by crowding of fish in a tightened net; Injury from collisions with net and other fish during net tightening; Removal from water during landing; Compression, broken fins and scale damage during landing; Possible predator attack during capture.*	*Entire operation may be 2 hours or more. Duration of the most stressful period when net is tightened and fish cannot school may be less than 1.5 hours.*	*Setting seine nets on fish aggregating devices (FAD's) results in large numbers of bycatch animals. Setting seine nets on cetaceans potentially harms dolphins and porpoises. Releasing fish from fully tightened purse seine nets, called "slipping", results in high numbers of wasted deaths.*	*Humane slaughter as soon as landed; Reduced time spent in net, especially in the tightened net; Develop systems, e.g. pumps, which land fish with less stress and injury; Avoid fishing on FAD's; Avoid setting on cetaceans unless they are released unharmed; End, or modify, the practice of "slipping" to avoid wasteful deaths of excessive catch.*	*Suffering could be greatly reduced. A well designed system for transferring fish onto deck, with reduced stress and injury could make this a relatively humane method.*

Table 2. Summary of the welfare impact of different fishing methods (continued)

Gill netting	*Fear caused by capture; Constriction of gills by netting preventing breathing; Injury from entanglement in netting; Increasing levels of stress and injury with time spent in the net; Removal from water and injury during landing; Possible predator attack during capture.*	*Several hours or days. Can be less than 1 hour in some cases (e.g. Columbia River, Canada).*	*Mammals, seabirds and turtles can be entangled in these nets and drown. Ghost fishing.*	*Humane slaughter as soon as landed; Reduced time spent in net; Handle fish carefully prior to humane slaughter or release as bycatch; Use nets that entangle rather than gill fish; Use netting materials that reduce injury; Effective measures and gears to reduce bycatch and ghost fishing e.g. pingers; Avoid fishing in warm-water weather.*	*Suffering could be greatly reduced. Short soak times not more than 30 minutes, as in Fair-fish scheme, and careful handling could make this a relatively humane method.*
Hook and line: **Pole & line**	*Use of live bait fish for chumming in most cases; Use of live bait fish impaled on hooks sometimes; Fear and stress during hooking and swinging the fish aboard; Possible predator attack during capture.*	*Very short.*	*Bycatch is relatively low.*	*Avoid the use of live bait fish, preferably avoiding purpose-caught bait fish; Humane slaughter as soon as landed; Handle fish carefully prior to humane slaughter (or release as bycatch).*	*Could be a relatively humane method. Only as humane as the capture and killing of any bait fish used.*
Hook and line: **rod & line and trolling**	*Use of live bait fish impaled on hooks sometimes; Fear and stress during hooking and landing the fish; Minor to major injuries caused by the hook, depending on where it embeds; Decompression effects; Possible predator attack during capture.*	*Fish are landed quickly.*	*Bycatch is relatively low.*	*Avoid the use of live bait fish, preferably avoiding purpose-caught bait fish; Humane slaughter as soon as landed; Keep the time for which a fish remains hooked as short as possible; Handle fish carefully prior to humane slaughter (or release as bycatch); Use hooks that reduce injury and remove them carefully from fish to be released; Avoid fishing from depths > 20m. Avoid fishing in warm-water weather.*	*Could be a relatively humane method. Only as humane as the capture and killing of any bait fish used.*

Table 2. Summary of the welfare impact of different fishing methods (continued)

Hook and line: long line fishing	*Use of live bait fish impaled on hooks common; Fear and stress during hooking and landing the fish; Minor to major injuries caused by the hook, depending on where it embeds (e.g. lip, throat, eye, gills); Decompression effects; Possible predator attack during capture.*	*Many hours or even days. A fishery which appears to have a minimal soak time for a fishery of this type is the Atlantic Cod long line fishery of the Northwest Atlantic. Capture duration for this fishery is 1-4 hours.*	*Bycatch includes large numbers of sharks and other fish. Long lines also kill sea birds and turtles.*	*Avoid the use of live bait fish, preferably avoiding purpose-caught bait fish; Humane slaughter as soon as landed; Reduce the time interval between setting and retrieving lines; Handle fish carefully prior to humane slaughter (or release as bycatch); Use hooks that reduce injury and remove them carefully from fish to be released; Effective bycatch reduction measures e.g. bird scarers; Avoid fishing from depths > 20m; Avoid fishing in warm-water weather.*	*Suffering could be greatly reduced. Could be a relatively humane method with soak times no more than 1 hour. Only as humane as the capture and killing of any bait fish used. Suffering of fish caught on long lines for hours may be less than with fish caught in gill nets for the same length of time.*
Trapping	*Use of bait fish; Fear and distress of being trapped; Attack by predators entering the trap; Fish injured trying to escape the trap; Decompression effects.*	*Variable?*	*Ghost fishing. Mammals can become entangled by ropes connecting traps to buoys. Fish bycatch can often be released alive and apparently uninjured.*	*Avoid the use of purpose-caught bait fish; Humane slaughter as soon as landed; Reduce the time interval between setting and retrieving traps; Handle fish carefully prior to humane slaughter (or release as bycatch); Trap designs to reduce time out of water during hauling; Trap designs to reduce bycatch and ghost fishing; Avoid fishing from depths > 20m.*	*This may be potentially the most humane method of fishing. Only as humane as the capture and killing of any bait fish used.*

where the limit is 30 minutes. As discussed in chapter 12, shorter soak times of around an hour may be possible for some long line fishing, which suggests that this fishing method could also be relatively humane.

Trawling does not seem to have the potential to be relatively humane since it inevitably involves the crushing of fish in nets. Trawling from deep water inevitably involves decompression injuries for certain species. Purse seining, on the other hand, possibly does. Fish caught in purse seines are initially trapped without injury. If the process of landing can be improved to land the fish without injury and with less stress, by adapting technology for farmed fish, this could be a relatively humane method of fishing. The potential for better welfare in small-scale purse seining is exemplified by the company Wild Salmon Direct, which claims to be the only wild-salmon producer using humane slaughter technology.

The Fair-fish welfare certification scheme (see page 96) allows a few relatively humane methods of fishing by its artisanal fishers. Fish must be caught and humanely killed within a maximum of 30 minutes. For fish caught by hook, this must be completed within 5 minutes. Fair-fish allows hook and line, encircling gill nets and beach seines as acceptable methods of capture. Other fishing methods may be introduced at a later time.

To fully address the suffering of fish in a given type of fishing, an animal welfare audit would be required, requiring more research. The factors affecting welfare will obviously vary between different fishing methods but also between different fisheries and vessels. Evaluating the welfare of target species, bait fish and bycatch will be complex and trade-offs may be required. An example of this arose in the Canadian chinook salmon study discussed in chapter 8 on gill netting. It was found that using 4.5-inch tangle nets, instead of 8-inch gill nets, halved the death rates in fish released as bycatch. However, this measure also increased the overall numbers of bycatch animals caught.

Further complexity arises from the fact that the experience of individual fish caught during the same fishing operation may vary considerably. Fish will suffer varying degrees of injury and some will be dead before landing. For fish caught in a trawl net, some will die from crushing while others will still be alive when landed. For fish caught by a trolling vessel, some will receive only minor injury from the hook while others will be severely injured by hooking through the gills or eye.

The development of a truly humane method of fishing is not only desirable for animal welfare. The researchers in the blue cod study envisaged the development of low-stress methods of capture (Cole et al, 2003):

> *"In order to maximise value of blue cod, low-stress harvesting methods which take advantage of the behaviour of fish are required."*

16.1 Possible ways to improve welfare

The following summarises measures that, combined with humane slaughter immediately the fish is landed, would improve the welfare of fish caught in commercial fishing:

Reduce the suffering of bait fish

- avoid the use of live fish as bait
- avoid the use of bait fish generally (use artificial baits or off-cuts instead).

Reduce the duration of capture

- reduce the duration of the capture process (the Fair-fish certification scheme (see page 96) limits capture duration to 5 or 30 minutes depending on capture method).

Reduce the numbers of bycatch animals

- use modifications to fishing gear and practice that reduce bycatch, without killing the escaping fish
- close fisheries as and when necessary to reduce high levels of bycatch
- use gear modifications and practices that reduce ghost fishing
- perform retrieval survey trawls for lost fishing gears.

Reduce stress and injury during capture

- use variations of gears that reduce stress and injury to fish e.g. circle hooks
- avoid fishing from depths greater than 20m (for fish with swim bladders).

Reduce stress and injury during landing

- develop methods of landing fish which reduce stress and injury and minimise time out of water
- avoid practices that injure fish during landing, such as gaffing and (for purse seining) ramping
- handle fish carefully, and with minimal time out of water, prior to humane slaughter (or release as bycatch).

Reduce death rates for released bycatch fish

- avoid fishing in warm-water weather when fish are likely to be particularly stressed.

Reduce harm to other non-target animals

- avoid gears that are damaging to fish habitat.

17 Processing of fish alive on landing

After landing, most fish are left to suffocate in air. Many are gutted alive (without stunning) before death intervenes. According to a Dutch study (V.d. Vis and Kestin, 1996), observation of fisheries at sea revealed that, when landed on deck from a trawl, many fish were alive and conscious. This was evidenced by the fact that, if experimentally put back into water, the following were able to swim in a coordinated way:

- 100% turbot and dogfish
- 96% cod
- 91% whiting
- 87% herring
- 86% brill
- 73% dab
- 55% sole
- 40% plaice
- 26% grey gurnard.

Removing fish from water is highly aversive to them (Robb and Kestin, 2002). In most cases violent escape attempts are made and an acute stress response is initiated. Most commercially-caught wild fish alive when landed die either from being left to suffocate in air or by a combination of suffocation and evisceration (i.e. disembowel-ment or gutting) without prior stunning. Evisceration methods vary with species (Robb and Kestin, 2002). Gibbing is a form used on herring in which the gills, long gut and stomach are removed from a fish by inserting a knife at the gills. The term vivisection, meaning literally dissecting a live animal, would not be inappropriate.

The time taken to die will depend on the species, treatment, and also on the temperature.
In the Dutch study mentioned above (V.d. Vis and Kestin, 1996), the time taken for fish to become insensible was measured for fish subjected to gutting and to asphyxiation without gutting. This was done for several species of fish (herring, cod, whiting, sole, dab and plaice). It was found that a considerable time elapsed before the fish became insensible as follows:

- gutting alive (gibbing in the case of herring): 25-65 minutes;
- asphyxiation without gutting: 55-250 minutes.

Some species adapted to spending periods of time out of water, such as eels, can survive for a very long time when removed from water. There is anecdotal evidence of landed flatfish surviving ten hours out of water (Gellatley, 2008):

> *"To find out about fishing I once sailed on a trawler…worst of all was what happened to a big orange-speckled flat fish – a plaice. It was tossed into a bin with other flat fish and four hours later I literally heard it croaking. I pointed out to one of the deckhands who, without even thinking about it, clubbed the fish. It was, I thought, better than suffocating and I presumed it had been killed. Six hours later I noticed that its mouth and gill covers were still opening and closing as it struggled for oxygen. Its misery had lasted ten hours."*

Sometimes fish are put onto ice as they suffocate, or into iced water. This is likely to result in rapid chilling. When fish are put into chilled water, they quickly experience muscle paralysis, after which they are unable to show stress behaviour. This makes it more difficult to assess the welfare impact, since many indicators used to measure stress are connected to behaviour or stress exercise. It is sometimes believed that cold-blooded animals become less sentient as they cool due to slowed nervous metabolism.

However, the process of chilling has been shown to be stressful to fish (Skjervold et al, 2001) and may cause violent escape behaviour (HSA, 2005 cited in Stevenson, 2007). Rapidly chilling live fish, therefore, is not humane and it seems likely that putting wild-caught fish onto ice, as they suffocate, will increase the severity of their distress.

This practice may also cause them to suffer for longer. It is common for farmed species to be killed by asphyxiation in ice slurry (Lines et al, 2003) and the impact on welfare has been studied. According to a review by Robb and Kestin (2002):

> *"Temperate fish take longer to lose brain function when killed in ice than when killed in air. For example, rainbow trout killed in ice slurry took 9.6 min to lose brain function, compared with 3.0 min when killed in air at 14°C."*

The issue is not straightforward and these reviewers point out that thermal shock can also have an effect. They cite a study in which sea bream, with an ambient temperature of 22°C, were killed in ice slurry. They took no longer to die than sea bream killed in air. It appeared that in this case the slowing effect of chilling on loss of sensibility was off-set by the hastening effect of thermal shock.

Some wild-caught fish are killed by methods that can be performed humanely (i.e. percussive stunning and spiking which are discussed in chapter 18) but these methods are exceptions (V.d. Vis and Kestin, 1996).

18 Introducing humane slaughter for wild-catch fish

Two traditional methods for killing fish have the potential to be humane, namely percussive stunning and spiking. As discussed in chapters 1 and 17, humane methods are ones that cause immediate loss of consciousness which lasts until death (or if not immediate, where the method of inducing unconsciousness does not cause suffering), and use of them in commercial fishing is the exception rather than the rule. Percussive stunning is the method used by artisanal fishers in the Fair-fish welfare certification scheme (see page 96). These methods kill fish individually, and so may not be practical for larger fishing operations with large numbers of smaller fish. For these cases, methods of en mass humane slaughter need to be developed.

Percussive stunning involves a blow to the head with a club or "priest". This must be performed accurately and with sufficient force to be humane. As Webster explains (Webster, 2005d):

> *"Stunning by a blow to the head, whether practised by the individual fisherman or the commercial salmon slaughterer wielding a "priest", can achieve an instantaneous and irreversible stun."*

Automatic percussive stunning devices have been developed for some species in fish farming. This presents the possibility of adapting the technology for use on fishing vessels. Stunning machines are more reliably accurate than manual stunning. In some cases, the fish are directed to stun machines without removing them from water or manual handling (both very stressful to fish) prior to stunning, as with the "Seafood Innovations SI~5 Flow-Through Fish Stunner". Pneumatic stunning machines are widely used by the farmed salmon, trout and yellowtail kingfish industries (Seafood Innovations, 2008). However, percussive stunning is an unsuitable method for certain types of fish such as sea bream, catfish or eels (Robb and Kestin, 2002). The fishing company "Wild Salmon Direct" claims to be the only fishery in the world using this technology to humanely stun wild-caught salmon prior to bleeding. This company fishes salmon with small purse seines in waters off the Kodiak Island Archipelago in Alaska (Wild Salmon Direct, 2008a) (see chapter 21).

To ensure that percussive stunning does kill humanely, it should be followed immediately by bleeding. Although percussive stunning can be irrecoverable, the Humane Slaughter Association (HSA, 2008) states:

> *"it is advisable to bleed the fish immediately after a stun to prevent recovery (and possibly improve appearance, taste and eating quality of the product)".*

The RSPCA Freedom Foods welfare certification scheme for farmed salmon requires the fish to be bled within 10 seconds of percussive stunning. The Swiss Fair-fish certification scheme for artisanal fishers also requires bleeding the fish while stunned, following a blow to the head with a priest.

In spiking (also called "ike jime") a fish is killed by inserting a spike into the brain. If this is performed accurately, the fish can become unconscious immediately. This method is sometimes used to kill tuna for the quality benefits of a quick kill (see chapter in 21). Spiking has not yet been automated for fish farming due to the difficulty in accurately locating the brain with varying fish size (Seafood Innovations, 2008). However, an automatic system for fish farms is currently being developed (Robb and Kestin, 2002).

Electrical stunning systems have been developed for en mass humane slaughter in fish farming. As with some automated percussive stunning, the fish are killed without taking them out of water. A current is passed though the water containing the fish. The fish are stunned immediately, and die without regaining consciousness, if the voltage and duration of the current are sufficient. These will depend on the species and the conductivity of the water. Electrical stunning must be performed correctly or the fish may be immobilised but not rendered insensible. The term “electrical stunning” should not be confused with other electrical processes that do not cause immediate loss of consciousness. One such electrical killing system is widely used for farmed trout in Denmark and may cause considerable suffering (Robb and Kestin, 2002).

Electrical stunning has not been developed for farmed salmon, where the most humane slaughter method generally available is automated percussive stunning. This is because farmed salmon are reared in salt water, for which electrical stunning has not yet been developed commercially. It is believed by some animal welfare professionals that electrical stunning technology in fish farming has the potential to be adapted for use on wild-caught fish at sea (DEFRA, 2002). An important step for this will be the development of electrical stunning systems for farmed saltwater species. Electrical stunning of saltwater species is technically more challenging than for freshwater species due to the greater conductivity of salt water.

Electrical stunning of fish can potentially cause carcass haemorrhages, reducing quality. This problem can be minimised by increasing the frequency of the current (Robb and Kestin, 2002) and the UK farmed trout industry is increasingly using this slaughter method (Lines et al, 2003).

Other methods for the humane slaughter of farmed fish may also present the possibility of being adapted for use in some commercial fishing. One other such method is the use of food grade anaesthetics added to the water. AQUI-S is the brand name for the fish anaesthetic, isoeugenol. This is licensed for use on fish farms in New Zealand, though not in Europe or the USA. AQUI-S is used for “rested harvest” in which anaesthetised fish are then slaughtered by percussive stunning or spiking. Quality benefits are also obtained from this low-stress slaughter method. While it is not clear if the fish are actually anaesthetised, or just sedated, they appear to suffer far less distress when removed from water for stunning (Robb and Kestin, 2002).

Rob and Kestin (2002) discuss the use of hydraulic shock as a possible future method of killing farmed fish humanely. Researchers have studied the welfare and quality implications for the killing of fish with explosive devices, and found that:

- fish sufficiently near the explosion (within the stunning range) are stunned
- fish very close to the explosion incur carcass damage
- fish a certain distance away from the explosion (outside the stunning range) suffered injury and internal damage from the shock wave but were not rendered insensible.

It is not clear if this killing method has potential for application in capture fisheries. For the method to be acceptable environmentally, it would need to be carried out inside an enclosed tank such that by-kill and habitat destruction are avoided.

For fish killed by suffocation in air, the practice of gutting them while they are still alive is likely to increase the severity of suffering, even though it may reduce the duration. The process of chilling live fish as they suffocate is also likely to increase the severity of suffering and may also prolong it. On this basis, fish should not be gutted or immersed in ice-slurry while they are still alive.

This section has discussed how the killing of fish on fishing vessels could be made more humane, if animal welfare was an objective. It is likely that different solutions will be required for different fisheries according to the composition and size of the catch (including the types of species caught) and the capture method.

19 How many fish are caught each year?

In writing this report a key question arises: how many fish are caught each year? One expects the number to be massive – the familiar sight of trawl nets full of fish being emptied on deck suggests that many hundreds may be caught in just a single catch. The numbers of land animals slaughtered for food every year is known, since these are published by the Food and Agriculture Organisation of the United Nations (FAO). These show that 3 billion mammals and 57 billion birds were killed for this purpose in 2008. Unfortunately, FAO statistics on wild caught and farmed fish are given only in tonnages. Nor, unfortunately, does the FAO publish mean weights of fish, which would enable numbers to be calculated from these tonnages.

The number of fish caught each year is an important question for animal welfare assessment because, as discussed earlier, most wild-caught fish are killed (i.e. left to die) in ways that meet no standard of humane slaughter. If not the FAO, has anyone else tried to estimate the total number of fish caught?

There are some estimates for particular species and for the following cases the numbers are huge. It has been reported that the number of sandeels caught (sandeels are small fish that burrow in the sand and are caught industrially for reduction to fishmeal and fish oil) is around 100 billion in "a good year" (Johannesson et al, 2000). On an even larger scale, it has been estimated that the number of Peruvian anchovy, also largely caught to manufacture fishmeal and fish oil, was 1.3 trillion (1,306 billion) in 1971 (Froese, 2001). However, searches by the current author revealed no estimate for the total number caught.

Despite the lack of official statistics on fish capture numbers, is it possible to estimate them from FAO fisheries capture tonnages and other available data? Searches on the internet show that, to varying degrees of accuracy and representativeness, there is a significant amount of fish size data around and average weights are cited for many species e.g. on seafood marketing and angling websites. As part of the project of writing this report, the current author attempted such a task in the following study.

19.1 Study to estimate numbers of fish caught

There are three main parts to the estimate presented in this study to estimate the numbers of fish caught in global fishing each year (Mood and Brooke, 2010):

(1) fish for which the FAO reports capture tonnages in single species categories, e.g. *Atlantic mackerel (Scomber scombus)*, and for which a mean weight was estimated from available fish size data
(2) fish for which the FAO reports capture tonnages in multi-species categories, e.g. *Anchovies, etc. nei (Engraulidae)*, and for which mean weights were estimated for the largest and smallest relevant species in each category
(3) fish for which the FAO reports capture tonnages in totally general categories, e.g. *marine fishes nei*, together with categories for which the species are given but for which a mean weight could not be estimated.

The first part comprises the single species categories for which it was possible to estimate a mean weight, and so estimate fish numbers. Where possible, estimated mean weights were obtained from average weight data but, where these were not available, various other types of data were used. These included typical weights/lengths or weight/length ranges. Each type of data was ranked according to the judged relative reliability of estimated mean weights obtained from it, with average weight data ranked the highest. For any mean weight estimate, only the most reliable type of data available was used, including more than one fish size reference where possible. All available data were used in this process, whether from commercial, scientific, sporting or other sources.

The second part comprises the multi-species categories for which fish size data were available. To estimate the mean weight for a multi-species category, the mean weight was estimated for the smallest and largest relevant species in the group and combined as a range. Relevant species were those in the species group that are both fished commercially or for subsistence and that are distributed in the region from which more than 20% of capture was taken. Note that the fish numbers estimated from the upper end of each such estimated mean weight range (i.e. the lower end of the estimated number range) will be very conservative since it will be based on the largest relevant species in the group.

The mean weights and estimated fish numbers for species categories (single or multi-species) for which it was possible to obtain an estimated mean weight are shown in Table 4 of Appendix A).

The third part comprises the species categories for which no estimated mean weight was obtained. The numbers of fish represented by these tonnages were estimated by extrapolating mean weight data from species for which a mean weight had been estimated. Wherever possible, this was based on extrapolated mean weight data for the same taxonomic class of fish species.

The estimated mean weights obtained in this study, and the fish numbers estimated for them, will vary in their accuracy owing to the variability of fish sizes and the limitations of the fish size data available. Issues of accuracy and representativeness were addressed as far as possible by including all fish size references for the most reliable types of data available while excluding those that were judged less reliable.

Key Results

An estimated mean weight was obtained for nearly 70% of fish capture tonnage (average annual capture tonnage for 1999-2007), for which the numbers of fish were estimated at between 0.68 and 1.97 trillion individuals. Adding the numbers of fish estimated from extrapolated mean weight data gave the total estimate of 0.97-2.74 trillion.

This estimated range is based entirely on the data used; the probability that the actual figure lies within this range has not been calculated, but it is considered that this figure is indicative of the numbers caught. The most reliable estimates of fish numbers are likely to be those based on average weight data taken from more than one reference. These total 0.43-1.14 trillion and account for 29% of fish capture tonnage. In addition, the lower estimate for multi-species categories with an estimated mean weight is likely to be very conservative and totals a further 0.079 trillion for another 7% of fish capture tonnage. Combining these two figures brings the lower estimate for this 36% of capture tonnage to 0.51 trillion. It is concluded that the number of fish caught each year is of the order of a trillion.

Fish capture not included in the estimate

This estimate of fish numbers includes only those represented by FAO recorded fisheries capture statistics for the period 1999-2007. It does not include the following:

- fish caught illegally
- fish caught as bycatch and discarded
- fish that die following escape from nets
- ”ghost fishing” by lost and discarded gears
- fish caught for the fishers own use as bait but not recorded
- fish caught for use as feed, either whole or chopped, on fish and shrimp farms but not recorded
- all other unrecorded or unreported capture.

Global fisheries capture (finfish and shellfish) for the period 1999 to 2007 averaged 92.2 million tonnes per year, of which 77.4 million tonnes comprised fish species (FAO, 2009a). As discussed in 20.1 of chapter 20, it has been estimated that 7.3 million tonnes of fish and shellfish catch is discarded and another 11.06-25.91 million tonnes is caught in illegal, unregulated and unreported (IUU) fishing each year. According to a study published in 2001 (Watson and Pauly), China, a target-driven economy, was actually over-reporting its fisheries capture by around 5 million tonnes per year in 1996-1999 (read from Figure 1 in the article). Allowing for this over-reporting by China, net estimated unrecorded fisheries capture (IUU and discards) therefore amounts to 13-28 million tonnes each year, i.e. up to nearly a third again of reported fisheries capture.

In addition, unaccounted numbers of fish are killed as a result of contact with trawl nets from which they escape (see 6.3), and by lost or discarded gill nets that continue to fish.

19.2 Welfare implications of the numbers of fish caught

It is estimated that 0.97-2.7 trillion wild fish are caught globally each year. Recognising the limitations of the fish-size data available, it is concluded that the number of fish caught is of the order of a trillion. This estimate does not include unrecorded fish capture, such as fish caught illegally and those caught as bycatch and discarded.

Measuring the animal welfare impact of fishing as the product of severity * duration * numbers, it is concluded that huge numbers of fish suffer pain and distress that is likely to be severe for significant periods of time. The suffering of wild fish caught at sea therefore represents a major animal welfare issue.

Previous chapters have suggested ways of reducing the suffering of individual fish caught. The next chapter examines ways of reducing the numbers of fish caught that are compatible with the needs of people and conservation.

20 Reducing suffering by reducing numbers caught

"It was considered more ethical to eat the meat of larger animals such as yaks than small ones, because fewer large animals would have to be killed"

Dalai Lama discussing Tibetan Buddhist tradition

As has been argued in previous chapters, the severity and duration of suffering caused to fish during capture and subsequent treatment is considerable and the scale of this suffering is huge, estimated to be in the order of 1 trillion individuals every year. The estimated number of fish caught per person in the world each year (assuming a human population of 6.8 billion) is in hundreds (around 100-400).

The reason the number of fish caught is so high is partly because the global tonnage of wild-caught fish species is high, averaging 77.4 million tonnes annually between 1999 and 2007 (FAO, 2009a). The other reason is that much of this catch comprises small fish like anchovy, individually weighing between 10 and 30g.

The previous sections have discussed how suffer-ing in commercial fishing could be mitigated by

THE MENHADEN FISHERY.
Fish pens on top floor of factory. The fish are led through a trough to the cooking-tanks. (Sect. v, vol. i, p. 337.)
From a photograph by T. W. Smillie.

Menhaden - an industrial species

Until World War I, the primary use of menhaden was to make fertilizer. After the war, this changed to use for animal feed. Menhaden oil has also been used to make soap and paint (Menhaden research council, 2006).

Credit: NOAA National Marine Fisheries Service. National Oceanic and Atmospheric Administration/Department of Commerce.

The numbers of fish suffering in commercial fishing can be reduced by the following measures:

I. Reduce the numbers of fish caught wastefully or illegally

- reduce the numbers of fish caught as bycatch
- reduce the numbers of fish killed following escape or release from fishing gear
- reduce the numbers of fish caught by ghost fishing
- reduce the numbers of fish caught illegally.

II. Catch fewer fish and let fish grow larger

- reduce overall levels of fishing
- increase the size of fish caught within a species
- increase the proportion of larger species caught.

III. Reduce the numbers of fish caught not directly for food

- reduce the numbers of fish caught for bait
- reduce the numbers of fish caught to feed whole to farmed fish
- reduce levels of industrial fishing.

measures to reduce the severity and duration of distress during and after capture. While there is potential to reduce suffering here, it seems unlikely that stress of some duration could be avoided for at least the majority of caught fish. Nor can bycatch be completely eliminated.

Another approach for reducing suffering in commercial fishing would be to reduce the number of fish caught each year. This could be achieved by some or all of the measures summarized in the box above. Each of these is discussed in more detail in this chapter.

Reductions in fishing are politically difficult to achieve. However, even a relatively small reduction in capture could prevent the inhumane treatment of millions of animals. For example, if the average annual number of fish caught, estimated to be in the order of 1 trillion, were reduced by only 0.1%, then the number of inhumane deaths would be reduced by something in the order of 1 billion each year.

20.1 Reducing numbers of fish caught wastefully or illegally

Reducing fish bycatch discards

Bycatch refers to the animals caught unintentionally by fishers in the process of trying to catch the target species. Bycatch may be retained and sold but often it is simply thrown back into the sea (often dead), in which case it is called “discarded bycatch” or “discards”. A fish is discarded for one of the following reasons:

- it is a bycatch species which has little or no market value
- it is a species for which the fisher has already met their quota (usually bycatch) and therefore not legal to land
- it is smaller than the minimum landing size and therefore not legal to land.

Levels of discarding fish catch can be high. The EU estimates that 40-60% of fish caught by trawlers in the mixed fishery of the North Sea is discarded. This has been described by the former

Fish caught in an illegal drift net

This fish was captured in an illegal driftnet set by pirate fishers. Illegal, unregulated and unreported fishing (IUU) is a global problem, capturing between 11.06 and 25.91 million tonnes annually (Agnew et al, 2008).

Credit: © Greenpeace / Gavin Parsons

UK Fisheries Minister Jonathan Shaw as "immoral dumping" (BBC News, 2007). The FAO estimates that 7.3 million tonnes of global fisheries capture (finfish and shellfish) were discarded annually for the period 1992-2001. This figure represents over 8% of the average recorded landed global catch of 83.8[4] million tonnes per year for the same period (Kelleher, 2005).

Bycatch is less of a problem with fishing methods that are inherently more selective. As discussed in chapter 9 on rod and line fishing, the size and species caught is determined by the size of hook and type of bait. In fast hook and line capture methods, as fish are generally reeled in soon after becoming hooked, unwanted catch can be released alive quickly. Trawling, on the other hand, is an unselective fishing method, although it can be made so by modifications to the gear called "bycatch reduction devices" or BRDs. Bycatch issues and BRDs related to different fishing methods are discussed in chapters 6-14 on fishing methods. Trawl and shrimp fisheries can have very high levels of bycatch, accounting for 55% and 27% of recorded discards respectively (Kelleher, 2005).

Bycatch can also be reduced in some fisheries by specific restrictions on fishing effort e.g. closing areas to fishing during seasons when levels of bycatch are particularly high (as in the Norwegian saithe purse seine fishery (see 6.3 of chapter 6)) or when survival chances of discarded bycatch are particularly low (as in the Tennessee paddlefish gill net fishery (see 8.3 of chapter 8)).

Reducing death rates for escaping and discarded fish

For fishing gear to be truly selective, fish of the wrong size or species must be allowed to escape the gear sufficiently unharmed to survive. Fish escaping from fishing gears may die immediately, or sometime later, from physical injury, exhaustion or increased vulnerability to disease or predation. As discussed in chapters 5-14 on fishing methods, there has been some research to assess the survival rates for fish that escape from trawl and seine nets, and fish released from gears following capture and landing, and how these might be improved by modifications to fishing gear and practice.

While accepting that being caught may severely compromise welfare for these escaping and discarded fish, taking measures to promote their survival does seem likely to reduce suffering. In the Fair-fish welfare certification scheme (see page 96) fish are only released if uninjured and not if caught by hook or gill net.

[4] The average annual capture tonnage (finfish and shellfish) for 1992-2001 is given as 83.8 million tonnes in table 2 on page 17 of Kelleher, 2005.

Reducing ghost fishing

Another way in which fish are caught wastefully is the killing of fish by lost or discarded fishing gear i.e. "ghost fishing". Examples of measures for preventing ghost fishing by gill nets are discussed in 8.3 of chapter 8. Fish traps can be fitted with time releases in case of loss (Suuronen, 2005).

Reducing illegal fishing

The management of fisheries can only be effective if regulations are enforced. Illegal, unreported and unregulated (IUU) fishing is a recognised global problem which needs to be addressed. It has been estimated that illegal fisheries capture amounts to between 11.06 and 25.91 million tonnes annually (Agnew et al, 2008). This equates to between 12 and 28 % of the average annual recorded global capture tonnage (finfish and shellfish) for 1999-2007 of 92.2 million tonnes (FAO, 2009a).

20.2 Catching fewer fish and letting fish grow larger

The suffering of wild-caught fish could be reduced by a strategy to catch fewer fish, and to catch them larger so that fewer are caught for the same amount of food. There are other good reasons for pursuing such a strategy besides those of animal welfare. Reductions in fishing effort are necessary to manage the world's fisheries sustainably. Fish are being caught too young and need to be allowed to spawn and to grow larger before being caught, in order to maintain or rebuild fish populations (Froese, 2004). The economic benefits from fisheries might be increased by setting fishing levels even lower than those required for biological sustainability, since increasing the relative abundance of fish reduces the fuel (and hence carbon footprint) and labour costs of catching them.

Overfishing is a serious problem in world fisheries. It reduces abundance of individuals in a fish stock, by removing fish faster than they can be replaced by breeding. If continued, it can lead to a collapse of the fishery, as happened with the Newfoundland cod fishery in the 1990s. A review of the state of the world's fisheries (Hilborn et al, 2003) explains how this fishery, which had been sustainably fished for 500 years, was overfished to the point of collapse within a few decades. The cause of the collapse was overfishing – too many fish were caught and at too young an age. The fishery was closed in 1992 and shows no sign of recovery yet.

Since World War II, fisheries management science has been based on the concept of "maximum sustainable yield" or "MSY". The MSY is a theoretical maximum catch of a species that can be taken from a fishery over an indefinite period. The problem with this approach has been that stock assessments based on the MSY have often been ignored on the basis that the evidence was not sufficiently conclusive. Stock assessments based on the MSY model have sometimes been inadequately implemented and sometimes overestimated the ability of stocks to recover following rapid or severe decline (Pauly et al, 2002). The MSY concept is a single-species model, and in itself does not take into account the ecosystem effects of fishing pressure e.g. changes to food webs, damage to habitat.

Overfishing tends to reduce the size of captured fish over time, leading to increasingly larger numbers of smaller fish, for the following reasons:

(1) The "fishing down the food web" phenomenon whereby fishing pressure on larger fish, which tend to be piscivores such as cod, produces a decline in their numbers and a corresponding increase in the number of prey species (which tend to be smaller, have smaller mouths and be therefore lower in the food web) such as herring (Pauly et al, 2002 and Watson, 2007).

(2) Fishing pressure can truncate the age structure of the target species, thereby decreasing the mean capture size for it. An example of this is the Pacific sardine, given by Krebs (Krebs, 1972 based on Murphy, 1966).

(3) There is some evidence of an evolutionary selection pressure for fish to become smaller as a result of fishing pressure.

> Research suggests that genetic selection pressure from fishing was the cause of the decline in mean capture weight recorded for Pacific pink salmon between 1951 and 1975 in British Columbia and Alaska (Law, 1991).

Many scientists and conservation groups, such as Greenpeace, argue that fisheries management needs to adopt the precautionary approach and to take into account the ecosystem effects of fishing when setting fishing levels, e.g. the impact on other species via feeding interactions and impacts of gears on habitats. Under the precautionary approach, fishing levels would be set cautiously without waiting for proof that reductions are necessary. It shifts the burden of proof, giving the benefit of the doubt which arises from the uncertainty inherent in fisheries science, to sustainability.

Fishing levels can be reduced by restrictions on fishing effort, such as setting quotas for the amount of allowable catch and restricting the number of days at sea allowed for each fishing vessel. Reductions in fishing fleets and in the subsidies given to fishing are also argued for. "No take" marine protected areas (MPAs) are spatial restrictions on fishing effort. As such, they have the advantage over catch quotas in that they do not result in excess fish catch being discarded because it cannot be legally landed. While the benefits of MPAs are more apparent for non migratory species, they can also protect migratory ones at vulnerable stages e.g. spawning (Greenpeace, 2006). The environmental group Greenpeace is calling for 40% of the oceans to be protected by marine reserves (Greenpeace, 2007).

Fisheries managers can increase the size at which fish are caught by minimum legal landing sizes. Specific restrictions on fishing effort, such as closing off a fishery during a particular time of year when catch of undersized fish is likely to be particularly high, are also sometimes used. Froese (2004) argues for selective fishing gear as a means of capturing fish only within the opt-imum size range in order to reduce "recruitment overfishing" (capture of immature fish before they can spawn) and "growth overfishing" (capture of fish before they have fully realized their growth potential).

Greenpeace campaigners promoting marine reserves

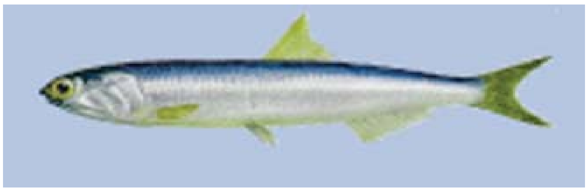
The environmental group Greenpeace is calling for 40% of the world's oceans to be protected as marine reserves, in which fishing is not permitted, to tackle overfishing.

The current author argues that overfishing is also a major animal welfare issue. Overfishing exacerbates the suffering caused by commercial fishing, both by increasing the numbers of fish caught beyond what is biologically sustainable, and by reducing the average size of fish so that increasing numbers are caught for the same amount of food.

Credit: © Greenpeace / Jiri Rezac

This section has discussed how overfishing exacerbates the suffering caused by commercial fishing, both by increasing the numbers of fish caught beyond what is biologically sustainable and by reducing the mean size of fish so that increasing numbers are caught for the same amount of food. The measures advocated by scientists for a more sustainable management of fisheries, i.e. of reducing fishing effort and letting fish grow bigger before being caught, would also serve the humane objective of reducing numbers of fish caught. Reducing fishing levels with a view to maximising economic yield could lower the numbers of fish caught further. Recognition of the moral obligation to reduce the suffering of animals, as well as to protect the natural environment, in respect to fisheries could result in still further reductions of fishing in the future.

20.3 Reducing numbers of fish not directly caught for food



Feed fish

22.2 million tonnes of fish, such as anchovy, are caught to process into fishmeal and fish oil each year. An additional 5-6 million tonnes of fish are fed whole to farmed fish annually.

It is estimated by the current author that in the order of 1 trillion fish are caught every year. A substantial proportion of these are used for animal feed and other non-food purposes.

Courtesy of Subsecretaria de Pesca of Chile. National Oceanic and Atmospheric Administration/Dept. of Commerce

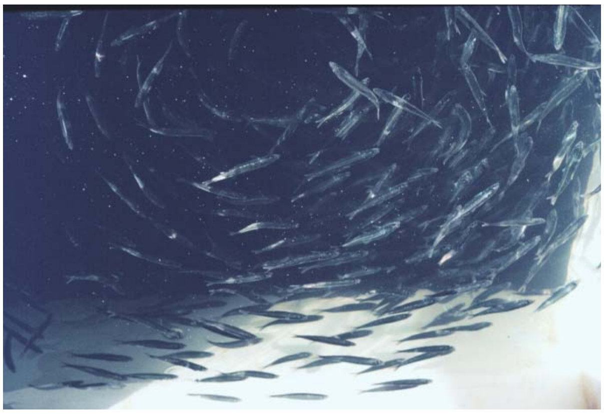
Most fish are caught either directly for human consumption, for industrial use or for use as bait. Fish are also caught for sport in recreational fisheries. Recreational fishing is largely beyond the scope of this report, but the work of animal welfare scientists and animal protection organisations in this area is discussed in chapter 22.

A substantial proportion of the huge number of fish captured annually (estimated to be in the order of 1 trillion (see chapter 19)) are caught for feed and non-food purposes, either whole or as fishmeal and oil. Further uncalculated numbers of fish are used as bait in catching other fish.

Reducing purpose-caught bait fish

An uncalculated number of bait fish are used to catch other fish. Some fishers catch their own bait to fish with (Sainsbury, 1996c), and this capture is presumably not even recorded.

Reducing the numbers of fish purpose-caught for bait will reduce the numbers of fish suffering capture. Artificial baits such as feathers are one alternative. Another alternative might be baits made from fish off-cuts.



Captive fish (mainly sardinella) for live bait

Countless fish are caught to use as bait. Much of this is likely to be unrecorded capture.

Credit: National Oceanic and Atmospheric Administration/ Department of Commerce

Californian anchovy

Around 1 billion Californian anchovy (Engraulis mordax) are caught each year[5] *in recorded capture. Californian anchovy are mostly used for bait, according to fishbase.org.*

Credit: OAR/National Undersea Research Program (NURP). National Oceanic and Atmospheric Administration/Department of Commerce

[5] This assumes an average weight of 22g and is based on FAO average capture tonnage for 1999-2007 (FAO, 2009a).

Reducing industrial fishing

Menhaden on a carrier vessel being taken to a fishmeal processing plant

Credit (above and below): National Oceanic and Atmospheric Administration/Department of Commerce. Photographer (above): Bob Williams. Photographer (below): Jose Cort.

Sacks of anchovy fishmeal

Industrial fish species like anchovy are increasingly being used to make fish oil and fishmeal to feed to farmed fish, such as salmon.

An anchovy weighing 20g will suffer a death which fails to meet any accepted standard for humane slaughter, in order to produce just 6g of farmed salmon.

Fisheries targeting species for reduction purposes i.e. for the manufacture of fishmeal and fish oil, are referred to as industrial fisheries, and the species caught as industrial species. Fishmeal and fish oil are used largely for animal feed, mainly for farmed fish (Schipp, 2008).

According to the FAO (Tacon et al, 2006), the top pelagic fish species mainly caught for reduction in 2003 included the following:

- Peruvian anchovy
- blue whiting
- Japanese anchovy
- Atlantic herring
- chub mackerel
- Chilean jack mackerel
- capelin
- European pilchard
- Californian pilchard
- European sprat
- gulf menhaden
- sandeels
- Atlantic horse mackerel
- Norway pout.

An average of 22.2 million tonnes of whole fish was used to make fishmeal and fish oil each year for 2001-2007 (FAO, 2009b). The amount of fish caught to make fishmeal was therefore between a quarter and a third of the total annual recorded fish capture which averaged 77.4[6] million tonnes for 1999-2007 (FAO, 2009a). However, because fish used for fishmeal are mainly small ones (IFFO, 2008) the proportion of fish numbers caught for fishmeal will be greater than this.

Increasingly this industrial fish catch is being used to feed farmed fish such as salmon. The feeding of purpose-caught fish to farmed salmon greatly increases the suffering involved in salmon production as the following statistics show:

[6] Total fisheries capture, including shellfish, averages 92.2 million tonnes each year for 1999-2007.

- It takes 3-4kg[7] of wild fish to produce 1kg of salmon (Schipp, 2008; Tuominen and Esmark, 2003). Fish used to make fishmeal vary in weight from 10g (e.g. sandeels) to 1000g (e.g. a jack mackerel). To take just one example a Peruvian anchovy, weighing 20g, is killed inhumanely to produce approximately 6g of salmon flesh.
- Depending on their size, it takes roughly 14kg and 14-1400 wild-caught fish to feed one 4kg farmed salmon. The likely average figure is hundreds. If the conservative assumption is made that each feed fish suffers for at least 5-6 minutes in the process of capture, the amalgamated **welfare cost of feeding such a salmon is between 50-6000 minutes i.e. 1-100 hours of significant to severe stress.** Tens of hours is likely to be an average.

A Greenpeace protest against fish farming in British Columbia

Farming of carnivorous fish, like salmon, relies on the fishing of large numbers of small "industrial" fish to feed them. Greenpeace argues that industrial fishing is harmful to marine ecosystems and that fish farms are polluting (Greenpeace, 2008).

Credit: © Greenpeace / Daniel Beltra

Environmentalists are concerned about the ecological impact of the removal of large numbers of these small fish from the ocean, e.g. how it affects the fish, seabirds and other marine wildlife that feed on them. In Europe, the blue whiting is a species that is sometimes eaten by people. Yet it is being fished primarily to turn into fishmeal, and at a level that is outside safe biological limits (Tuominen and Esmark, 2003).

An RSPB publication discusses how the industrial fishing in EU waters has developed partly as a result of declines in cod, mackerel and other predators of small fish, a classic example of "fishing down the food web" (Dunn, 2003). The RSPB argues that these industrial fishing levels (total allowable catches or TACs) need to be reduced to prevent competition with recovering whitefish populations and other marine wildlife.

Reducing fish caught to feed whole to farmed fish

In addition, many fish with low commercial value (sometimes described as "trash" species by the industry) such as anchovies, pilchards and herring, are fed whole to farmed fish (Tacon et al, 2006). According to the FAO, an estimated 5 to 6 million tonnes of fish are used in this way each year (Tacon et al, 2006). In 2002, 3 to 4 million tonnes of bait fish were fed whole to farmed fish in China alone, according to Schipp (2008).

Williams and Rimmer (2005) report that the bait fisheries in the Asia-Pacific region are not sustainable:

"Trash fish remains the traditional method of feeding marine carnivorous fish throughout the Asia-Pacific region and is likely to remain so for some time yet….The demand for trash fish or low-value fish in the region has steadily increased with continued expansion of mariculture [marine aquaculture]. Satisfying this demand has caused a severe problem of over-fishing."

[7] In some fish farming, even greater amounts of wild fish are required per kg of farmed fish. Jenkins et al (2009) cite a range of 2.5 to 5kg feed fish

21 Better welfare improves fish quality

Chapter 20 discussed how the numbers of fish caught could be reduced by fishing at lower and more sustainable levels. This has a clear long term benefit to both fishers and consumers, and is likely to increase the overall economic benefit from fisheries. In a number of fisheries the fishers have volunteered to accept catch reductions knowing it would lead to higher prices and lower costs of fishing (Hilborn et al, 2003). The use of bycatch reduction measures and devices, as well as helping fish stocks and reducing animal suffering, can benefit fishers by reducing the time spent sorting and discarding. This chapter considers how the fishing industry could benefit from other measures to reduce suffering during capture and from humane slaughter methods.

Reducing the stress suffered by fish at slaughter can improve the quality of the flesh, as is the case for other species killed for food. Improving animal welfare at capture and slaughter is also, in itself, a quality enhancement that could attract a higher price. In Section 2 on fishing methods, some possible measures to reduce the suffering of fish were proposed which can be summarized as follows:

(1) *speeding up the capture process with shorter net and line soak times and trawl times etc.*
(2) *modifications to gear and handling to reduce injury and distress*
(3) *methods for humane slaughter*
(4) *avoidance of live bait fish and purpose killed bait fish*
(5) *choosing more humane capture methods.*

Gregory (1998) describes some of the severe stressors to which wild fish are subjected during capture, discussed in chapters 6-14, and their impact on quality. Reducing injury during capture would reduce carcass damage. Reducing skin and scale damage reduces the risk of spoilage. The relationship between stress and flesh quality in wild-caught fish is complex, but severe exercise during catching is known to be detrimental for quality, and the effect is likened to the PSE condition in pork (Gregory, 1998). In PSE, stress at slaughter results in pale, soft, exudative ("PSE") flesh.

Gregory (1998) explains that in some long line and trolling fisheries, the relatively humane slaughter method of spiking is used soon on landing in order to improve the flesh quality by reducing the pre-slaughter activity. This delays the onset of rigour mortis by slowing the rate of ATP degradation in the muscle. This helps to preserve the period of translucency of the chilled meat, and delays the onset of opaqueness.

According to its website, the "Wild Salmon Direct" company is the only company which uses humane slaughter technology (automatic percussive stunners) on its wild-caught salmon. It is proud of its humane slaughter and of the resulting quality (Wild Salmon Direct, 2008a):

> *"Our salmon are humanely stunned prior to bleeding....*
>
> *"Wild Salmon Direct is the only salmon producer in the world using this method of stunning on wild salmon. This stunning method renders the fish totally unconscious immediately resulting in fish of unparalleled quality."*

After stunning, the fish enter a bleeding machine where a cut is made in the area of the heart.

Video footage of the stunning and bleeding process is viewable on this website[8]. This company, which catches fish with small purse seines, also appears to be handling the fish better during landing:

> *"We then use a pump that was specifically designed to transport live fish to move the live salmon out of the pens. The salmon are then pumped aboard the F/V Seldovia where they are humanely stunned and bled."*

Customer testimonials published on the website include the following from a multiple line seafood distributor (Wild Salmon Direct, 2008b):

> *"We buy and sell Alaska salmon from many different sources. This salmon is the best salmon we have ever seen, including troll caught."*

All salmon from the Wild Salmon Direct company is sourced from a fishery that has been certified as sustainable by the Marine Stewardship Council. There is a welfare disadvantage in the processing of fish by this company. This is that fish are held in net pens for up to 7 days between capture and slaughter. An animal welfare audit would be required to assess the extent to which this compromises welfare. In other respects, this commercial fishing operation appears to be exceptional in view of its humane slaughter and handling.

Humane slaughter methods for farmed fish have been shown to improve quality by reducing stress at slaughter. This is examined in the review of killing methods for fish (Robb & Kestin, 2002) discussed in chapter 18. Humane slaughter methods reduce the physical activity at slaughter. Vigorous exercise in fish before death leads to increased muscular lactic acid concentration immediately after death, resulting in faster rigor mortis. For this reason, flesh from fish that show vigorous escape attempts before killing is usually more prone to gaping (i.e. a softening of fish muscle accompanied with gaps, tears and splits in the flesh) and of reduced quality. Use of humane slaughter methods reduce this effect and might obtain similar eating quality improvements for wild catch fish.

The development of electrical stunning for wild fish, adapted from aquaculture, seems to offer the greatest potential for humane en mass slaughter in commercial fishing. Farmed fish killed using humane electrical stunning show improved flesh quality over those left to suffocate in air or gutted alive. Although electrical stunning can itself sometimes cause carcass damage, this problem has been satisfactorily overcome in the electrical stunning of farmed trout by using higher current frequencies.

Wild-caught fish are often chilled or frozen while still alive and this seems likely to cause additional suffering (see chapter 17). Rob and Kestin (2002) reviewed the practice of chilling live farmed fish and found no convincing reason for the fish to be alive when immersed in ice slurry. Any quality benefits could be obtained equally well if the fish were killed before chilling.

The FAO discusses the influence of capture method on quality and states (Clucas, 1997):

> *"the best quality fish at capture will be associated with fishing methods that remove fish from the water immediately they are caught and where fish are usually alive at this stage".*

For instance, fishing methods with shorter duration of capture, such as surrounding and lifting nets (purse seines) and some hook and line methods such as pole and line and hand lines, usually result in higher quality fish than trawl-caught fish. These faster capture methods, by being shorter in duration, have the potential to be relatively more humane provided that fish are humanely despatched soon on landing and that

[8] On viewing this video, notice that 1 or 2 individuals show movement and appear to have "come round" after bleeding (1.55, 4.05, 4.55 and 5.05 seconds in). This system would be improved with a manual backup i.e. a worker to manually stun any fish showing signs of recovery. This system is, however, a huge improvement over normal practice in commercial fishing where fish are not stunned but are left to die from suffocation in air, or gutted, bled or chilled while still alive.

purpose-caught bait fish (especially live ones) are not used.

To summarize, humane slaughter of wild-caught fish and measures to make capture and handling more humane seem likely to benefit quality as well as welfare. All measures to improve the welfare of wild-caught fish potentially add value to the fish product by increasing the ethical value. Ethical consumers will pay extra for more humanely produced fish.

22 Key roles for improving welfare of wild-caught fish

The welfare of wild-caught fish has so far received little attention. Why is this so? Every other industry which deals with animals, at least in the UK (with the notable exception of pest control), has had to engage seriously with animal welfare issues. There is a range of possible reasons why this has not been the case with the fishing industry. People empathise less with fish than they do with birds and mammals and some even question whether fish are sentient. It all happens out at sea and generally out of mind. It is also seen as a difficult issue to deal with. It may well prove impossible to catch a wild fish in a genuinely humane manner.

However, the issue of fish welfare and sentience has achieved greater prominence in recent years. The RSPCA's Medway report in 1980, drawing on the then knowledge of fish pain physiology, concluded that fish are sentient and recommended the drawing up of codes of practice for anglers aimed at reducing fish suffering. The RSPCA has also worked to improve the welfare of farmed fish by including farmed salmon in its Freedom Food welfare scheme, to which around 50% of UK salmon farmers now belong.

Humane slaughter technology for farmed fish has been developed by animal welfare scientists within the last decade. The RSPCA Freedom Food certification scheme, together with the Soil Association and Organic Food Federation organic certification schemes, require farmed fish to be slaughtered humanely. The UK website *fishwelfare.net* is dedicated to disseminating information on fish welfare research and is currently focused on farmed fish. The EU is funding research into the welfare of farmed fish through the "Benefish" project.

Persuaded by the growing evidence of fish sentience, governments are beginning to bring fish into animal welfare legislation. As discussed in 22.6 of this chapter, legislation to protect fish by law for the first time was introduced in Switzerland in 2008. This legislation sets welfare standards for aquarium fish and includes a requirement that these animals should not be killed without prior stunning using a fish anaesthetic. It also requires that fish caught for retention by anglers must be killed humanely by a blow to the head. 22.2 discusses the ban on the use of live vertebrate bait (which includes fish) introduced by Scotland in its inland waters in 2007. The Council of Europe has published welfare recommendations on farmed fish (COE, 2005) and it seems likely these will form the basis of future EU legislation. The World Organisation for Animal Health (OIE) is currently developing guidelines for the welfare of farmed fish during transport and slaughter (OIE, 2008a), which will provide a framework for legislation in its 172 member countries. These guidelines look likely to state that the carbon dioxide stunning, asphyxiation in air and exsanguination (gill cutting) without prior stunning are unacceptable for farmed fish on welfare grounds (OIE WGAW, 2007).

Animal rights and vegetarian groups are working to raise awareness of the suffering caused to fish by commercial fishing. There are now signs that scientists and animal welfare groups may also be starting to engage on this issue. In 2008, the Fisheries Society of the British Isles hosted a symposium on fish welfare and fisheries at a fisheries conference in Japan. The Swiss animal welfare group Fair-fish has developed a certification scheme for wild-caught fish designed, initially, for artisanal fishers in Senegal. The Dutch Society for the Protection of Animals has lobbied the Dutch government to fund research into the welfare of wild-caught fish, the results of which have been quoted in this report. They are continuing to lobby for more research and for supermarkets to take action, and are hoping to develop a certification scheme similar to Fair-fish. Another hopeful sign is that one wild salmon producer, Wild Salmon Direct, is now using humane slaughter technology and promoting the welfare and quality benefits.

This report has argued that commercial fishing causes suffering to fish on a huge scale and that this could be substantially reduced. Firstly, the numbers of fish caught could be reduced. This should at least be possible where it does not conflict with the sustainable and optimal use of wild fish as food. This report has argued that reducing the numbers of fish caught illegally and wastefully, and catching fewer fish and letting them grow larger, is not only compatible with, but necessary for, the long term use of fish as food. It has also argued that the industrial fishing of small feed fish often causes a wholly disproportionate degree of suffering for the miniscule amount of food obtained from each individual. For example, the inhumane capture of a 10g sandeel typically produces just 3g of farmed salmon. Such measures for reducing the numbers of fish caught are discussed in chapter 20. Secondly, humane methods of slaughter and more humane methods of capture need to be developed. These are discussed in chapters 5-18.

Improving the welfare of wild-caught fish is likely to be beneficial for fish quality, as discussed in chapter 21. Small-scale artisanal fisheries may be particularly suited to better welfare fishing, as in the Fair-fish scheme (see page 96), and could obtain great benefit from sales of higher welfare, sustainable fish aimed at niche markets.

To achieve any of this requires the issue of wild fish welfare to be on the radar of a range of stakeholders. It will need animal welfare scientists to develop welfare assessment tools and methods of humane slaughter for use on vessels. It will need fisheries scientists to research alternatives to purpose-caught bait fish and to develop effective bycatch reduction measures. It will require animal welfare campaigners and educators to put wild fish welfare onto the social and political map. Welfare campaigners will need to make common cause with environmentalists to protect fish as well as fisheries and the marine environment. Supermarkets and retailers will have a role in developing higher welfare niche markets and, ultimately, global fish welfare standards. The fishing industry will need to engage with the issue of fish welfare. Governments ultimately need to legislate for, and enforce, standards of fish welfare locally, nationally and, eventually, globally.

The purpose of this chapter is to outline the roles of different stakeholders in rising to this challenge. It does this by looking at their contributions to the welfare of fish, and other aquatic animals, in other areas. This report has argued that the suffering of fish in commercial fishing is a huge animal welfare problem which urgently needs to be addressed by the animal welfare network because:

- fish caught in commercial fishing are killed in ways that would fail any standard of humane slaughter (e.g. buried alive in trawls; snared in gill nets or hooked on long lines for hours or days; impaled on hooks as live bait and left to die from asphyxiation, live dissection or freezing) and
- the numbers of animals affected is huge and estimated to be in the order of 1 trillion fish every year.

Table 3. Some developments in fish welfare (and related issues) 1980-2009

	Date	Country	Event	Details
1	*1980*	*UK*	*RSPCA's Medway Report published (Medway, 1980)*	*Concluded that fish can feel pain. Recommended that welfare of codes of practice be drawn up for anglers and in fish farming.*
2	*1994*	*UK*	*Shellfish Network founded*	*A campaigning NGO specifically to promote the humane treatment of lobsters, crabs and other shellfish.*
3	*1995*	*global*	*United Nations (FAO) adopts its voluntary 1995 Code of Conduct for Responsible Fisheries (FAO, 1995)*	*Giving international recognition of the need to conserve fish species, this code sets out general principles for effective conservation and management of fisheries.*
4	*1995*	*UK*	*Welfare of Animals (Slaughter or Killing) Regulations 1995 introduced (OPSI, 1995) (implementing EU Council Directive 93/119/EC) (DEFRA, 2009a)*	*UK legislation on welfare at slaughter that covers farmed fish. Note that although this legislation covers fish in its general requirements, it does not set specific requirements in terms of permissible humane methods for the killing of fish.*
5	*1996*	*Nether-lands*	*A study into the welfare of fish caught by commercial fishing was published (V.d. Vis and Kestin, 1996)*	*A study conducted into the methods used to kill fish (asphyxiation and live gutting) in commercial fishing. It proposed a research programme for the development of more humane methods.*
6	*1996*	*UK*	*The Government's Farm Animal Welfare Council (FAWC) publishes its report on fish farming (FAWC, 1996)*	*"Report on the welfare of farmed fish" made a series of recommendations for improving the welfare of farmed salmon and trout, and of wrasse fish kept with salmon. It stated that allowing trout to suffocate in air, and gill-cutting salmon without prior stunning, are unacceptable and that humane methods of slaughter should be used.*
7	*1997*	*UK*	*Marine Stewardship Council (MSC) founded*	*International non profit making organisation which aims to promote solutions to the problem of overfishing. It is the world's leading environmental eco-labelling assurance scheme for wild-caught seafood.*
8	*1997*	*Canada*	*Animal Welfare Foundation of Canada (AWFC) publishes its report on fish farming (AWFC, 1997)*	*"A report on the animal welfare aspects of fish farming (1997)" raised concerns about the slaughter methods and husbandry practices in Canadian salmon farming.*
9	*1997*	*UK*	*Welfare of Animals (Transport) Order (1997) introduced (implementing EU Council Directive 91/628/EEC) (OPSI, 1997)*	*UK legislation on welfare during transport that covers farmed fish.*

Table 3. Some developments in fish welfare (and related issues) 1980-2009 (continued)

	Date	Country	Event	Details
10	*1998-9*	*UK*	*Soil Association Organic certification scheme launches its standards for farmed salmon and trout (FAO, 2008a)*	*Soil Association certified organic salmon and trout are reared at lower stocking densities than the industry standard. They also prohibit inhumane methods of slaughter for fish and use of genetically engineered fish.*
11	*2001*	*UK*	*LINK project to develop an automatic humane slaughter system for farmed trout concludes successfully*	*A working prototype electrical stunner was developed for trout that meets all the requirements for both welfare and carcass quality (CEFAS, 2002).*
12	*2002*	*UK*	*RSPCA Freedom Foods certification scheme launches its welfare standards for farmed salmon (FishOnline, 2008b)*	*In this scheme, salmon must be humanely slaughtered with a percussive stun followed immediately by bleeding. Freedom Foods standards also prohibit prolonged pre-slaughter starvation, the use of wrasse fish and the use of genetically engineered fish.*
13	*2002*	*UK*	*Compassion in World Farming published its report on fish farming (Lymbery, 2002)*	*"In too deep" argued for humane methods of slaughter for farmed fish. It stated that the use of genetically engineered fish and the use of wrasse fish as "cleaner fish" for treating sea lice are unacceptable on welfare grounds, as is the use of hydrogen peroxide. It also recommended lower stocking densities for salmon and trout.*
14	*2002*	*UK*	*Fisheries Society of the British Isles publishes its welfare briefing paper (FSBI, 2002)*	*This paper presents the evidence that fish feel pain and recognised the welfare impact on fish of commercial fishing as being of "serious concern".*
15	*2002*	*UK*	*Sainsbury's made a commitment to source all its wild fish from sustainable sources by 2010 (Sainsbury, 2008)*	*It admits it is still some way from meeting this target. The main reason seems to be the shortage of supply of MSC-certified fish. ASDA make the same commitment on their website (ASDA, 2008). TESCO say they are seeking to source their seafood sustainably using the FAO Code of Conduct for Responsible Fisheries as a sourcing reference (TESCO, 2008).*
16	*2003*	*UK*	*BBC News reports "Fish do feel pain, scientists say" (BBC News, 2003a)*	*Research into pain perception in fish by Dr. Lynn Sneddon's team was widely reported in the media.*
17	*2003*	*UK*	*BBC News reports that fish "do not deserve their reputation as the dim-wits of the animal kingdom" (BBC News, 2003b)*	*A scientific review of research into fish learning and cognition was widely reported in the media.*

Table 3. Some developments in fish welfare (and related issues) 1980-2009 (continued)

	Date	Country	Event	Details
18	*2004*	*Australia*	*RSPCA Australia's scientific seminar "Welfare underwater: issues with aquatic animals"*	*A forum to share information on the humane methods to kill fish and crustaceans in the commercial and recreational sectors. Although the slaughter of commercially-caught fish was not directly addressed, it was recognised as "an area of growing concern. Most wild fish die by anoxia in air followed by chilling without exsanguination." (RSPCA Australia, 2004).*
19	*2004*	*UK*	*Universities Federation for Animal Welfare (UFAW) and HSA fund a PhD research project into humane slaughter of farmed sea fish (HSA, 2004)*	*The development of electrical humane slaughter technology in sea water will assist the development of humane slaughter technology for use on fishing vessels.*
20	*2004*	*Scotland*	*"The Welfare Code for Fin Fish Aquaculture" voluntary welfare code developed (SFSA, 2004)*	*This voluntary welfare code, developed by the Scottish Executive, includes welfare issues of stocking density, grading, transport and slaughter. It requires that inhumane slaughter methods be phased out over the next 5 years, and routine use of carbon dioxide stunning is not permitted. Fish should only be starved prior to slaughter for as long as is necessary to clear the gut.*
21	*2005*	*UK*	*The "Crustastun" humane crustacean killer launched*	*The "Crustastun" enables lobsters and crabs to be killed humanely and instantly by an electrical stun. Developed by scientists at Bristol University, it is available in two forms: one for shellfish processors and one for restaurants and fishmongers (Crustastun, 2008).*
22	*2005*	*UK*	*Website fishwelfare.net launched*	*This website works to disseminate information on research into fish welfare, with a current focus on farmed fish.*
23	*2005*	*EU*	*Council of Europe adopted a recommendation on the welfare of farmed fish (COE, 2005)*	*This includes the recommendations: that stress and handling should be minimised during grading; that the period of pre-slaughter starvation should be kept as short as possible; for humane emergency killing. These are, in time, likely to be adopted as an EU Directive for implementation by all member states.*
24	*2006*	*UK*	*A review paper "Animal welfare perspectives on recreational angling" (Cooke and Sneddon, 2007) published.*	*This review argues that a global code of conduct, which includes welfare codes, is needed for recreational fishing. The authors propose general guidelines on which such codes should be based.*

Table 3. Some developments in fish welfare (and related issues) 1980-2009 (continued)

	Date	Country	Event	Details
25	*2007*	*EU*	*"Benefish" project started*	*EU funded farmed fish welfare research project.*
26	*2007*	*UK*	*M&S and Waitrose are joint winners of the MSC Supermarket league table for 2007 (FishOnline, 2007a)*	*Waitrose and M&S have a policy of obtaining all their wild-caught fish from well-managed fisheries (FishOnline, 2007b). Sainsbury's and Tesco came respectively 3rd and 4th.*
27	*2007*	*UK*	*M&S and Waitrose achieved the highest scores for farmed fish welfare in the 2007-8 CIWF supermarket survey (Fraser, 2007)*	*M&S, Somerfield, Tesco and Waitrose have all their own label farmed salmon and trout killed by humane methods. Unfortunately, for other supermarkets some of their salmon and/or trout are still being killed by inhumane methods, as are other farmed fish species, such as sea bass. High stocking densities also continue to be a problem.*
28	*2007*	*UK*	*Compassion in World Farming publishes its new report on farmed fish welfare in collaboration with the World Society for the Protection of Animals (Stevenson, 2007)*	*"Closed waters: the welfare of farmed Atlantic salmon, rainbow trout, Atlantic cod & Atlantic halibut" recognised that the British industry had made some progress on welfare, but that there remained serious welfare problems in intensive fish farming, in Britain and elsewhere.*
29	*2007*	*Scotland*	*Aquaculture and Fisheries (Scotland) Act 2007 passed which includes some new welfare regulations for inland fishing (OPSI, 2007a and 2007b)*	*This bans the use of live vertebrate bait in its inland waters. It also bans certain types of fishing gear and practice on welfare grounds e.g. landing nets with knotted mesh and gaff hooks to impale fish during landing.*
30	*2007*	*EU*	*EU Commission reports the failure of the EU Common Fisheries Policy (CFP) to protect fish stocks (EU Commission, 2007)*	*The EU Commission reported that 80% of EU fish stocks remain outside safe biological limits. The reason it gives is that the total allowable catches (TACs) agreed each year by the Council of Ministers are much higher than are recommended by scientists.*
31	*2008*	*global*	*World Organisation for Animal Health (OIE) adopts its "Introduction to Guidelines for the welfare of farmed fish"*	*These guidelines will provide a framework for legislation in its 172 member countries. This introduction states (OIE, 2008b): "the use of fish carries with it an ethical responsibility to ensure the welfare of such animals to the greatest extent practicable".*
32	*2008*	*USA*	*Humane Society of the United States (HSUS) published its report into fish farming (HSUS, 2008)*	*"An HSUS report: the welfare of animals in the aquaculture industry" argues that that farmed fish should be given the environment and space which "enables them the full range of their natural behaviours" and that, from a welfare perspective, "painless slaughter is a non-negotiable goal".*

Table 3. Some developments in fish welfare (and related issues) 1980-2009 (continued)

	Date	Country	Event	Details
33	*2008*	*UK*	*Draft Marine Bill promises better protection of the UK marine environment (DEFRA, 2008a)*	*As DEFRA's website explains (DEFRA, 2008a), the marine bill will set up marine protected areas which will enjoy protection, to varying degrees, from activities like fishing which impact on the environment. It will also mean, according to DEFRA, better management of inshore fisheries and enhanced powers to tackle illegal fishing further offshore.*
34	*2008*	*Switzer-land*	*New legislation to protect fish by law for the first time is introduced (Practical Fishkeeping, 2008)*	*Includes the requirement for the killing or aquarium fish and fish caught and retained by anglers to be humane. Aquarium fish must not be kept in aquariums that are transparent on all sides and social fish must not be kept alone.*
35	*2009*	*EU*	*The AHAW scientific panel adopts its "General approach to fish welfare and to the concept of sentience in fish"*	*The AHAW scientific panel was commissioned by the EU to issue a Scientific Opinion on the animal welfare aspects of fish farming.*
36	*2009*	*EU*	*Public consultation process begins for reform of the Common Fisheries Policy*	*The EU is seeking to reform the Common Fisheries Policy in order to manage EU fisheries responsibly and sustainably.*
37	*2009*	*EU*	*EU Lisbon Treaty enters into force*	*Under this Treaty member states are required to give "full regard" to the welfare needs of animals in fisheries (CONSILIUM, 2008). See page 20.*
38	*current as at 2010*	*Nether-lands*	*The Dutch Society for the Protection of Animals continues to campaign for humane treatment of wild-caught, as well as farmed, fish*	*This organization continues to lobby the Dutch government and supermarkets to address the welfare of wild-caught, as well as farmed, fish. They also hope to develop a certification scheme similar to Fair-fish.*
39	*current as at 2010*	*Switzer-land and Senegal*	*The Fair-fish certification scheme is currently being developed*	*The Swiss Fair-fish certification scheme is currently being developed as a pilot project in Senegal. It is the only certification scheme ensuring humane treatment of wild catch fish and assures standards for animal welfare, conservation and fair trade.*
40	*current as at 2010*	*Global*	*World Organisation for Animal Health (OIE) is currently developing guidelines for the welfare of farmed fish during transport and slaughter (OIE, 2008a)*	*These guidelines will provide a framework for legislation in its 172 member countries and look likely to state that the CO_2 stunning, asphyxiation in air and exsanguination (gill cutting) without prior stunning are unacceptable for farmed fish on welfare grounds (OIE WGAW, 2007).*

22.1 Animal welfare and fisheries scientists

Animal welfare scientists work to further scientific knowledge of animal welfare science through research and teaching. Animal welfare science seeks answers to the following questions (Dawkins, 2005):

- are animals conscious?
- how can we assess good and bad welfare in animals?
- how can we use science to improve animal welfare in practice?

The role of animal welfare scientists in providing scientific evidence that fish are sentient (and therefore conscious) is clear from the discussion in chapter 3. Some of this research has been widely reported in the media (e.g. BBC News, 2003a and 2003b, Telegraph, 2009**).**

Assessing good and bad welfare in fish

The ability to assess good and bad welfare for fish will be important in welfare-auditing current fisheries practice and the development of good practice codes.

Stress responses of fish are often used as indicators of impaired welfare. These include behavioural and physiological stress responses (e.g. blood levels of the stress hormone cortisol). Disease is an indicator of longer term stress and poor welfare.

Researchers have studied the welfare impact of "catch and release" angling by looking at death rates, injury and behavioural and physiological changes, as welfare indicators. Plasma cortisol levels were measured to study the stress experienced by sea bream caught in trammel nets (see chapter 8.1 of chapter 8). Stress behaviour in fish during slaughter, such as making vigorous escape attempts, is another indicator of suffering.

Researching more humane methods of killing fish relies on the ability to determine unconsciousness in them. The Dutch study (V.d. Vis and Kestin, 1996) stressed the importance of this, stating that:

> *"Whilst some progress has been made, the development of good methods for assessing insensibility in fish as they are killed, both electrophysiologically and behaviourally, is considered to be an important initial objective if improvements are to be made."*

In more recent research, unconsciousness has been determined by measurement of visual evoked responses (VER's). A VER is the response in the brain to flashes of light directed towards the eyes, the absence of which indicates unconsciousness (V.d. Vis et al, 2003).

Researching the possibility for retrospectively assessing welfare at slaughter from examination of the fish carcass could also be very useful. It might enable an audit of welfare without the auditor being present on the fishing vessel, and so assist the enforcement of welfare standards in certification schemes etc.

Improving fish welfare

Some animal welfare scientists have looked at the welfare implications of angling. In a review entitled "Animal welfare perspectives on recreational angling" (Cooke and Sneddon, 2007) it is argued that a global code of conduct that includes welfare codes is needed for recreational fishing. The authors propose some general guidelines on which such codes should be based, which are summarised as follows:

- minimise angling duration
- minimise exposure to air and improve handling
- choose gear that reduces injury (e.g. use barbless hooks and avoid live bait)
- avoid angling in extreme environmental conditions or habitats (e.g. when temperatures or levels of predators are high)
- avoid angling during the reproductive period
- use humane methods to kill retained fish (percussive stunning with a club is humane if performed properly).

Some factors influencing the welfare of these fish will vary between species. For example, the use of circle hooks tends to reduce mortality by 50% relative to the use of "J" hooks but this pattern does vary between species. Cooke and Sneddon conclude that the welfare of fish in recreational fishing would benefit from more research.

Many rainbow trout and Atlantic salmon on UK fish farms are now humanely killed with a percussive or an electric stun, rather than by being taken out of water and left to suffocate. Humane slaughter technology for farmed fish has been developed by animal welfare scientists and encouraged by animal welfare organizations and certification schemes (discussed later in this chapter). The UK website *fishwelfare.net* has been set up to disseminate information on research into fish welfare, with a current focus on farmed fish.

New technology has also been developed for crustaceans in the form of the "Crustastun" which was launched in 2005. The use of inhumane methods to kill lobsters and crabs, such as dropping them alive into boiling water, is widespread. The Crustastun enables these animals to be killed humanely and instantly by an electric stun. As the Crustastun website explains (Crustastun, 2008), it is available in two forms, one for shellfish processors and a stainless steel unit for restaurants and fishmongers. It was developed by scientists at Bristol University.

Other areas of scientific research will also be important for improving welfare in commercial fishing, for example research into bycatch reduction; reducing ghost fishing and developing alternatives to the use of fish as bait.

To summarize, scientists have worked to promote the welfare of fish by

- producing scientific evidence for the sentience and welfare needs of fish
- researching the welfare impact of fish farming and angling
- developing ways to measure welfare and unconsciousness in fish
- developing humane slaughter technology for farmed fish (and wild-caught crustaceans)
- researching ways of reducing bycatch, discard deaths, ghost fishing etc.

Fish welfare work by animal welfare scientists has tended to focus on farmed fish. The welfare implications of fish capture in sport fishing are sometimes discussed by scientists but the suffering in commercial fisheries has received little attention so far. There are signs that this may be beginning to change. An animal welfare briefing paper produced by the Fisheries Society of the British Isles (FSBI, 2002) gives a brief mention of this issue as one of "serious concern" in which large numbers of fish are killed by methods that are "highly stressful". A promising development in 2008 was the holding of a "Symposium of Fish Welfare and Fisheries" by this organisation, which says (FSBI 2008):

> *"To date, little attention has been paid to the welfare of fish in the context of commercial fisheries, although such attention will surely come and the industry should be prepared for it. The aim of this symposium is to open up debate, exchanging thoughts and hopefully identify a way forward, drawing on the experience gained in discussion of aquaculture and recreational fisheries."*

In animal welfare terms, the suffering of fish in commercial fishing is a huge problem. There is a need for animal welfare scientists to work with fisheries technologists to develop humane slaughter technology for use on fishing vessels. There is also a need for animal welfare scientists to work with fishers to develop humane methods and protocols for the capture, landing and slaughter of fish. As John Webster, Emeritus Professor of Animal Husbandry at the University of Bristol, said in "Limping towards Eden" (Webster, 2005d):

> *"There is a real need for research into more humane, practical slaughter methods for fish and other sources of seafood."*

22.2 Animal protection NGOs

Animal protection NGOs work to prevent the suffering of animals through campaigning, lobbying, public education, providing free veterinary care, through direct rescue work and by funding research. Though the welfare of fish has generally received less attention than that of mammals and birds, many animal protection groups work to improve it.

Promoting concern for fish welfare

Many animal welfare and animal rights groups promote understanding of animal sentiency, including that of fish, to encourage a general concern for the welfare of animals. In the UK, the RSPCA has produced manuals for the care of pet fish. It has also campaigned against the sale of goldfish at fairs, and has attempted to prosecute people for cruelty to fish. In the 1970s the RSPCA set up a *Panel of Enquiry into Shooting and Angling* chaired by Lord Medway. Its brief was to (Medway, 1980):

> *"enquire into practices relating to shooting and angling in the United Kingdom, whether for the purposes of control, sport or food, which may involve cruelty, and to make recommendations as may appear appropriate in relation to such practices".*

As discussed in chapter 3, the Medway Report concluded that fish feel pain and recommended that *"codes of practice should be formulated to cover the veterinary care and welfare of fish involved in fish farming".* In the area of sport fishing, the report recommended a ban on the use of all vertebrates, which includes fish, as live bait. It also recommended methods for the humane slaughter of fish intended as food as well as a number of measures designed to reduce injury to fish that are to be returned to the water. This included the use of barbless hooks and minimising the time that fish are held in keep nets. Following this publication, the RSPCA lobbied the angling fraternity to produce a code of conduct to improve the welfare of fish caught for sport. Its stated policy is (RSPCA, 2006):

> *"The RSPCA believes that current practices in angling involve the infliction of pain and suffering on fish. The Medway Report has proved to the satisfaction of the RSPCA that fish are capable of experiencing pain and suffering. The RSPCA advocates that those anglers who see fit to pursue their activities adopt a code of practice based on this report."*

Some animal rights groups such as PETA go further than this, advocating that angling should be abandoned as a sport. Animal rights and vegetarian groups also address the issue of commercial fishing, arguing that commercial fishing causes suffering to fish and is unsustainable (e.g. Animal Aid, 2006; PETA, 2008; Viva, 2008). These groups promote a diet free from fish and other animals.

Animal welfare organisations, on the other hand, generally accept the use of animals for food and some other purposes, so long as it is produced, transported and slaughtered as humanely as possible. These groups tend to promote a more animal-friendly, rather than animal-free, diet. They encourage people to buy meat and eggs produced in ways that meet the needs of farm animals e.g. free range or organic chicken. The focus of fish welfare for these groups has so far been to improve the rearing conditions and welfare at slaughter for farmed fish.

Improving welfare in fish farms and recreational fisheries

Fish farming, in which large numbers of fish are confined in under-water cages, raises a number of welfare and environmental concerns. Welfare problems include the following (Stevenson, 2007):

- crowding and confinement restricts natural behaviour
- farmed fish can incur physical injuries such as fin damage
- farmed fish can suffer high incidence of cataracts and associated blindness
- grading fish (separating fish by size to prevent the bullying of smaller fish which is encouraged by the confinement of fish in

cages) involves crowding and handling – both are stressful to fish
- transporting juvenile fish to farms or sea cages is stressful to fish
- farmed salmon attract sea lice. Use of hydrogen peroxide to treat lice is highly aversive to fish
- wrasse cleaner fish are sometimes used to eat off sea lice – these suffer starvation and aggression from larger salmon
- Atlantic salmon and rainbow trout are often starved for several days before slaughter.

In addition to these, farmed fish are often killed by inhumane methods, involving several minutes of distress, including:

- carbon dioxide stunning followed by gill-cutting (salmon)
- suffocation in air or on ice (trout)
- live chilling.

In 1997, the Animal Welfare Foundation of Canada (AWFC) published a report (AWFC, 1997) into Canadian fish farming. This report raised concerns about the slaughter methods and husbandry practices in Canadian salmon farming, stating *"it is vitally important to ensure that the animal welfare issues raised in this brief are addressed"*.

The previous year, the UK government's Farm Animal Welfare Council (FAWC) had produced its report on fish farming, which made a series of recommendations for improving the welfare of farmed salmon and trout, and of wrasse fish kept with salmon (FAWC, 1996). FAWC recommended that humane methods of slaughter should be used, and that the common practices of allowing trout to suffocate in air, and of gill-cutting salmon without prior stunning, were unacceptable. It argued for research to find alternatives to carbon dioxide stunning, and that fish should not be starved prior to slaughter for more than 72 hours for salmon or 48 hours for trout.

In 2002, Compassion in World Farming (CIWF) published its report on fish farming (Lymbery, 2002) and went further in its recommendations than FAWC. It recommended lower stocking densities for salmon and trout, and against the use of genetically engineered fish. It argued that use of wrasse fish as "cleaner fish", and of hydrogen peroxide, for treating sea lice are unacceptable on welfare grounds.

CIWF's report gives figures for the slaughter methods used on salmon and trout sold in 2001 for a number of UK supermarkets. Much of the salmon and most of the tout sold were killed by the inhumane methods given above. Supermarkets were recommended to demand from their suppliers that only humane methods of slaughter were used and without prolonged pre-slaughter starvation. Consumers concerned about animal welfare and the environment were encouraged to consider alternatives to standard farmed salmon and trout, namely wild fish or fish farmed to organic standards. Organic certification schemes were encouraged to improve their welfare standards regarding pre-slaughter starvation and their methods of treating sea lice.

CIWF encourages supermarkets to improve welfare standards for farm animals with its "Compassionate Supermarket" biennial award and its supermarket survey, available online, which publishes welfare standards for most of the major supermarkets. Looking at the section on farmed fish for 2007-8 (Fraser, 2007), the uptake of humane slaughter methods for farmed trout has clearly improved since 2001. M&S, Somerfield, Tesco and Waitrose have all their own label salmon and trout killed by humane methods. Unfortunately, for other supermarkets some of their salmon and/or trout are still being killed by inhumane methods, as are other farmed fish species like sea bass. High stocking densities also continue to be a problem, especially for salmon.

In 2007, CIWF produced a new report on the welfare of farmed salmon, trout, cod and halibut (Stevenson, 2007) in collaboration with the World Society for the Protection of Animals (WSPA). This report recognised that the British industry had made some progress tackling welfare problems, but that there remained serious welfare problems in intensive fish farming, in Britain and elsewhere.

In 2008, The Humane Society of the United States (HSUS) published its report into fish farming (HSUS 2008). This report argues that farmed fish should be given the environment and space to *"enable them the full range of their natural behaviours"* and that for these animals, from an animal welfare perspective, *"painless slaughter is a non-negotiable goal".*

In the UK, the RSPCA has also worked to improve the welfare of farmed fish. In 1994 the RSPCA founded the Freedom Foods certification scheme dedicated to improving the welfare of farm animals and this scheme has developed standards for farmed salmon. For compliance, slaughter must be humane and percussive stunning is the only method permitted. Freedom Foods standards also prohibit prolonged pre-slaughter starvation, the use of wrasse fish and the use of genetically engineered fish.

The Soil Association organic scheme is a UK organic certification scheme which seeks to improve animal welfare standards as well as improving sustainability and food quality. Soil Association certified organic salmon and trout are reared at lower stocking densities than the industry standard. Soil Association standards require the method of slaughter to make the fish instantly insensible, and explicitly prohibit suffocation in air, the use of ice, carbon dioxide and bleeding without prior stunning (Stevenson, 2007). They also prohibit the use of genetically engineered fish. However, they have not met CIWF's recommendations regarding pre-slaughter starvation for trout and the use of wrasse cleaner fish. The Organic Food Federation is another leading UK organic certification body which certifies organically farmed salmonids (salmon and trout) and gadoids (cod, hake, halibut, pollack and saithe). These standards (Organic Food federation, 2005a and 2005b) similarly explicitly prohibit suffocation in air, the use of ice or ice slurry, carbon dioxide and bleeding without prior stunning and similarly require that the method of slaughter renders the fish *"instantly insensible immediately they are taken from the water"*. They explicitly permit percussive stunning (followed by bleeding) and electrocution ("electrocution" presumably does not include the inhumane types of electrical killing discussed in chapter 18 – the current author is not aware of any reports of such methods being used in UK fish farms).

Another way in which UK animal welfare groups have helped promote fish welfare is by lobbying government on the Aquaculture and Fisheries (Scotland) Bill, first introduced in 2006. This bill sought to address some of the environmental problems caused by fish farming, particularly those of sea lice and escapees, by codes of practice. It also introduced some welfare codes in freshwater fisheries. Animal welfare groups Advocates for Animals (Stevenson, 2006a), The Scottish Society for the Prevention of Cruelty to Animals (Scottish SPCA) (Merry, 2006), Compassion in World Farming (Stevenson, 2006b), and Animal Concern (Robbins, 2006) made comments on a list of proposals. CIWF and Advocates for Animals expressed extreme disappointment that the Bill did little to recognise the welfare problems in fish farming. Advocates for Animals, the Scottish SPCA and Animal Concern strongly endorsed the Scottish Executive's recommendation to ban the use of the following, which cause suffering to fish, in freshwater angling. These were made unlawful when the Aquaculture and Fisheries (Scotland) Act was passed in 2007 (OPSI, 2007a and 2007b):

- live vertebrate bait (including frogs and fish)
- tailers (wire hoops for lifting fish ashore by the tail)
- gaffs (tools for hooking a fish through the muscle, head or abdomen to bring it ashore)
- pike gags (devices to hold a pikes mouth open for removing hooks)
- landing nets with knotted mesh
- foul hooking (attempting to hook a fish other than by inducing it to take the hook in its mouth).

Animal Concern also suggested an additional code that anglers intending to kill fish should be required to ensure quick and humane despatch with a priest.

Improving the welfare of wild-caught fish and crustaceans

In 2004, the RSPCA Australia held a scientific seminar called "Welfare underwater: issues with aquatic animals" designed as a forum to share information on the humane methods to kill fish and crustaceans in the commercial and recreational sectors. Welfare in fish farming and ways of reducing fisheries bycatch were discussed. A presentation was made on humane slaughter technology for farmed fish and, although the seminar did not address the welfare of commercially-caught fish, the presenter gave mention of this issue (RSPCA Australia, 2004):

> *"The slaughter of wild fish is not covered in this paper but it represents an area of growing concern. Most wild fish die by anoxia in air followed by chilling without exsanguination."*

Animal protection groups have worked for the welfare of wild-caught crustaceans. The Shellfish Network is a campaigning NGO set up in 1994 specifically to promote the humane treatment of lobsters, crabs and other shellfish. Some campaigns have successfully persuaded supermarkets and retailers to stop, or abandon plans for, selling live lobsters. The Humane Slaughter Association (HSA) funded the development of the "Crustastun" humane killer for crustaceans.

The Universities Federation for Animal Welfare (UFAW) and HSA have funded a PhD research project into the humane slaughter of farmed sea fish (HSA, 2004). The development of humane slaughter technology for use in sea water will be necessary for humane slaughter solutions on fishing vessels where large numbers of fish are caught.

The Dutch Society for the Protection of Animals has worked with the Dutch government to commission the study on fisheries slaughter methods discussed in chapter 17. They continue to lobby the Dutch government and supermarkets to address this welfare issue and are hoping to develop a certification scheme similar to Fair-fish.

The Fair-fish Association

The Fair-fish Association is dedicated to improving the welfare of commercially-caught and farmed fish by campaigning and through its certification scheme for wild-caught fish. The Fair-fish certification scheme is currently being developed as a pilot project in Senegal. It is the only certification scheme ensuring humane treatment of wild catch fish and assures standards for animal welfare, conservation and fair trade. The aims of the scheme are as follows (Fair-fish, 2007b):

- fish are caught quickly and killed humanely
- the species and environment are protected
- fishers and their communities are fairly remunerated
- highest quality produce is obtained in order to reduce waste.

The whole process of capture, stunning and killing of caught fish is limited to a maximum duration of 30 minutes, with the exception of fish caught by hook. For fish caught by hook, each fish has to be stunned and killed within 5 minutes of capture (Heinzpeter Studer, personal communication, 2008). The fish must be stunned before removing the hook. On removing the fish from water, the fish must be stunned immediately with a blow to the head from a Fair-fish priest. Every fish must then be killed, while stunned, by gill cutting to severe the main artery (Fair-fish, 2007a).

Undersized fish must be returned to the water unless injured, in which case they must be kept for the fisher's personal use (as must be any undersized fish caught with a hook or gill net). Fishers are required to report to Fair-fish any bycatch they observe during fishing for Fair-fish. If Fair-Fish is advised by experts that bycatch levels are too high, the fishers are required to take corrective measures.

To summarize, animal protection organisations have worked to promote the welfare of fish by:

- promoting awareness of the sentience and welfare needs of fish
- producing science-based reports on welfare in fish farming and angling

- encouraging supermarkets to insist on higher welfare standards for farmed fish from their suppliers
- encouraging consumers to make better welfare choices for farmed fish
- encouraging higher welfare standards for farmed fish in welfare certification schemes
- funding research into humane slaughter technology for farmed fish (and wild-caught crustaceans)
- encouraging information sharing on fish welfare issues in industry
- providing input to consultancy phases of government fisheries legislation.

Commercial fishing causes the inhumane slaughter of more animals than any other industry. Humane slaughter is widely considered to be a "non-negotiable" goal for animal welfare. There is a need for animal welfare organisations to expand this work to recognise and address the suffering of wild-caught fish.

22.3 Environmental and conservation NGOs

Conservation and environmental organisations work to protect species, their habitats and the environment. For some people, the main purpose of conservation is to manage the earth's resources, like fish, sustainably so that future generations can continue to use them. Others believe that protecting the world's wildlife is important in its own right. This view may be based on the idea that future generations have a right to inherit and enjoy a largely natural world with all its fascinating creatures. It may also be based on the idea that non-human species have a collective right to exist in the world. For many, support for conservation starts from a concern for animal welfare.

Environmental groups want to see lower levels of fishing for the protection of fish stocks, the oceans and the planet. High fishing pressure and dwindling fish stocks mean that fishing vessels must go further to find fish, increasing their consumption of fuel and therefore their contribution to climate change emissions.

Researchers have estimated that global fishing fleets account for 1.2% of global oil consumption (Tyedmers et al, 2005) and that this is equal to the annual consumption of oil by the Netherlands, ranked 18 in the world's oil-consuming countries. Tyedmers et al (2005) calculated that global fishing directly emits 130 million tonnes of CO_2 into the atmosphere. They also calculated that the energy burned as fuel by fisheries amounted to 12.5 times the edible energy value of the resulting fish catch.

Conservation and environmental groups raise awareness and concern for the impact of commercial fishing on marine ecosystems and biodiversity, and call for urgent action to address the decline in fish stocks. They campaign for the introduction of large nature reserves in the sea that are protected from fishing, lower levels of fishing and for action to address the birds, dolphins, turtles, sharks and other fish caught as bycatch. They investigate and report illegal fishing, calling for tougher enforcement of fishing regulations.

Environmental groups encourage supporters to lobby government for action to protect the marine environment e.g. to legislate for marine protected areas. Some encourage supporters to buy seafood from sustainable sources e.g. UK supporters are encouraged to buy fish carrying the Marine Stewardship Council logo. Some, like Greenpeace, also encourage people to eat less fish.

In supporting fish protection measures, e.g. lower levels of fishing and the creation of "no take" marine protected areas, environmentalists and those concerned about animal welfare share

Whale shot by a harpoon

Whales, like fish, suffer slow and inhumane slaughter.

Credit (above): © Greenpeace / Jeremy Sutton-Hibbert
Credit (above right): © Greenpeace / Pierre Gleizes

A Greenpeace anti-whaling demonstration in Brighton, UK in January 1982

Would the "Save the Whale" campaign have achieved so much if people did not care about the suffering of these animals, as well as about conserving their numbers?

much common ground. Both groups can perhaps broaden their support by realising that concern for the environment sometimes begins with a concern for animal suffering, and vice versa.

A prime example of an organisation working for both environmental protection and animal welfare is the UK Soil Association. This organisation works to promote organic farming which is one of, if not the, most sustainable types of farming. Soil Association organic farming has high welfare standards and farm animals are free range for at least a good part of their life.

Another example of conservation and animal welfare working together is in the campaigning against whaling. There has been a worldwide ban on commercial whaling, for conservation reasons, since 1986. Although some countries ignore the ban and continue to hunt whales, the numbers of whales killed each year is now far less. The "Save the Whale" campaign was started as a conservation campaign by Greenpeace, but would it have gained as much public support if people did not also care about the suffering of these animals killed by exploding harpoons?

Environmental groups can highlight the huge scale of animal suffering caused by commercial fishing as an additional reason for reducing it. Animal protection groups can campaign for the welfare benefits of MPAs (see 20.2 of chapter 19) as animal sanctuaries for fish. Joint campaigns can be considered. In this way, conservation and environmental groups can play a role in addressing the suffering of wild-caught fish and can encourage more people to care about marine conservation.

22.4 Supermarkets and retailers

Supermarkets generally define their purpose as providing a quality service to their customers, while at the same time recognising their responsibilities to producers, to the environment and for animal welfare.

Some supermarkets have set their own minimum animal welfare standards for what they sell, for example by not selling any eggs from caged hens. Most give shelf space to high welfare produce such as that certified by the RSPCA Freedom Foods and Soil Association schemes.

Most supermarkets also stock fish carrying the Marine Stewardship Council (MSC) logo which certifies it was fished from a sustainable source (of course in this context sustainable does not mean humane). In 2002 Sainsbury's made a commitment to source all its wild fish from sustainable sources by 2010 (Sainsbury, 2008). It admits it is still some way from meeting this target. The main reason seems to be the shortage of supply of MSC-certified fish. A similar commitment was made on ASDA's website (ASDA, 2008). TESCO say they seek to source their seafood from responsibly managed fisheries and use the FAO Code of Conduct for Responsible Fisheries as their sourcing reference (TESCO, 2008).

Sainsbury's and Tesco came respectively 3rd and 4th in the MSC Supermarket league table for 2007. Joint winners were Waitrose and Marks & Spencer who have a policy of obtaining all their wild-caught fish from well-managed fisheries (FishOnline, 2007b). These two companies also achieved the highest scores for farmed fish welfare in the 2007-8 CIWF supermarket survey (see page 96).

Supermarkets have worked to improve the welfare of farmed fish, and the sustainability of wild-caught fish through welfare and environmental certification schemes and by setting their own standards. There is a need for supermarkets to address the welfare of wild-caught fish.

Supermarkets and other retailers have influence over their suppliers and can encourage them to meet higher welfare and environmental standards. For example, Waitrose is encouraging measures to reduce bird bycatch in the long line vessels that supply it. It could, for example, also encourage these long liners to avoid using live fish for bait, a particularly abusive treatment of fish.

Retailers can encourage the MSC, and other fishery certification schemes, to incorporate animal welfare standards. As well as encouraging their fish suppliers to work to a welfare "good practice" code, they can also help industry find solutions by sponsoring research.

Supermarkets should stop selling fish caught with live bait. Failing this, they should at least ensure that fish products are labelled accordingly. Labelling which includes sufficient information on how the fish was caught, e.g. how long the lines and nets are left between setting and retrieving, would enable consumers to make more humane choices.

22.5 The fishing industry

The fishing industry includes seafood companies, wholesalers, industry groups and fishers. The purpose of this industry is the employment and income of its members both in the short and longer term. There is a need for this industry to seek ways of reducing the suffering of the fish it catches, and this could well bring economic benefits to it.

In the longer term, the interests of fishers are best met by conserving and re-building fish stocks and by a greater emphasis on quality, rather than quantity, of catch. Fishing in better managed, healthier fish stocks reduces fuel costs since less fishing effort will be required where stocks are in abundance. Reducing bycatch saves on labour costs. Using faster and less stressful methods or capture and killing can improve eating quality.

In the farming industry, animal welfare standards are widely recognised not just a means of improving public perception of the industry, but also as a means to add value to produce. The free range egg market in the UK, for example, has greatly increased in the last 10 or 20 years. More than 50% of shell eggs sold were from non-caged hens, in all but one of the supermarkets surveyed by Compassion in World Farming in 2005 (Pickett, 2005). This is despite the fact that free range and barn eggs are slightly more expensive, and demonstrates the economic benefits of animal welfare.

The UK fish farming industry has improved welfare at slaughter in recent years. This industry has helped to fund research into humane slaughter technology which is increasingly used on UK trout farms. Some fish farmers have joined welfare certification schemes.

It is long overdue for commercial fishers to address fish welfare. For some fishermen, quick use of the traditional priest may remain the most appropriate method for humane slaughter, but development of new technology will be required to make the means by which most caught fish die much more humane.

The commercial fishing industry does not recognise the sentience of fish and has so far failed to recognise its responsibility for their welfare. Codes of practice within fisheries, including the Marine Stewardship Council standards for well-managed fisheries, fail even to acknowledge fish suffering. The only exceptions to this, of which the current author are the Fair-fish certification scheme (see page 96) and the Wild Salmon Direct company (see chapter 21 on quality benefits), although a small number of fishers are using relatively more humane methods for quality reasons (see chapter 21).

Seafood companies and fishers need to recognise they have a responsibility to reduce the suffering of the huge numbers of fish that they kill. A UK fisher, interviewed on Radio 4's Farming Today, stated (21st July, 2008): *"the future of fishing is in quality"*. Animal welfare is a key part of good quality.

22.6 Governments and intergovernmental bodies

Animal welfare and wildlife conservation are among the recognised responsibilities of governments, as well as managing food security strategies and supporting the fishing and farming industries. Promoting good practice and funding research and are of key importance. Legislation to improve the welfare of fish is currently lacking in fish farming, and is off the radar in fisheries. Regulation to make fisheries more sustainable, such as the setting of catch quotas, has generally been inadequate so far.

Managing fisheries for sustainability

Under the United Nations Convention on the Law of the Sea (UCLOS), a nation state has the right to manage fisheries within its Exclusive Economic Zone (EEZ). The EEZ is generally the area of sea within 200 miles of the coastline. For countries in the European Union (EU), most management of fisheries, besides inland and inshore ones (up to 12 miles offshore), is conducted at EU level under the EU Common Fisheries Policy (CFP). The CFP sets fishing catch quotas agreed each year by the EU council of ministers, while the national governments are responsible for allocating their quota and for enforcement.

Non compliance of fisheries regulation is a problem. For example, in Europe a reported 60% of hake caught, landed mostly in Spain, is caught illegally, as is 50% of British cod (Clover, 2005b).

The failure of the CFP to protect fish stocks has been recognised by the European Commission. In 2007, the commission reported that 80% of EU fish stocks remain outside safe biological limits (EU Commission, 2007) and the reason for this problem, they say, is that

> *"the total allowable catches (TACs) agreed each year in Council are much higher than those recommended by scientists".*

The EU CFP is clearly failing to put the long term benefits of sustainable fisheries management above short term interests of fishers and politicians.

The need to protect fish stocks is at least recognised at an international level. The Food and Agriculture Organisation of the United Nations (FAO) promotes its voluntary 1995 Code of Conduct for Responsible Fisheries which (FAO, 2008b):

> *"recognizes the state of world fisheries and proposes action that would help achieve long-term sustainability".*

In the UK, an EU member, national fisheries management policy is carried out by the government Department of the Environment, Food and Rural Affairs (DEFRA) which, according to its website, is *"custodian of the marine and aquatic environment" (DEFRA, 2009b)*. Key to its strategy for managing use of the marine environment sustainably is the new Marine Bill, published in draft in 2008 (DEFRA, 2008a). The Marine Bill will set up marine protected areas (Marine Conservations Zones or MCZs) which will enjoy protection, to varying degrees, from activities like fishing which impact on the environment. It will also mean, according to DEFRA, better management of inshore fisheries and enhanced powers to tackle illegal fishing further offshore.

DEFRA acknowledges the need to reduce fishing (DEFRA, 2008b) while, at the same time, the UK Government's "Food Standards Agency" (FSA) seemingly does not. FSA advice encourages people to increase their consumption of fish to two portions a week (UK Cabinet Office, 2008). This advice has been challenged by a UK committee of MP's (EFRA, 2009) arguing

> *"Defra, the Department of Health and the Food Standard Agency should consider the wisdom of continuing to advise consumers to eat at least two portions of fish a week at a time when the ability of the marine environment to meet this demand is questionable."*

A paper published in the Canadian Medical Association Journal (Jenkins et al, 2009) argues that evidence for the health benefits of increased fish consumption is *"not as clear-cut as protagonists suggest"*. Even if the evidence were more compelling, it argues, the environmental threat posed by increased fish consumption is now obvious and advice to people to eat more fish *"does not seem wise"*. Moreover, the report says, the current levels of fish consumption in developed countries are having a harmful affect on poor coastal communities in developing ones:

> *"declining catches are increasingly diverted toward affluent markets rather than local ones, with dire consequences for the food security of poorer nations, islands and coastal communities".*

It concludes that it is vital that studies which seek to clarify the benefits of omega-3 fatty acids continue, and that alternative sources of omega-3 are developed and evaluated. Alternative sources of the long chain omega-3 fatty acids obtained from eating fish include DHA produced on algae, which is added to infant formula.

With a growing population, the average consumption of wild-caught fish (and of farmed carnivorous fish fed on wild fish) per person in the world will necessarily fall. Rather than advising people to eat more fish, alternative non-fish sources of omega-3 should be sought.

Scientists advocating more sustainable management of the world's fisheries argue that reductions in fishing fleets and fishery subsidies are necessary. Overfishing arises because there are too many people catching too few fish, and this is being aided by taxpayer subsidies. According to the World Bank, subsidies amount to 20-25% of the value of fish brought to port.

Governments recognise their responsibility to manage fisheries sustainably but are failing to do so effectively. Tougher action from governments is needed to reduce the numbers of fish caught by effective restrictions on fishing effort, and more selective ways of fishing.

Promoting humane treatment of fish

The most obvious way that Governments have encouraged humane treatment of fish is through legislation.

In 2008, Practical Fishkeeping reported that new legislation to protect fish by law for the first time was being introduced in Switzerland that year. This legislation sets welfare standards for aquarium fish, which must not be kept in aquariums that are transparent on all sides. Water quality must be maintained and social fish must not be kept alone. These fish must not be killed without prior stunning, which must be performed using narcotic substances available without veterinary prescription. The legislation also covers angling and states that fish caught to be killed should be *"killed immediately following capture with a sharp blow to the head from a blunt instrument"* (Practical Fishkeeping, 2008).

In the UK, the selling of goldfish, and other vertebrate animals, to children that are under 16 and not accompanied by an adult, was made illegal by the Animal Welfare Act 2006. This act gives general protection to fish and other animals and it is an offence to cause unnecessary suffering to an animal. Legally speaking, fish have been protected from "unnecessary suffering" since 1911 by the Protection of Animals Act which preceded the 2006 Act. The 2006 Animal Welfare Bill, however, does not apply to suffering caused in the normal course of commercial or recreational fishing. As discussed in 22.2, in 2007 the Scottish Parliament passed legislation prohibiting certain practices that cause suffering to fish in freshwater fisheries.

UK farmed fish are also covered by the Welfare of Animals (Slaughter or Killing) Regulations 1995 (transposed into British law from the EU Council Directive 93/119/EC) in the general requirements, but these do not set specific requirements in terms of permissible humane methods for the killing of fish. The Welfare of Animals (Transport) Order 1997 also applies to fish and requires that they are transported in a way that does not, and is not likely to, cause unnecessary suffering. An example of where this law could apply is where fish are being transported using a suction system for moving fish from one site to another. If a problem occurred in the system which caused injury to some fish, then continuing the use the system with a risk of injuring more fish could be an offence (Voas, 2005).

UK farm animals are additionally protected by the Welfare of Farm Animals Regulations 2007 which implement EU directives on animal welfare. These EU directives include some species-specific directives, such as those for laying hens and pigs, and a general animal welfare framework directive. However, none of these directives yet cover farmed fish. The Council of Europe published recommendations on farmed fish in 2005 (COE, 2005). These are, in time, likely to be adopted as an EU Directive for implementation by all member states (BENEFISH, 2008). These recommendations address some of the welfare concerns raised by fish farming. They state that, for example, where fish need to be graded by size, that handling and any stress caused should both be minimised. They also state that the period of pre-slaughter starvation should be kept as short as possible. Recommendations are made for humane emergency killing. They state that gill-cutting without prior stunning should not be allowed and that carbon dioxide stunning should not be used except where *"larger numbers of fish have to be killed rapidly, to protect their welfare or for disease control"*.

In Scotland, a voluntary welfare code was developed by the Scottish Executive for farmed fish in 2004, "The Welfare Code for Finfish Aquaculture", which includes issues of stocking density, grading, transport and slaughter (SFSA, 2008). These codes include a requirement that traditional methods of slaughter that may not cause immediate unconsciousness should be phased out over the next 5 years, and that routine use of carbon dioxide stunning is not permitted. They also state that fish should only be starved prior to slaughter for as long as is necessary to clear the gut.

The World Organisation for Animal Health (OIE) has become an important focus for the development of international standards and guidelines for animal welfare. This organisation is currently developing guidelines for the welfare of farmed fish, which will provide a framework for legislation in its 172 member countries (OIE, 2008a). These guidelines look likely to state that the carbon dioxide stunning, asphyxiation in air and exsanguination (gill cutting) without prior stunning are unacceptable on welfare grounds (OIE WGAW, 2007).

In its report on the welfare of farmed fish, the UK government's independent advisory body, the Farm Animal Welfare Council (FAWC), highlighted a general lack of understanding and the need for research (see 22.2). DEFRA has supported research in this area, for example the research into humane electrical killing of trout was partly funded by DEFRA (and also by the Humane Slaughter Association (HSA) and industry). The European Union has commissioned the Scientific Opinion on fish sentience discussed in chapter 3, and is also funding research into the welfare of farmed fish through the "Benefish" project. This project evaluates the welfare benefits and economic costs associated with welfare measures for farmed fish.

While it is questionable how far the welfare needs of salmon and trout can be met on fish farms, government and intergovernmental bodies have, to some extent, begun to address the welfare issues in fish farming. They have not recognised the major welfare issue of wild-fish capture. An exception to this is the Dutch government, which sponsored the Dutch study into killing methods in capture fisheries (V.d. Vis and Kestin, 1996), discussed in chapter 17, with a view to improving welfare and future legislation.

Summary

Governments and intergovernmental institutions, including the EU and the OIE, have begun to recognise the sentience of fish. The Council of Europe has published recommendations on the welfare of farmed fish. The OIE is currently developing welfare codes for farmed fish and these will give a framework for future legislation. It seems likely that these codes will state as unacceptable the inhumane slaughter practices that have been common in the industry, e.g. carbon dioxide stunning, asphyxiation in air and prolonged pre-slaughter starvation.

Governments and intergovernmental institutions have also funded research into farmed fish welfare. The development of humane electrical stun/kill technology, which is increasingly being used in the British trout industry, was partly funded by the UK government.

Despite the high numbers and likely severity of fish suffering caused by commercial fish capture, this issue has not been recognised by governments (none, apparently, other than the Dutch government) as a welfare issue.

Governments should recognise and begin to address this problem. Under the EU Lisbon Treaty, the EU is required to recognise the welfare needs of animals in fisheries (see page 20). There are already pressing reasons why governments should take tougher action to reduce levels of fishing and to make it more sustainable. The suffering of fish is another reason for doing so. As Gandhi once said:

> *"The greatness of a nation and its moral progress can be judged by the way its animals are treated."*

22.7 Welfare and conservation assurance schemes for wild-caught fish

Assurance schemes are a powerful means by which consumers can exert pressure on industry to become more humane and more sustainable. The RSPCA "Freedom Food" scheme and the "Soil Association" organic scheme are two examples of current schemes which assure welfare standards for farmed fish during slaughter and rearing. Farmers who can demonstrate compliance with the respective standards of these schemes can become accredited by them, and are then entitled to display the scheme logo on their produce. These schemes enable consumers to make compassionate choices when shopping, and reward farmers for higher welfare standards by enabling them to attract a better price for their farmed fish.

There is a need for assurance schemes that give animal welfare standards in wild fish capture. There are currently no such schemes besides the Fair-fish scheme, which is currently being developed (see page 96).

One possibility is that existing welfare schemes could be expanded to cover wild-caught fish. It is also possible is that a marine conservation assurance scheme, such as the Marine Stewardship Council (MSC) discussed below, could broaden its scope to include welfare of caught fish. Another possibility is the creation of new assurance schemes for the welfare of wild-catch fish, similar to the Swiss Fair-fish scheme (see page 96).

Monitoring and enforcing welfare codes for wild-caught fish assurance schemes will present challenges. However, monitoring compliance with existing fisheries regulations is happening already for conservation and catch levels. In the US, for example, 42 different fisheries are monitored by Governmental observer programs annually, logging over 60,000 observer days at sea (NOAA, 2008e). It may therefore be possible for welfare checks to be carried out by existing observer programs. It may also be possible to scientifically assess the likely stress caused to a fish during capture and killing by testing the carcass. Testing samples of landed catch might therefore assist monitoring, as might developments in webcam technology.

The Marine Stewardship Council

The Marine Stewardship Council (MSC) is the world's leading eco-labelling assurance scheme for wild-caught seafood. At present, 26 Fisheries are certified under the scheme, accounting for 4 million tonnes, or 4%, of annual global seafood catch. MSC accreditation is awarded to fisheries that can demonstrate they are subject to an effective management system which prevents overfishing; protects the diversity of the ecosystem and which respects the local, national and international laws. Most fisheries currently accredited pertain to fish stocks for which there are exclusive national access rights and limited access. Accredited fisheries are comprised of individual fishers and companies that work cooperatively and input into the management process.

Any organization wishing to apply the MSC logo to a product must source fish from a certified supplier and obtain a "Chain of custody" certification. The latter is the means by which MSC ensures traceability from the fisher through the supply chain.

Although the MSC is not an animal welfare certification scheme, some of the MSC principles do have relevance to reducing suffering as well as to sustainability e.g. the requirement to set catch levels that maintain the target population; to make use of fishing gear and practices designed to avoid bycatch and to minimise lost fishing gear (MSC, 2002).

Some environmental groups such as Greenpeace believe the MSC principles and criteria need to be stricter and that, for example, the MSC should not certify fisheries that are *"by any reasonable standard highly controversial"* or fisheries with a depleted fish stock (Greenpeace UK, 2007).

While some believe the rules of the MSC are not strict enough, Kaiser and Edwards-Jones (2006) argue it may be time to consider a tiered ranking within the scheme (e.g. gold, silver, bronze) as a way of rewarding achievement *"on the road to full sustainability"*. They also suggest a switch of focus from consumers to retailers, and refer to some success with this approach in promoting eco-labelled timber products. Another option suggested is to certify individual fishers who fish sustainability even if the stock itself is overfished. This latter option would seem to give the scheme greater potential to begin to incorporate animal welfare standards.

23 Strategies for improving welfare of wild-caught fish

In the order of 1 trillion fish are caught from the wild each year for human consumption, feed and oil production, bait and other purposes. Most probably suffer severe stress of a considerable duration during the course of capture. Humane slaughter following landing is the exception rather than the rule. In fact, rather than being slaughtered at all, most fish die in the process of capture, storage and processing which includes gutting, filleting, chilling and freezing.

As has been discussed in chapter 3, fish are sentient beings capable of suffering pain and fear. The suffering caused by commercial fishing is therefore a major animal welfare problem.

Some individuals and cultures are vegetarian and avoid eating fish. On the other hand, fishing is widely considered important for its roles in providing nutrition including proteins and vital fatty-acids, for providing employment and for its place in human culture. Whatever the merits of these different ethical, religious or cultural views, fishing is likely to continue. What steps can be taken, then, to reduce the animal welfare impact of fishing whilst maintaining many of its advantages to society? The welfare cost of commercial fishing could be substantially reduced by taking the steps 1-4 given on the following page.

To date, relatively few animal welfare groups have seriously addressed the welfare issues associated with commercial fishing. Reasons for this include the following:

- there are serious practical difficulties involved in catching fish without suffering. Genuinely humane slaughter may be unachievable
- a systematic approach to the problem would involve international agreements which are difficult enough to achieve for fishery sustainability where the human welfare benefit is obvious
- enforcement would be challenging
- many people who care about the welfare of companion or other domestic animals, have yet to develop an equivalent empathy for fish.

These practical difficulties are real, but the overwhelming magnitude of the welfare cost of commercial fishing means that even modest measures may benefit very large numbers of animals. How animal welfare groups might work towards this is discussed on the subsequent page.

Strategies for reducing the welfare cost of commercial fishing

1. **Reduce the numbers of fish caught**. This could be achieved by:

   a) Reducing levels of fishing to more sustainable levels, by:

      (i) reducing fishing effort
      (ii) setting up temporary or permanent no-catch zones
      (iii) selectively fishing for larger fish
      (iv) selectively fishing to avoid bycatch (and bycatch death rates)
      (v) reducing ghost fishing
      (vi) better enforcement of regulations.

      A balance between human and fish welfare is achieved by aiming to catch a smaller number of fish and letting fish grow larger. This will also be necessary for preserving fish stocks, and a more natural marine environment, for future generations. Reducing the level of fishing effort should also reduce the significant greenhouse gas emissions of the fishing industry. Rather than encouraging people to eat more fish, alternative non-fish sources of omega-3 should be developed and evaluated.

   b) Reducing levels of industrial fishing for species intended for conversion to feed or oil. The number of fish affected here is large since these include small species such as anchovies, capelin, sandeels and sprats which are caught in huge numbers. The human benefit is lessened by the feed conversion rule that it takes between 2.5 and 5 tonnes of feed fish, converted to fish oil and meal, to produce one tonne of farmed carnivorous fish. It must be questioned whether the production of 1.5-3g of cod or salmon flesh in a fish farm justifies the stressful death of a 5g sprat or a 10g anchovy or sandeel. A substantial proportion of fish caught are captured for feed or non food uses, either whole or (mostly) as fishmeal and fish oil.

   c) Reducing the use of bait fish. Wherever possible, fish off-cuts or synthetic lures should be used instead.

2. **Reduce fish suffering during the process of capture**. All major methods of fish capture cause stress and, usually, injury. Long durations of capture, which may exceed 24 hours in some cases, multiply the suffering many times. Further, the severity of stress and injury is likely to increase the longer the fish remains caught in a net or on a hook. Steps to bring nets and lines in as frequently as possible should significantly reduce this suffering, especially if followed by humane slaughter and quick release of bycatch. Reduced stress and quicker landing are also likely to benefit fish quality. The Fair-fish fish welfare certification scheme limits the whole capture and slaughter process to a maximum duration of 30 minutes.

3. **Slaughtering fish humanely as soon as possible after landing**. Artisanal fishermen could achieve this manually. Humane slaughter methods for farmed fish need to be adapted for use at sea. It needs to become unthinkable, as well as unacceptable, to gut or fillet fish that are still alive and conscious.

4. **Ban the use of live fish as bait**. This should be seen as contrary to any norms of civilised animal treatment.

Animal welfare groups can achieve much by:

1. Recognising that commercial fishing raises major welfare problems and that long-term strategies are required to address them.
2. Persuading the public that fish welfare matters. This includes educational programmes to promote animal sentiency.
3. Lobbying governments and intergovernmental organisations such as the European Commission to:
    - develop humane slaughter technology for wild-caught fish
    - carry out welfare assessment of different catching methods and develop welfare codes
    - promote greater understanding of fish sentience.
4. Lobbying the OIE and Council of Europe to develop fish welfare standards for wild-caught fish
5. Campaigning alongside environmental groups for:
    - lower levels of fishing effort, for sustainability and welfare objectives, including the development of "no take" zones
    - policies that reduce levels of bycatch
    - a reduction in industrial fishing for feed and oil.
6. Lobbying governments, retailers and fisheries for an end to the use of live fish as bait
7. Lobbying the Marine Stewardship Council to develop a welfare scheme which fisheries could subscribe to.
8. Encouraging the development of fish welfare certification schemes such as Fair-fish and lobbying retailers to subscribe to such schemes.

Environmental groups could widen their support base by acknowledging that fish are sentient beings and that fish welfare matters. Respect for the sentience of whales, and other cetaceans, has done much to garner public support for their protection. Increased public understanding of the welfare problems associated with commercial fishing could only be helpful in developing sustainable fish management strategies in the future.

Retailers have a role in developing Corporate Social Responsibility policies which assert that ethical fishing practices encompass fish welfare as well as sustainability and fair trade issues. Product lines based on welfare principles need to be developed and promoted to the public. The fishing industry could benefit from recognising that there are commercial opportunities for sustainable higher welfare practices which could earn better wages for fishermen, especially those working on a smaller–scale. Fair-fish certification could be seen as one such model.

Animal scientists will play a key role in establishing fish welfare science, developing more humane practices and educating the next generation. Governments and intergovernmental bodies will have a key role in funding this research, in developing national and international codes of practice and, ultimately, passing and enforcing the necessary legislation.

Better things could be happening at sea.

Glossary

Glossary

Term	Explanation
Affective states	*Feelings that matter to an animal. These include emotions, desires, preferences, intentions, pleasures, pains, drives, moods and attitudes.*
Analgesic	*A pain killing drug. Unlike anaesthetics, which work by reducing or removing all sensation, analgesics work specifically to reduce or remove pain.*
Bottom trawling	*See trawling.*
Brailing	*A method of landing fish. Brailing fish from a purse seine net involves scooping up part of the catch in a smaller net, the bottom of which is opened and closed by a drawstring rope, and then dropping the fish on the vessel.*
BRD	*See "bycatch reduction device".*
Bycatch	*Bycatch refers to the animals caught unintentionally by fishers in the process of trying to catch the target species. Bycatch can also include under-sized individuals of the target species.*
Bycatch reduction device	*A "bycatch reduction device" (BRDs) is a modification to fishing gear that helps prevent bycatch. BRDs fitted to trawl nets (or purse seine nets) allow non-target animals to escape. A pinger (q.v.) is a BRD fitted to gill nets to reduce mammal bycatch.*
Cartesian	*Of, or relating to, the French philosopher René Descartes (1596-1650). Descartes believed that animals are not conscious and therefore cannot experience pain and suffering.*
"Catch and release" fishing	*"Catch and release" fishing is where fish are caught by hook and line and subsequently released, usually for sport.*
Cetaceans	*A taxonomic group of mammals which includes whales, dolphins and porpoises.*
CFP	*The European Union's "Common Fisheries Policy". The CFP sets the overall catch limits (TAC's (q.v.)) for each country in the European Union.*
Chumming	*The practice of scattering bait fish (usually live) among tuna to encourage them to snap at the fishers hooks. Chumming is used in pole and line fishing (q.v.).*
Circle hook	*A type of fishing hook that is more circular than the J-shaped hook. The point is turned inward so that the fish is more likely to be hooked around the mouth than in the stomach, throat or vital organs.*
CIWF	*See Compassion in World Farming.*
Cod end	*The cod end (or cod-end) is the narrow, closed end of a trawl net where the captured fish collect.*

Glossary (continued)	
Compassion in World Farming	*A leading international farm animal welfare charity.*
Convergent evolution	*The process by which unrelated species acquire similar biological traits in adapting to similar environmental pressures. A classic example is the wing which has developed separately in birds, bats and insects.*
Cortisol	*A hormone associated with stress and other forms of arousal. Measurements of cortisol are used as an indicator of stress and suffering in animals, including fish.*
Decompression	*Fish species with a closed swim bladder that are caught from some depth can experience decompression effects. This is due to the sudden change in pressure as they are raised to the surface, causing the swim bladder to over-inflate or burst. Parts of the gut may be forced out through the mouth and anus.*
DEFRA	*The UK government Department of Environment, Food and Rural Affairs.*
Demersal	*Demersal refers to the part of the sea near to the sea bottom.* *Demersal species are those that inhabit this area. Demersal trawling, also called bottom trawling, targets such species.*
Diencephalon	*Part of the brain in vertebrates. The diencephalon, together with the telencephalon, constitute the forebrain. The diencephalon includes the thalamus and hypothalamus.*
Discards	*Bycatch may be retained and sold but often it is simply thrown back into the sea (often dead), in which case it is called "discarded bycatch" or "discards". A fish may be discarded because it has low market value or because it cannot be legally landed. This would apply where the fisher has already exceeded their legal quota (q.v.) for the species, or where the fish is smaller than the minimum legal landing size (q.v.).*
Drift net	*A drift net is a gill net (q.v.) that is allowed to drift with prevailing currents.*
Electrical stunning	*A method sometimes used to stun/kill farmed fish by passing an electrical current through the water. If performed properly, this method can stun and kill the fish with immediate loss of consciousness.*
Endogenous opioids	*Substances produced in the brain in order to reduce pain (sometimes called endogenous opiates).*
Enkephalin	*Enkephalins are endogenous opioids (sometimes called endogenous opiates). These are substances produced in the brain in order to reduce pain.*
Escapees	*Escapees are the fish that come into contact with fishing gear and subsequently escape without being caught and landed. The term is usually applied to fish that enter trawl nets and escape through the mesh or through a "bycatch reduction device". Escapees may die as a result of stress or injury incurred.*
EU	*The European Union.*
Exsanguination	*Draining the blood from an animal by, for example, cutting the gills.*
FAD	*See "fish aggregating device".*

Glossary (continued)

Fair-fish certification scheme	*The Fair-fish certification scheme is a welfare certification scheme for wild-caught fish that is currently being developed for artisanal fishers in Senegal.*
FAO	*Food and Agriculture Organization of the United Nations.*
FAOSTAT	*An internet source of statistics relating to global food and agriculture, published by the FAO (q.v.).*
Feed fish	*Fish caught to feed to animals (either whole or, more usually, as fishmeal (q.v.)) rather than humans.*
Finning	*The practice of cutting the fins of a shark and throwing it back to sea, often still alive. This practice is banned in many fisheries but is still common.*
Fish aggregating device	*"Fish aggregating device" (FAD). An object, which is sometimes called a "fish attraction device", floated in the water to attract fish. This exploits the natural behaviour of some species to congregate beneath floating logs.*
Fish attraction device	*See "fish aggregating device".*
Fish pump	*Fish pumps are a means of landing or moving fish without removing them from water. Fish pumps used in fishing can cause injury. Fish pumps which minimise stress and injury have been designed for use on fish farms.*
Fishing down the food web	*A phenomenon whereby fishing pressure on larger fish such as cod, which tend to be piscivores (fish eaters), produces a decline in their numbers and a corresponding increase in the number of prey species such as herring. As a consequence, catches increasingly consist of fish species that are lower down in the food web.*
Fishmeal or fish meal	*Fishmeal is a brown powder processed largely from fish caught specifically for the purpose together with some fish trimmings (q.v.) i.e. off-cuts from food fish. Fish are converted into fish oil and fishmeal in a process called reduction (q.v.). Fishmeal and fish oil are mostly used as animal feed, mainly for farmed fish.*
Gaffing	*Spiking fish with a hand held hook to bring them aboard. Sometimes called "foul hooking".*
Gas bladder	*See swim bladder.*
Ghost fishing	*The capture of fish by lost or discarded fishing nets or traps.*
Gibbing	*A form of gutting used on herring in which the gills, long gut and stomach are removed from a fish by inserting a knife at the gills.*
Gill net or gillnet	*A gill net is a wall of netting, hanging in the sea, which is invisible to fish and traps fish as they swim into it. As the try to reverse out, they become trapped by the gills.*
Gutting	*Cutting a fish open to remove its guts.*
Harpooning	*A fishing method in which a large fish is speared and then generally allowed to swim to exhaustion before landing.*
Humane slaughter	*Humane slaughter methods are ones that kill without causing suffering. A method is humane if it causes an immediate loss of consciousness which lasts until death (or if not immediate, where the means of inducing unconsciousness does not cause suffering (e.g. food grade anaesthetics)).*

Glossary (continued)	
Industrial fishing	*"Industrial fishing" is the capture of wild fish for industrial use i.e. for conversion to fishmeal and fish oil, rather than for direct human consumption.*
Industrial species	*Species such as Peruvian anchovy that are mostly caught to make fishmeal and fish oil i.e. for industrial use.*
Knot	*A unit of speed equal to 1 nautical mile per hour or approximately 1.15 miles (1.85km) per hour.*
Live bait fish	*Live fish that are used as bait in hook and line fishing. Live bait fish are scattered among tuna or impaled on hooks.*
Live bait	*In this report, the term "live bait" refers to live bait fish (q.v.)*
Long line fishing or longlining	*A fishing method in which long lines, of up to 100km, are set horizontally or vertically in the water. Short lengths of line carrying baited hooks are attached at intervals. Lines are retrieved hours, or perhaps days, later.*
Marine Protected Area	*Marine Protected Area (MPA) is an area of sea which enjoys some protection from environmentally damaging activity such as fishing.*
Marine Reserve	*See Marine Protected Area.*
Mid-water trawling	*See trawling.*
Minimum legal landing Size	*Sometimes a fishery sets a "minimum legal landing size" for a given species in order to help address overfishing. This is to try to prevent fish being caught before they are old enough to have bred or have reached their growth potential.*
Morphine	*An analgesic drug which is used to reduce pain.*
MPA	*See Marine Protected Area.*
Neocortex	*This is a laminated structure which forms the outer layer of the telencephalon in mammals.*
NGO	*Non-governmental organisation.*
"No take" zone	*A Marine Protected Area (q.v.) in which fishing is not allowed.*
Nociception	*The detection of a noxious (i.e. potentially or actually damaging to body tissue) stimulus by nociceptors.*
Nociceptors	*Pain receptors in the skin, so-called because they detect noxious stimuli such as high temperatures or harmful chemicals.*
Noxious	*Potentially or actually damaging to body tissue, such as high mechanical pressure, extremes of temperature or venoms.*
OIE	*World Organisation for Animal Health. This organisation has changed its name since it was called the "Office International des Epizooties" but has kept its historical acronym OIE.*

Glossary (continued)

Overfishing	*A level of fishing that is unsustainable owing to its effect on the target species or on other species in the ecosystem.*
Pelagic	*Pelagic refers to any part of the sea that is not on or near the sea bottom. Pelagic species are those that inhabit this area. Pelagic trawling, also called mid-water trawling, targets such species.*
Percussive stunning	*A method used to stun/kill fish with a blow to the head. This can be humane, causing immediate loss of consciousness, if performed correctly and if followed up immediately by bleeding (i.e. draining the blood to ensure the fish dies before recovering consciousness). Percussive stunning may be performed manually with a priest (q.v.) or by an automatic stunning machine (used on fish farms).*
Pinger	*A pinger is a bycatch reduction device (q.v.) for gill nets. The device emits sound and can be attached to gill nets to make the nets audibly "visible" to mammals.*
Pole and line fishing	*A hook and line fishing method in which schooling fish, such as tuna, are enticed to snap at hooks by chumming (q.v.). Once hooked, the fish are quickly landed.*
Priest	*A club used to percussively stun a fish with a blow to the head. This is a manual method of potentially humane slaughter used on fish individually.*
Purse seine fishing	*Purse seine fishing, or purse seining, is a fishing method in which a wall of netting encircles a school of fish and is then pulled tight like a draw-string purse.*
Quota	*A quota is a legal limit on the amount of fish that a fishing vessel is allowed to land, for a given species. Quotas are allocated according to the "Total Allowable Catch" (q.v.) for the fishery, and the number of fishing boats.*
Ramping	*A method of landing fish caught in a purse seine net. The stern end of the boat is tilted down and the entire catch is hauled on deck.*
Reduction	*Reduction is the process of converting wild-caught fish into fishmeal and fish oil.*
Reflex	*An involuntary response to a stimulus mediated through the nervous system. In humans, the knee-jerk and withdrawal of the hand from a hot object are examples. Simple reflex behaviour is not learned and is not considered to imply consciousness.*
Retrieval survey	*A vessel survey of fishing grounds to retrieve lost nets (and so stop them "ghost fishing" (q.v.)).*
Revival box	*A tank which holds fish caught as bycatch prior to releasing them.*
Rockhoppers	*Large heavy wheels that are attached to trawl gear to enable it to travel over rocky terrain. These are particularly damaging to the seabed.*
RSPCA	*Royal Society for the Prevention of Cruelty to Animals. A leading animal welfare charity in the UK.*
RSPB	*Royal Society for the Protection of Birds. A leading conservation charity in the UK.*
Selectivity	*The selectivity of a fishing method is the extent to which the unintended capture of animals, i.e. bycatch, is avoided.*

Glossary (continued)

Sentient	*Sentient animals have feelings that matter to them. In other words, a sentient animal is one that has the capacity to suffer or to experience a sense of well being.*
Slipping	*The practice of deliberately releasing part of the catch from a purse seine net prior to landing it.*
Soak time	*The time interval between setting fishing gear (e.g. gill nets, long lines or fish traps) and retrieving it.*
Sorting grid	*A sorting grid is a type of "bycatch reduction device" (q.v.). It is a rigid grid consisting of bars spaced a few centimetres apart such that fish below a certain size are able to swim through. The grid is positioned within a trawl or purse seine net so as to enable these smaller fish, but not larger ones, to escape the net.*
Spiking	*Spiking (also called "ike jime") is a method of killing a fish by inserting a spike into the brain. If this is performed accurately, the fish can become unconscious immediately and is therefore potentially humane.*
Swim bladder	*This is an internal gas-filled organ that helps a fish maintain its buoyancy.*
TAC	*See "Total Allowable Catch".*
Tangle net	*A tangle net is a variation of gill net with a smaller mesh so that fish become entangled in it rather than snared by it.*
TED	*See "Turtle exclusion device".*
Telencephalon	*Part of the brain in vertebrates. The telencephalon, together with the diencephalon, constitute the forebrain. Sometimes called the cerebrum.*
Total Allowable Catch	*"Total Allowable Catch" (TAC) is a legal limit on the amount of fish that can be legally landed in a given fishery and for a given species. In the European Union, the total allowable catches (TACs) are agreed each year by the Council of Ministers.*
Trammel net	*A trammel net is a variation of gill net comprising an inner layer of fine mesh and one or two outer layers of a larger mesh. The inner net is looser than the outer ones, ensuring that the fish become entangled. Fish become both snared and entangled in it.*
Trash species	*A term sometimes used by the fishing industry to describe fish of low commercial value which are often used for bait, feed or to make fishmeal.*
Trawling	*Trawling is a method of fishing in which a bag-shaped net is towed through the water, catching fish as they become exhausted and out-swum. Trawling may operate at a depth between the surface and the sea bottom (mid-water trawling) or the net may be towed along the seabed (bottom trawling).*
Trimmings	*Fish trimmings are the off-cuts, such as heads and guts, from fish eaten as food. Trimmings, along with whole fish, are used in the production of fishmeal (q.v.).*
Trolling	*A hook and line fishing method in which lines bearing baited hooks or lures are towed through the water by a slow moving vessel.*
Turtle-exclusion devices	*Turtle exclusion devices (TEDs) are metal grids fitted to shrimp trawl nets that allow most marine turtles to escape.*

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Appendix A

Table 4 is discussed in chapter 19. Estimated numbers in this table are to 2 significant figures. * indicates a multi-species category.

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights

Species (scientific name)	Average annual capture 1999-2007 (t) (FAO, 2009a)	Estimated mean weight range (g)	Estimated number range (lower) in millions	Estimated number range (upper) in millions
Anchoveta(=Peruvian anchovy) (Engraulis ringens)	8,736,862	10-29	300,000	870,000
Japanese anchovy (Engraulis japonicus)	1,607,856	20-22	73,000	80,000
Sandeels(=Sandlances) nei (Ammodytes spp)*	530,823	10	53,000	53,000
European sprat (Sprattus sprattus)	652,621	17	39,000	39,000
Black and Caspian Sea sprat (Clupeonella cultriventris)	92,852	3-4	22,000	30,000
Capelin (Mallotus villosus)	1,034,615	17-50	21,000	61,000
European anchovy (Engraulis encrasicolus)	598,248	8-38	16,000	74,000
Araucanian herring (Strangomera bentincki)	427,893	27-34	13,000	16,000
Stolephorus anchovies (Stolephorus spp)*	269,407	3-22	12,000	87,000
European pilchard(=Sardine) (Sardina pilchardus)	1,049,680	69-127	8,300	15,000
Southern African anchovy (Engraulis capensis)	235,294	8-38	6,200	29,000
Blue whiting(=Poutassou) (Micromesistius poutassou)	1,864,858	135-340	5,500	14,000
Pacific anchoveta (Cetengraulis mysticetus)	125,698	11-24	5,200	11,000
Scads nei (Decapterus spp)*	1,100,340	63-231	4,800	17,000
Pacific saury (Cololabis saira)	378,620	83	4,600	4,600
Round sardinella (Sardinella aurita)	445,777	100	4,500	4,500
Pacific sandlance (Ammodytes personatus)	176,519	46	3,900	3,900
Sardinellas nei (Sardinella spp)*	821,669	7-224	3,700	120,000
Atlantic herring (Clupea harengus)	2,165,610	100-600	3,600	22,000
Japanese jack mackerel (Trachurus japonicus)	300,172	15-84	3,600	20,000
Indian scad (Decapterus russelli)	174,162	50	3,500	3,500
Goldstripe sardinella (Sardinella gibbosa)	169,019	10-55	3,100	18,000
Alaska pollock(=Walleye poll.) (Theragra chalcogramma)	2,903,353	227-1,000	2,900	13,000
Anchovies, etc. nei (Engraulidae)*	268,825	3-94	2,800	87,000
California pilchard (Sardinops sagax)	516,144	120-183	2,800	4,300
Indian oil sardine (Sardinella longiceps)	370,242	87-132	2,800	4,300

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)

Species (scientific name)	Average annual capture 1999-2007 (t) (FAO, 2009a)	Estimated mean weight range (g)	Estimated number range (lower) in millions	Estimated number range (upper) in millions
Yellowstripe scad (Selaroides leptolepis)	176,757	64-66	2,700	2,800
Bombay-duck (Harpadon nehereus)	181,818	5-69	2,600	38,000
Norway pout (Trisopterus esmarkii)	70,670	20-28	2,500	3,500
Chub mackerel (Scomber japonicus)	1,781,553	100-750	2,400	18,000
Gulf menhaden (Brevoortia patronus)	513,153	234	2,200	2,200
Elongate ilisha (Ilisha elongata)	87,018	31-42	2,100	2,800
Largehead hairtail (Trichiurus lepturus)	1,298,327	32-713	1,800	41,000
Chilean jack mackerel (Trachurus murphyi)	1,778,803	200-1,000	1,800	8,900
Japanese pilchard (Sardinops sagax)	263,117	120-183	1,400	2,200
Atlantic mackerel (Scomber scombrus)	650,054	389-454	1,400	1,700
Atlantic horse mackerel (Trachurus trachurus)	228,074	160	1,400	1,400
Southern African pilchard (Sardinops sagax)	243,062	120-183	1,300	2,000
Rainbow sardine (Dussumieria acuta)	35,592	23-28	1,300	1,600
Indian mackerel (Rastrelliger kanagurta)	226,216	54-193	1,200	4,200
Kelee shad (Hilsa kelee)	87,178	40-73	1,200	2,200
Whitehead's round herring (Etrumeus whiteheadi)	49,414	29-40	1,200	1,700
Cape horse mackerel (Trachurus capensis)	361,017	291	1,200	1,200
Bali sardinella (Sardinella lemuru)	120,128	49-112	1,100	2,400
Californian anchovy (Engraulis mordax)	24,102	22	1,100	1,100
Pacific thread herring (Opisthonema libertate)	111,174	33-110	1,000	3,400
Argentine anchovy (Engraulis anchoita)	27,179	4-31	890	7,600
Pacific herring (Clupea pallasii pallasii)	351,598	64-400	880	5,500
Madeiran sardinella (Sardinella maderensis)	145,688	30-224	650	4,900
Japanese scad (Decapterus maruadsi)	41,089	63	650	650
Silver pomfrets nei (Pampus spp)*	320,531	455-500	640	700
Red-eye round herring (Etrumeus teres)	39,976	63	640	640
Argentine hake (Merluccius hubbsi)	375,198	400-600	630	940
Bonga shad (Ethmalosa fimbriata)	181,398	143-292	620	1,300
Atlantic menhaden (Brevoortia tyrannus)	211,127	162-349	600	1,300
Bigeye grunt (Brachydeuterus auritus)	26,586	10-45	590	2,600
South American pilchard (Sardinops sagax)	108,655	120-183	590	910
Bigeye scad (Selar crumenophthalmus)	133,386	230	580	580
Yellow croaker (Larimichthys polyactis)	272,569	229-499	550	1,200
Falkland sprat (Sprattus fuegensis)	10,043	16-19	520	630
Brazilian sardinella (Sardinella janeiro)	37,329	72	520	520

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)

Species (scientific name)	Average annual capture 1999-2007 (t) (FAO, 2009a)	Estimated mean weight range (g)	Estimated number range (lower) in millions	Estimated number range (upper) in millions
Pacific menhaden (Ethmidium maculatum)	23,980	39-53	450	610
Beaked redfish (Sebastes mentella)	76,115	195	390	390
Yellowfin sole (Limanda aspera)	73,558	200	370	370
Goatfishes (Upeneus spp)*	66,693	7-189	350	9,500
Jack and horse mackerels nei (Trachurus spp)*	340,018	11-1,000	340	30,000
Southern blue whiting (Micromesistius australis)	135,050	400	340	340
Whiting (Merlangius merlangus)	54,774	122-165	330	450
North Pacific hake (Merluccius productus)	278,506	500-1,035	270	560
Bogue (Boops boops)	30,319	58-112	270	520
Frigate and bullet tunas (Auxis thazard, A. rochei)*	255,070	237-1,034	250	1,100
Polar cod (Boreogadus saida)	27,374	83-112	250	330
Brazilian flathead (Percophis brasiliensis)	7,953	4-33	240	1,900
Atlantic cod (Gadus morhua)	898,998	800-4,000	220	1,100
Skipjack tuna (Katsuwonus pelamis)	2,161,174	2,000-10,000	220	1,100
Atlantic thread herring (Opisthonema oglinum)	18,992	65-91	210	290
Bigeyes nei (Priacanthus spp)*	121,170	50-618	200	2,400
Klunzinger's mullet (Liza klunzingeri)	5,429	20-28	200	270
Japanese sardinella (Sardinella zunasi)	1,998	10	190	190
Hilsa shad (Tenualosa ilisha)	246,823	1,400	180	180
Snakeskin gourami (Trichogaster pectoralis)	26,137	154	170	170
Haddock (Melanogrammus aeglefinus)	282,227	900-1,800	160	310
Pink(=Humpback)salmon (Oncorhynchus gorbuscha)	357,492	1,364-2,273	160	260
Okhotsk atka mackerel (Pleurogrammus azonus)	208,605	1,295	160	160
Cape hakes (Merluccius capensis,M.paradox.)*	305,500	465-2,030	150	660
Cunene horse mackerel (Trachurus trecae)	66,436	21-498	130	3,200
Silver-stripe round herring (Spratelloides gracilis)	503	3-4	130	160
Blue grenadier (Macruronus novaezelandiae)	198,697	1,500	130	130
Mullets nei (Mugilidae)*	244,721	20-2,000	120	12,000
Patagonian grenadier (Macruronus magellanicus)	252,763	993-2,103	120	250
Nile tilapia (Oreochromis niloticus niloticus)	234,894	2,000	120	120
Atlantic bumper (Chloroscombrus chrysurus)	16,007	21-140	110	760
Butterfishes, pomfrets nei (Stromateidae)*	56,937	80-500	110	710
Big-scale sand smelt (Atherina boyeri)	963	3-9	110	290

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Black pomfret (Parastromateus niger)	64,381	583	110	110
Torpedo scad (Megalaspis cordyla)	86,578	931	93	93
Atlantic silverside (Menidia menidia)	424	5	92	92
Common dab (Limanda limanda)	16,287	166-178	91	98
Flathead grey mullet (Mugil cephalus)	122,175	909-1,364	90	130
Saithe(=Pollock) (Pollachius virens)	396,027	2,200-4,500	88	180
European plaice (Pleuronectes platessa)	94,826	1,100	86	86
Silver pomfret (Pampus argenteus)	42,526	455-500	85	93
Goatfishes, red mullets nei (Mullidae)*	25,723	7-313	82	3,700
Atlantic redfishes nei (Sebastes spp)*	104,973	109-1,284	82	960
Chacunda gizzard shad (Anodontostoma chacunda)	6,440	78-79	82	82
Nile perch (Lates niloticus)	318,445	2,000-4,000	80	160
Cabinza grunt (Isacia conceptionis)	4,396	40-55	80	110
Whitemouth croaker (Micropogonias furnieri)	80,366	638-1,023	79	130
Pacific cod (Gadus macrocephalus)	354,889	2,273-4,545	78	160
Bobo croaker (Pseudotolithus elongatus)	16,150	216	75	75
Wolf-herrings nei (Chirocentrus spp)*	54,007	90-757	71	600
Arrow-tooth flounder (Atheresthes stomias)	18,062	131-260	69	140
Atka mackerel (Pleurogrammus monopterygius)	51,226	697-748	68	73
Yellowfin tuna (Thunnus albacares)	1,257,110	5,000-20,000	63	250
Indo-Pacific king mackerel (Scomberomorus guttatus)	43,983	730	60	60
Surmullet (Mullus surmuletus)	15,153	81-260	58	190
So-iny (redlip) mullet (Chelon haematocheilus)	70,635	1,238	57	57
Roundnose grenadier (Coryphaenoides rupestris)	27,617	372-507	54	74
South Pacific hake (Merluccius gayi gayi)	134,328	886-2,699	50	150
European flounder (Platichthys flesus)	18,006	239-367	49	75
Kawakawa (Euthynnus affinis)	233,558	5,000	47	47
Brazilian codling (Urophycis brasiliensis)	5,604	118-121	46	47
Scaled sardines (Harengula spp)*	1,404	19-32	44	74
Common sole (Solea solea)	41,471	23-971	43	1,800
Whitefin wolf-herring (Chirocentrus nudus)	5,136	90-123	42	57
European hake (Merluccius merluccius)	72,895	1,800	40	40
Frigate tuna (Auxis thazard thazard)	39,814	237-1,034	39	170
Chum(=Keta=Dog)salmon (Oncorhynchus keta)	316,054	3,182-8,182	39	99

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Crucian carp (Carassius carassius)	5,648	150	38	38
Mediterranean horse mackerel (Trachurus mediterraneus)	19,823	11-600	33	1,800
Narrow-barred Spanish mackerel (Scomberomorus commerson)	197,585	5,750-5,900	33	34
Tadpole codling (Salilota australis)	10,247	210-329	31	49
Argentines (Argentina spp)*	31,780	56-1,079	29	560
Atlantic saury (Scomberesox saurus saurus)	3,158	80-110	29	39
Bleak (Alburnus alburnus)	800	23-28	29	35
Roach (Rutilus rutilus)	7,044	69-255	28	100
Yellowtail flounder (Limanda ferruginea)	16,521	500-600	28	33
Blue tilapia (Oreochromis aureus)	2,568	95	27	27
Sockeye(=Red)salmon (Oncorhynchus nerka)	131,284	2,300-5,000	26	57
Daggertooth pike conger (Muraenesox cinereus)	263,236	10,689	25	25
Black scabbardfish (Aphanopus carbo)	11,901	499	24	24
Japanese Spanish mackerel (Scomberomorus niphonius)	49,813	1,562-2,130	23	32
Alewife (Alosa pseudoharengus)	6,372	227-273	23	28
Argentine (Argentina sphyraena)	1,505	56-64	23	27
Bigeye tuna (Thunnus obesus)	439,009	15,000-20,000	22	29
Large yellow croaker (Larimichthys crocea)	73,610	451-3,490	21	160
Indian halibut (Psettodes erumei)	19,801	941	21	21
So-iuy mullet (Mugil soiuy)	4,947	67-247	20	74
Argentine croaker (Umbrina canosai)	14,510	394-739	20	37
Blackbelly rosefish (Helicolenus dactylopterus dactylopterus)	5,782	218-284	20	27
European perch (Perca fluviatilis)	23,493	1,200	20	20
Mozambique tilapia (Oreochromis mossambicus)	19,884	1,000	20	20
Pacific ocean perch (Sebastes alutus)	28,472	1,400	20	20
Dorab wolf-herring (Chirocentrus dorab)	14,605	717-757	19	20
Snoek (Thyrsites atun)	43,106	2,289	19	19
Japanese threadfin bream (Nemipterus japonicus)	5,500	42-309	18	130
Orange roughy (Hoplostethus atlanticus)	26,490	1,500	18	18
Rainbow smelt (Osmerus mordax mordax)	1,562	85	18	18
Witch flounder (Glyptocephalus cynoglossus)	16,946	300-1,000	17	56
Ballyhoo halfbeak (Hemiramphus brasiliensis)	2,125	134	16	16
Greenback horse mackerel (Trachurus declivis)	13,401	850	16	16

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Surmullets(=Red mullets) nei (Mullus spp)*	14,963	81-1,000	15	190
Silver hake (Merluccius bilinearis)	23,169	1,298-1,524	15	18
Golden threadfin bream (Nemipterus virgatus)	3,569	208-231	15	17
Pike-perch (Sander lucioperca)	16,989	146-1,200	14	120
Lemon sole (Microstomus kitt)	12,639	649-885	14	19
Freshwater bream (Abramis brama)	49,501	3,600	14	14
Cape bonnetmouth (Emmelichthys nitidus nitidus)	4,168	66-324	13	63
Atlantic croaker (Micropogonias undulatus)	11,442	227-909	13	50
Brazilian menhaden (Brevoortia aurea)	1,222	67-91	13	18
African sicklefish (Drepane africana)	2,873	165-225	13	17
Boe drum (Pteroscion peli)	1,522	98-114	13	16
Blue mackerel (Scomber australasicus)	13,012	1,000	13	13
Bluefish (Pomatomus saltatrix)	26,158	1,943	13	13
Red porgy (Pagrus pagrus)	8,366	660	13	13
Red bigeye (Priacanthus macracanthus)	2,456	50-200	12	49
Albacore (Thunnus alalunga)	233,056	4,540-21,364	11	51
Atlantic anchoveta (Cetengraulis edentulus)	278	16-25	11	18
Longtail tuna (Thunnus tonggol)	208,271	15,000-20,000	10	14
Atlantic moonfish (Selene setapinnis)	3,440	333	10	10
Bastard halibuts nei (Paralichthys spp)*	7,173	368-754	9.5	19
Barracudas nei (Sphyraena spp)*	85,722	187-9,072	9.4	460
Grey gurnard (Eutrigla gurnardus)	5,416	538-574	9.4	10
American yellow perch (Perca flavescens)	4,071	114-454	9.0	36
Atlantic pomfret (Brama brama)	10,910	737-1,260	8.7	15
Bagrid catfish (Chrysichthys nigrodigitatus)	11,272	951-1,296	8.7	12
Red mullet (Mullus barbatus barbatus)	8,603	500-1,000	8.6	17
Bigeye croaker (Pennahia anea)	1,480	172	8.6	8.6
Atlantic searobins (Prionotus spp)*	4,456	121-527	8.5	37
Greater weever (Trachinus draco)	854	78-110	7.7	11
Tigertooth croaker (Otolithes ruber)	6,788	953	7.1	7.1
Atlantic bonito (Sarda sarda)	34,255	1,818-5,000	6.9	19
John dory (Zeus faber)	9,717	1,400	6.9	6.9
Japanese eel (Anguilla japonica)	584	86	6.8	6.8
Bluefin gurnard (Chelidonichthys kumu)	3,986	603	6.6	6.6
Black seabream (Spondyliosoma cantharus)	6,424	1,000	6.4	6.4

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Burbot (Lota lota)	3,167	497	6.4	6.4
Goldfish (Carassius auratus auratus)	3,580	7-567	6.3	500
Bastard grunt (Pomadasys incisus)	2,417	27-419	5.8	89
Australian pilchard (Sardinops sagax)	1,059	120-183	5.8	8.8
Lebranche mullet (Mugil liza)	3,109	550	5.7	5.7
Sablefish (Anoplopoma fimbria)	25,657	4,536	5.7	5.7
Tub gurnard (Chelidonichthys lucernus)	2,585	220-464	5.6	12
Northern pike (Esox lucius)	24,541	4,500	5.5	5.5
Silver scabbardfish (Lepidopus caudatus)	12,490	1,000-2,300	5.4	12
Amer. plaice(=Long rough dab) (Hippoglossoides platessoides)	13,127	909-2,500	5.3	14
Barramundi(=Giant seaperch) (Lates calcarifer)	73,485	1,500-14,000	5.2	49
Picked dogfish (Squalus acanthias)	23,160	3,000-4,500	5.1	7.7
Atlantic wolffish (Anarhichas lupus)	33,220	6,804	4.9	4.9
Common carp (Cyprinus carpio carpio)	71,339	2,000-15,000	4.8	36
Garfish (Belone belone)	2,335	20-500	4.7	120
African moonfish (Selene dorsalis)	2,328	142-494	4.7	16
North African catfish (Clarias gariepinus)	39,147	5,411-8,249	4.7	7.2
Pacific sierra (Scomberomorus sierra)	8,581	1,814	4.7	4.7
Winter flounder (Pseudopleuronectes americanus)	6,602	1,400	4.7	4.7
Walleye (Sander vitreus)	8,264	907-1,814	4.6	9.1
Greenland halibut (Reinhardtius hippoglossoides)	111,415	2,273-25,000	4.5	49
Angolan dentex (Dentex angolensis)	1,697	101-386	4.4	17
Blackmouth croaker (Atrobucca nibe)	412	93	4.4	4.4
Cassava croaker (Pseudotolithus senegalensis)	4,407	1,000	4.4	4.4
Scup (Stenotomus chrysops)	3,280	750	4.4	4.4
Blackbanded trevally (Seriolina nigrofasciata)	5,941	1,500	4.0	4.0
Benguela hake (Merluccius polli)	1,758	55-467	3.8	32
Rough scad (Trachurus lathami)	960	251	3.8	3.8
Amberjacks nei (Seriola spp)*	100,700	1,057-27,300	3.7	95
Bonytongues nei (Heterotis spp)*	11,054	2,244-3,060	3.6	4.9
Serra Spanish mackerel (Scomberomorus brasiliensis)	6,831	1,476-2,013	3.4	4.6
American angler (Lophius americanus)	22,812	3,182-6,818	3.3	7.2
Patagonian toothfish (Dissostichus eleginoides)	32,503	9,000-10,000	3.3	3.6

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Black cusk-eel (Genypterus maculatus)	1,729	523	3.3	3.3
Tusk(=Cusk) (Brosme brosme)	26,487	8,000	3.3	3.3
American gizzard shad (Dorosoma cepedianum)	1,683	18-520	3.2	93
Yellowtail snapper (Ocyurus chrysurus)	6,487	750-2,000	3.2	8.6
Coho(=Silver)salmon (Oncorhynchus kisutch)	18,889	6,000	3.1	3.1
Milkfish (Chanos chanos)	1,857	600	3.1	3.1
Bartail flathead (Platycephalus indicus)	2,894	166-969	3.0	17
Summer flounder (Paralichthys dentatus)	6,887	907-2,268	3.0	7.6
Atlantic Spanish mackerel (Scomberomorus maculatus)	7,972	907-2,722	2.9	8.8
Red codling (Pseudophycis bachus)	7,174	1,500-2,500	2.9	4.8
Axillary seabream (Pagellus acarne)	1,273	13-447	2.8	95
Alfonsinos nei (Beryx spp)*	8,933	596-3,239	2.8	15
African lungfishes (Protopterus spp)*	13,692	217-5,100	2.7	63
Greater Argentine (Argentina silus)	2,893	300-1,079	2.7	9.6
Little tunny(=Atl.black skipj) (Euthynnus alletteratus)	14,774	3,723-5,548	2.7	4.0
False scad (Caranx rhonchus)	2,387	34-933	2.6	69
Crevalle jack (Caranx hippos)	5,952	1,361-2,268	2.6	4.4
Redfish (Centroberyx affinis)	1,477	160-600	2.5	9.2
Blue runner (Caranx crysos)	2,863	1,164	2.5	2.5
Pink cusk-eel (Genypterus blacodes)	48,684	50,00-20,000	2.4	9.7
White hake (Urophycis tenuis)	8,620	2,361-3,656	2.4	3.7
Pacific halibut (Hippoglossus stenolepis)	41,587	13,640-18,180	2.3	3.0
Blackspot(=red) seabream (Pagellus bogaraveo)	1,790	658-772	2.3	2.7
Northern red snapper (Lutjanus campechanus)	4,503	2,000	2.3	2.3
Kingklip (Genypterus capensis)	9,965	3,300-4,500	2.2	3.0
Australian salmon (Arripis trutta)	7,347	200-3,500	2.1	37
Blotched picarel (Spicara maena)	635	19-298	2.1	34
Lumpfish(=Lumpsucker) (Cyclopterus lumpus)	14,979	2,000-7,000	2.1	7.5
Giant catfish (Netuma thalassina)	585	220-300	2.0	2.7
Common warehou (Seriolella brama)	4,373	2,200	2.0	2.0
European eel (Anguilla anguilla)	6,603	3,500	1.9	1.9
Swordfish (Xiphias gladius)	107,980	31,000-60,000	1.8	3.5
River lamprey (Lampetra fluviatilis)	144	48-81	1.8	3.0
Blue shark (Prionace glauca)	30,300	14,412-16,562	1.8	2.1

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Common dolphinfish (Coryphaena hippurus)	49,628	28,000	1.8	1.8
Gulf kingcroaker (Menticirrhus littoralis)	807	454	1.8	1.8
Red hake (Urophycis chuss)	2,652	1,500	1.8	1.8
Argentine goatfish (Mullus argentinae)	256	110-149	1.7	2.3
Giant stargazer (Kathetostoma giganteum)	3,458	2,000	1.7	1.7
Spotted weakfish (Cynoscion nebulosus)	3,403	2,000	1.7	1.7
Aba (Gymnarchus niloticus)	8,844	4,070-5,550	1.6	2.2
Rainbow runner (Elagatis bipinnulata)	15,983	10,000	1.6	1.6
Great barracuda (Sphyraena barracuda)	14,018	907-9,072	1.5	15.
Cape gurnard (Chelidonichthys capensis)	650	436	1.5	1.5
Rex sole (Glyptocephalus zachirus)	2,203	1,500	1.5	1.5
Blue ling (Molva dypterygia)	12,224	6,600-9,000	1.4	1.9
Bastard halibut (Paralichthys olivaceus)	8,896	6,042-6,298	1.4	1.5
Chinook(=Spring=King)salmon (Oncorhynchus tshawytscha)	11,529	8,341	1.4	1.4
Indo-Pacific tarpon (Megalops cyprinoides)	1,512	1,062-1,065	1.4	1.4
Gilthead seabream (Sparus aurata)	8,068	590-6,254	1.3	14
Barred grunt (Conodon nobilis)	180	141	1.3	1.3
King mackerel (Scomberomorus cavalla)	12,721	10,000	1.3	1.3
Lake(=Common)whitefish (Coregonus clupeaformis)	12,612	10,000	1.3	1.3
Squeteague(=Gray weakfish) (Cynoscion regalis)	1,456	1,134	1.3	1.3
Tuna-like fishes nei (Scombroidei)*	208,362	54-180,000	1.2	3,900
Bearded brotula (Brotula barbata)	1,616	909-1,364	1.2	1.8
Bobo mullet (Joturus pichardi)	296	247	1.2	1.2
Brushtooth lizardfish (Saurida undosquamis)	384	21-361	1.1	18
European conger (Conger conger)	15,622	1,718-14,854	1.1	9.1
Shallow-water Cape hake (Merluccius capensis)	2,260	490-2,030	1.1	4.6
Bluespot mullet (Valamugil seheli)	2,175	500-2,000	1.1	4.4
Bluestripe herring (Herklotsichthys quadrimaculatus)	27	13-25	1.1	2.2
Canary drum (=Baardman) (Umbrina canariensis)	2,550	2,400	1.1	1.1
Eastern Pacific bonito (Sarda chiliensis chiliensis)	4,538	4,000	1.1	1.1
European seabass (Dicentrarchus labrax)	10,225	300-10,000	1.0	34
Angler(=Monk) (Lophius piscatorius)	28,964	30,000	0.97	0.97

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Baird's slickhead (Alepocephalus bairdii)	2,254	33-2,431	0.93	69.
Atlantic salmon (Salmo salar)	3,917	4,500	0.87	0.87
Batfishes (Platax spp)*	2,919	775-3,521	0.83	3.8
Atlantic sabretooth anchovy (Lycengraulis grossidens)	50	19-61	0.82	2.6
Silver carp (Hypophthalmichthys molitrix)	10,523	12,794	0.82	0.82
West African Spanish mackerel (Scomberomorus tritor)	1,405	1,711	0.82	0.82
Brill (Scophthalmus rhombus)	2,800	3,475	0.81	0.81
Argentinian sandperch (Pseudopercis semifasciata)	2,414	2,200-3,000	0.80	1.1
Masu(=Cherry) salmon (Oncorhynchus masou masou)	1,570	2,000	0.79	0.79
Tench (Tinca tinca)	3,087	3,900	0.79	0.79
Lake cisco (Coregonus artedi)	646	832	0.78	0.78
Pacific jack mackerel (Trachurus symmetricus)	1,435	190-1,866	0.77	7.5
Indo-Pacific sailfish (Istiophorus platypterus)	20,954	13,640-27,270	0.77	1.5
Blackhead seabream (Acanthopagrus schlegelii schlegelii)	730	704-960	0.76	1.0
Rainbow trout (Oncorhynchus mykiss)	3,744	500-5,000	0.75	7.5
Widow rockfish (Sebastes entomelas)	1,287	300-1,814	0.71	4.3
Blackmouth catshark (Galeus melastomus)	197	65-280	0.71	3.0
Petrale sole (Eopsetta jordani)	2,055	1,040-3,000	0.69	2.0
American eel (Anguilla rostrata)	935	1,364	0.69	0.69
Black cardinal fish (Epigonus telescopus)	2,723	900-4,138	0.66	3.0
Grass carp(=White amur) (Ctenopharyngodon idella)	23,689	29,540-36,360	0.65	0.80
Turbot (Psetta maxima)	7,165	2,065-11,225	0.64	3.5
Sea trout (Salmo trutta trutta)	3,855	6,000	0.64	0.64
Red grouper (Epinephelus morio)	1,395	1,364-2,273	0.61	1.0
Common dentex (Dentex dentex)	1,387	1,260-2,350	0.59	1.1
Black seabass (Centropristis striata)	1,605	227-2,750	0.58	7.1
Chilipepper rockfish (Sebastes goodei)	264	339-462	0.57	0.78
Blue antimora (Antimora rostrata)	62	87-116	0.54	0.72
Southern bluefin tuna (Thunnus maccoyii)	15,054	7,000-28,333	0.53	2.2
Cachama (Colossoma macropomum)	4,552	8,836	0.52	0.52
Cobia (Rachycentron canadum)	9,128	6,364-18,182	0.50	1.4
Freshwater drum (Aplodinotus grunniens)	496	1,000	0.50	0.50
Bluenose warehou (Hyperoglyphe antarctica)	2,882	6,000	0.48	0.48

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Bighead carp (Hypophthalmichthys nobilis)	1,506	3,306	0.46	0.46
Ladyfish (Elops saurus)	915	2,000	0.46	0.46
Sheepshead (Archosargus probatocephalus)	1,024	2,268	0.45	0.45
Argentine angelshark (Squatina argentina)	3,980	9,017	0.44	0.44
Asp (Aspius aspius)	1,151	2,720	0.42	0.42
American shad (Alosa sapidissima)	890	907-2,272	0.39	0.98
White grouper (Epinephelus aeneus)	943	2,419	0.39	0.39
Blackfin tuna (Thunnus atlanticus)	2,626	3,182-7,000	0.38	0.83
Argentine conger (Conger orbignianus)	213	428-583	0.37	0.50
Thornback ray (Raja clavata)	1,536	4,536	0.34	0.34
Cape elephantfish (Callorhinchus capensis)	527	1,155-1,575	0.33	0.46
Anglerfishes nei (Lophiidae)*	9,346	413-30,000	0.31	23
Grayling (Thymallus thymallus)	246	300-800	0.31	0.82
Hapuku wreckfish (Polyprion oxygeneios)	1,654	6,000	0.28	0.28
Malabar blood snapper (Lutjanus malabaricus)	453	1,633	0.28	0.28
Antarctic rockcods, noties nei (Nototheniidae)*	2,742	21-10,000	0.27	130
Boarfishes nei (Caproidae)*	31	35-116	0.27	0.88
Stargazer (Uranoscopus scaber)	122	111-460	0.26	1.1
Blue catfish (Ictalurus furcatus)	717	3,000	0.24	0.24
Slender rainbow sardine (Dussumieria elopsoides)	14	5-62	0.23	2.9
Buffalofishes nei (Ictiobus spp)*	1,560	908-6,810	0.23	1.7
Lingcod (Ophiodon elongatus)	2,941	9,072-13,608	0.22	0.32
Boxfishes nei (Ostraciidae)*	133	93-637	0.21	1.4
Atlantic halibut (Hippoglossus hippoglossus)	4,325	21,000	0.21	0.21
Argentine menhaden (Brevoortia pectinata)	72	162-349	0.20	0.44
Atlantic goldeneye tilefish (Caulolatilus chrysops)	190	951	0.20	0.20
Black drum (Pogonias cromis)	2,759	13,636	0.20	0.20
Striped bass (Morone saxatilis)	3,093	6,820-15,900	0.19	0.45
Tope shark (Galeorhinus galeus)	4,812	25,000	0.19	0.19
Black catfishes nei (Chrysichthys spp)*	7,337	3-40,500	0.18	2,400
Great Northern tilefish (Lopholatilus chamaeleonticeps)	877	2,000-5,000	0.18	0.44
Blue marlin (Makaira nigricans)	33,134	180,000	0.18	0.18
Law croaker (Pseudotolithus senegallus)	1,077	6,080	0.18	0.18

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Alexandria pompano (Alectis alexandrinus)	488	2,851	0.17	0.17
Striped bonito (Sarda orientalis)	509	3,000	0.17	0.17
Bonefish (Albula vulpes)	517	3,333	0.16	0.16
Atlantic emperor (Lethrinus atlanticus)	78	509-511	0.15	0.15
Atlantic bluefin tuna (Thunnus thynnus)	35,935	262,000	0.14	0.14
Channel catfish (Ictalurus punctatus)	250	2,000	0.13	0.13
Atlantic tomcod (Microgadus tomcod)	32	108-258	0.12	0.30
Atlantic sailfish (Istiophorus albicans)	2,753	18,140-27,220	0.10	0.15
Two-spot red snapper (Lutjanus bohar)	282	2,759-2,795	0.10	0.10
Pacific bluefin tuna (Thunnus orientalis)	9,786	38,000-99,300	0.099	0.26
Greater amberjack (Seriola dumerili)	2,451	8,182-27,300	0.090	0.30
Antarctic toothfish (Dissostichus mawsoni)	2,312	28,000	0.083	0.083
Nassau grouper (Epinephelus striatus)	358	4,540	0.079	0.079
Wahoo (Acanthocybium solandri)	3,017	4,536-38,636	0.078	0.67
Black skipjack (Euthynnus lineatus)	550	695-7,165	0.077	0.79
Blueback shad (Alosa aestivalis)	5	44-60	0.076	0.10
Splendid alfonsino (Beryx splendens)	247	3,102-3,239	0.076	0.080
Antarctic silverfish (Pleuragramma antarcticum)	2	21	0.074	0.074
Black rockfish (Sebastes melanops)	103	1,056-1,440	0.071	0.097
Striped marlin (Tetrapturus audax)	7,845	56,750-113,500	0.069	0.14
Black marlin (Makaira indica)	5,861	85,000-90,000	0.065	0.069
Brown bullhead (Ameiurus nebulosus)	10	35-168	0.060	0.28
Dusky grouper (Epinephelus marginatus)	2,583	44,079	0.059	0.059
Broad-striped anchovy (Anchoa hepsetus)	1	16	0.056	0.056
Canary rockfish (Sebastes pinniger)	111	2,000	0.056	0.056
Brazilian groupers nei (Mycteroperca spp)*	1,433	660-26,000	0.055	2.20
Mountain mullet (Agonostomus monticola)	7	128	0.054	0.054
Yellowtail amberjack (Seriola lalandi)	790	4,397-15,000	0.053	0.18
Dusky smooth-hound (Mustelus canis)	332	6,752	0.049	0.049
Birdbeak dogfish (Deania calcea)	202	1,242-4,253	0.047	0.16
Wels(=Som)catfish (Silurus glanis)	9,153	100,000-200,000	0.046	0.092
Geelbek croaker (Atractoscion aequidens)	483	11,000	0.044	0.044
Wreckfish (Polyprion americanus)	923	22,600	0.041	0.041
California flounder (Paralichthys californicus)	399	7,260-9,900	0.040	0.055

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Shortfin mako (Isurus oxyrinchus)	4,694	60,000-135,000	0.035	0.078
Barbel (Barbus barbus)	124	1,800-3,636	0.034	0.069
Black dogfish (Centroscyllium fabricii)	78	1,085-2,328	0.033	0.072
Dogtooth tuna (Gymnosarda unicolor)	653	15,000-20,000	0.033	0.044
Black goby (Gobius niger)	2	63	0.032	0.032
Arctic char (Salvelinus alpinus alpinus)	135	454-4,545	0.030	0.30
Angelsharks, sand devils nei (Squatinidae)*	532	1,684-19,794	0.027	0.32
Atlantic white marlin (Tetrapturus albidus)	731	27,215	0.027	0.027
Barbus cyclolepis (Barbus cyclolepis)	2	44-94	0.026	0.056
Blonde ray (Raja brachyura)	104	3,146-4,290	0.024	0.033
Tarpon (Megalops atlanticus)	952	40,000	0.024	0.024
Brown meagre (Sciaena umbra)	40	524-1,790	0.022	0.076
Cabezon (Scorpaenichthys marmoratus)	93	3,080-4,200	0.022	0.030
Leaping mullet (Liza saliens)	8	128-402	0.020	0.063
Blacktip shark (Carcharhinus limbatus)	294	18,000	0.016	0.016
Starry sturgeon (Acipenser stellatus)	147	8,953	0.016	0.016
Blacktip grouper (Epinephelus fasciatus)	3	138-167	0.015	0.019
Opah (Lampris guttatus)	706	50,000	0.014	0.014
Blue skate (Dipturus batis)	596	5,232-44,213	0.013	0.11
Cero (Scomberomorus regalis)	67	5,000	0.013	0.013
Antarctic starry skate (Amblyraja georgiana)	20	1,201-1,731	0.012	0.017
Bocaccio rockfish (Sebastes paucispinis)	34	2,119-2,889	0.012	0.016
Allis shad (Alosa alosa)	30	2,700	0.011	0.011
Porbeagle (Lamna nasus)	1,542	135,000	0.011	0.011
California sheephead (Semicossyphus pulcher)	50	3,520-4,800	0.010	0.014
Yellowedge grouper (Epinephelus flavolimbatus)	40	2,270-4,540	0.0088	0.018
Biglip grunt (Plectorhinchus macrolepis)	4	472	0.0087	0.0087
White sturgeon (Acipenser transmontanus)	157	9,072-18,144	0.0086	0.017
Bar jack (Carangoides ruber)	7	454-909	0.0082	0.016
Smooth-hound (Mustelus mustelus)	135	4,508-19,539	0.0069	0.030
Bullet tuna (Auxis rochei rochei)	6	861-890	0.0062	0.0065
American conger (Conger oceanicus)	44	4,545-9,090	0.0049	0.0098
Thresher (Alopias vulpinus)	473	113,500	0.0042	0.0042
Bigspined boarfish (Pentaceros decacanthus)	4	500-1,000	0.0041	0.0082

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)

Species (scientific name)	Average annual capture 1999-2007 (t) (FAO, 2009a)	Estimated mean weight range (g)	Estimated number range (lower) in millions	Estimated number range (upper) in millions
Blackbellied angler (Lophius budegassa)	9	1,631-2,120	0.0040	0.0052
Bigeye grenadier (Macrourus holotrachys)	2	468	0.0040	0.0040
Flat needlefish (Ablennes hians)	9	2,036-2,900	0.0033	0.0046
Arapaima (Arapaima gigas)	239	73,100	0.0033	0.0033
Scalloped hammerhead (Sphyrna lewini)	365	115,102	0.0032	0.0032
Oceanic whitetip shark (Carcharhinus longimanus)	212	35,000-70,000	0.0030	0.0060
Broomtail grouper (Mycteroperca xenarcha)	79	20,020-27,300	0.0029	0.0040
Ballan wrasse (Labrus bergylta)	5	1,000-2,000	0.0024	0.0049
Red drum (Sciaenops ocellatus)	7	1,818-3,636	0.0020	0.0039
Blackfin icefish (Chaenocephalus aceratus)	2	788-929	0.0018	0.0021
Black carp (Mylopharyngodon piceus)	27	15,000	0.0018	0.0018
Brook trout (Salvelinus fontinalis)	8	500-5,000	0.0016	0.016
Black driftfish (Hyperoglyphe bythites)	4	1,364-2,727	0.0016	0.0032
Angelshark (Squatina squatina)	22	14,000-18,000	0.0012	0.0016
Snowy grouper (Epinephelus niveatus)	5	3,636-4,545	0.0012	0.0015
Golden grey mullet (Liza aurata)	1	924	0.0012	0.0012
Brown smooth-hound (Mustelus henlei)	3	471-2,685	0.0011	0.0064
Nurse shark (Ginglymostoma cirratum)	159	90,000-150,000	0.0011	0.0018
Sickle pomfret (Taractichthys steindachneri)	9	7,128-8,036	0.0011	0.0012
Gag (Mycteroperca microlepis)	9	909-9,091	0.0010	0.010
Bigeye thresher (Alopias superciliosus)	160	160,000	0.0010	0.0010
Beluga (Huso huso)	75	35,000-100,000	0.00075	0.0022
Warsaw grouper (Epinephelus nigritus)	26	13,636-36,364	0.00072	0.0019
Bathyraja rays nei (Bathyraja spp)*	2	277-3,180	0.00070	0.0080
Sandbar shark (Carcharhinus plumbeus)	50	60,000-96,000	0.00052	0.00083
Arctic skate (Amblyraja hyperborea)	1	1,201-1,731	0.00045	0.00065
Giant guitarfish (Rhynchobatus djiddensis)	85	190,000	0.00045	0.00045
Basketwork eel (Diastobranchus capensis)	1	2,250-3,068	0.00036	0.00049
Broadnose sevengill shark (Notorynchus cepedianus)	4	22,613	0.00019	0.00019
Yellowfin grouper (Mycteroperca venenosa)	1	6,810	0.00013	0.00013
Black grouper (Mycteroperca bonaci)	3	26,000	0.00012	0.00012
Basking shark (Cetorhinus maximus)	246	3,000,000	0.000082	0.000082
King of herrings (Regalecus glesne)	6	59,840-81,600	0.000075	0.00010
Tiger shark (Galeocerdo cuvier)	38	385,000-685,000	0.000055	0.000099

Table 4. Numbers of fish caught estimated from FAO capture tonnages and estimated mean weights (cont.)				
Species (scientific name)	**Average annual capture 1999-2007 (t) (FAO, 2009a)**	**Estimated mean weight range (g)**	**Estimated number range (lower) in millions**	**Estimated number range (upper) in millions**
Bluntnose sixgill shark (Hexanchus griseus)	9	500,000	0.000018	0.000018
Ocean sunfish (Mola mola)	11	1,000,000	0.000011	0.000011
Great white shark (Carcharodon carcharias)	2	680,000	0.0000025	0.0000025
Total for species with an estimated mean weight	53,025,428		680,000	2,000,000
Total for species without an estimated mean weight	24,362,894		300,000	760,000
Total fish capture	77,388,322		970,000	2,700,000