



How many more fish in the sea?

Commercial fisheries worldwide are being driven to collapse. Quirin Schiermeier wonders why fisheries scientists are failing to halt this pillage, and asks what hope is there for the future sustainability of fish stocks.

I. MITCHELL/REUTERS

For centuries, the Canadian Grand Banks, off the coast of Newfoundland, were prime fishing grounds. The region's abundance of Atlantic cod (*Gadus morhua*) supported entire communities. At its height, in 1968, the industry employed 40,000 people and landed more than 800,000 tonnes of the fish.

But the factory trawlers that subsequently moved onto the banks exacted a dreadful toll. Stocks collapsed, and in 1992, Canada's Department of Fisheries and Oceans belatedly closed the fishery. Thousands of fishermen and workers in the fish-processing industry lost their jobs; others redirected their efforts to crabs and shrimp. A decade later, the Grand Banks' cod stocks show little sign of recovery.

The Grand Banks disaster shows just how badly fisheries policies can go wrong. And unfortunately, the same mistakes are being

made across the world's oceans. In many cases, scientists are warning that populations are being overexploited. But all too often, their advice of setting lower catch quotas, reducing the size of fishing fleets and using less harmful fishing gear is ignored or watered down. When push comes to shove, it seems that short-term economic interests steamroller scientific arguments.

In part, fisheries scientists are cursed by the uncertainties that swathe their work. At best, their models of the dynamics of fish populations produce imprecise estimates of the maximum catches that can be taken without driving a stock to extinction. Here, it's easy for those with vested interests to ignore unpalatable messages and to argue that larger catches might be sustainable. At worst, the models can incorporate misleading data that simply give the wrong answer, causing scientists to help speed fisheries towards collapse. In the case of the Grand Banks, both scenarios came into play.

Given such failures, some conservation biologists are now arguing that fisheries scientists must abandon their focus on individual stocks and adopt a whole-ecosystem perspective. But whatever methods are used to determine the advice given to policy-makers, scientists need to find ways to involve fishermen in their work, to break down the 'us-and-them' interaction that helps to foster the current gulf between science and policy. "It is utterly important to get fishermen's legitimate inter-

ests involved," says John Pope, an independent consultant and former chief scientist at the Lowestoft Laboratory in East Anglia, part of Britain's Centre for Environment, Fisheries and Aquaculture Science.

Scale of the problem

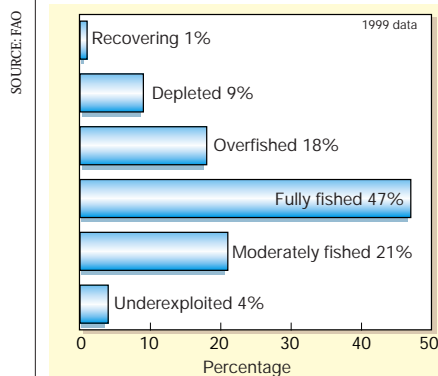
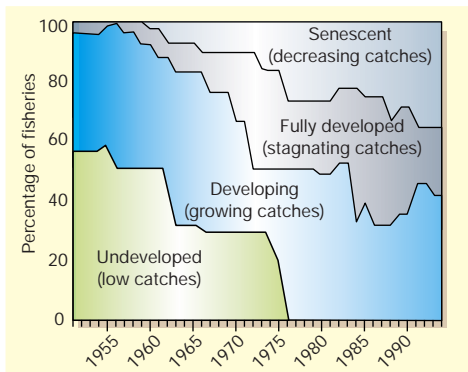
Sticking to business as usual would be a recipe for disaster, warn scientific critics of current fisheries-management practices. According to global statistics compiled by the United Nations' Food and Agriculture Organization (FAO) in Rome, the number of stocks that are being overexploited is high, and rising (see graphs, opposite). In fact, the FAO may be painting an unduly optimistic picture, having for years incorporated inflated figures that overestimate the health of China's fisheries¹. If current trends continue, claims Daniel Pauly, a conservation biologist at the University of British Columbia in Vancouver, fisheries could collapse throughout most of the world within a few decades².

Pauly is one of the foremost critics of the 'single-species' stock models that are used to calculate 'safe' allowable catches. The models can be labyrinthine in their complexity, incorporating hundreds of parameters. At their heart, however, they all rely on assessing the size and age structure of fish populations on the basis of data from experimental fishing cruises and commercial catches. The routine work of government fisheries laboratories consists largely of compiling

S. PAULY



Rocking the boat: Daniel Pauly (rear) is a vocal critic of 'single-species' modelling of fish stocks.



End of the line? Many of the world's fisheries are being plundered at or beyond sustainable limits.

these data and feeding them into the models.

But factors such as a varying climate can exert a dramatic influence on fish population dynamics, obscuring the effects of fishing pressure. And the data fed into stock-assessment models can be seriously deceiving. In the case of the Grand Banks, fisheries scientists knew that stocks were declining, but were somewhat reassured by the relatively healthy catches still being landed. They were, however, neglecting to consider the fact that fishermen were spending more time at sea, with improved equipment, fishing selectively in warmer waters where the remaining fish were congregating. Across most of the banks, there was barely an adult cod to be found.

Even scientists who regularly work with single-species stock models accept that these tools have limitations. "The links between fishing pressure, environmental changes and breeding success are not sufficiently understood," says John Shepherd, a marine ecologist at the Southampton Oceanography Centre, and formerly senior scientific fisheries adviser to the British government.

One important area of doubt is how the breeding success of different fish populations changes when their populations become diminished. Ecological theory suggests that the remaining fish, competing less intensely for food, should come to sexual maturity more quickly and boost their rate of reproduction. But a phenomenon known as depensation — a reduction in reproductive



Dutch trawlers blockade Rotterdam harbour in protest at restrictions on cod fishing in the North Sea. But enforcing 'no-go zones' may be the only way to preserve stocks in the most exploited fisheries.

success at low population densities, caused for example by the difficulty in finding a mate — can also come into play. "A key question in fisheries science is why, after a reduction of mortality, some species recover and some don't," says Jeff Hutchings, a marine biologist at Dalhousie University in Halifax, Nova Scotia. The presence or absence of depensation could be an important factor.

A 1995 paper³, co-authored by Hutchings, provided some grounds for optimism. The researchers examined 128 fish stocks, looking at catch data to determine numbers of spawning fish, and 'recruits' — young fish that have survived to adulthood. For only three of the stocks did these data fit with a model of population dynamics incorporating depensation. "We conclude that the effects of overfishing are, at this point, still generally reversible," Hutchings and his colleagues wrote.

Today, however, Hutchings feels rather less upbeat. If overfishing is reversible, he says, the situation can't be turned around overnight. Hutchings has analysed 90 stocks worldwide, using the largest available data set: the Stock Recruitment Database maintained by his Dalhousie colleague Ransom Myers. Many of the stocks had experienced massive declines due to overfishing. With the possible exception of fast-maturing species such as Atlantic herring (*Clupea harengus*), these stocks showed little signs of recovery as much as 15 years after their collapse⁴. "The life history of species matters," says Hutchings. "Small, early-

maturing, mid-water species like herring might recover faster than late-maturing, bottom-living species such as cod."

No way back?

Analysing the same data, Hutchings has also found that there was no association between a depleted population's recovery and the extent to which it continued to be fished after the collapse⁵. What, exactly, is holding back the recovery of overexploited stocks remains unclear — depensation might still be a factor, despite the earlier indications to the contrary. But to Hutchings, these findings demand a more precautionary approach in setting catch limits to prevent stocks from collapsing in the first place. "If there is not much we can do after the damage is done, then it is an even stronger case that we should not let fish stocks fall beyond safe levels," he says.

There is also a growing awareness that the dynamics of individual fish populations need to be considered in a wider ecological context. "Changes in predator-prey interactions and in food-web structures may interlink to cause an irreversible downward spiral," says Hutchings. Fishing for one species may also cause collateral damage elsewhere in a marine ecosystem. The barndoor skate (*Raja laevis*), for instance, has been driven to the brink of extinction largely as a result of being caught incidentally by vessels trawling for cod in the northwest Atlantic⁶. And recently, marine



Sea change: the photograph on the right shows the devastation wrought by trawlers on ancient corals (left, before fishing) in the northeast Atlantic Ocean.

scientists have begun to document the damage wrought on important habitats by trawling or dredging gear, likened by some to the clear felling of terrestrial forests⁷. Seagrass meadows off Spain, which serve as spawning grounds for many fish species, have been extensively disturbed. And in February this year, researchers led by Jason Hall-Spencer of the University of Glasgow, UK, showed that trawlers have wrecked ancient coldwater corals in the northeast Atlantic⁸.

To conservation biologists such as Pauly, these findings strengthen the case for abandoning the single-species approach to fisheries management, and turning instead to the analysis of entire marine ecosystems. Refinements to single-species stock models, and to the data that are plugged into them, offer little hope of improving the “dreadful shape” that these ecosystems are in, Pauly argues.

When fisheries are considered from an ecosystems perspective, trends emerge that otherwise aren't readily evident. In 1998, for instance, Pauly and his colleagues assigned fish to different ‘trophic levels’ in marine food webs. In their scheme, photosynthetic algae represent level 1, animals that graze on these algae are level 2, their predators form level 3, and so on. Looking at FAO catch statistics from 1950 to 1994, the researchers found that the world's fishing fleets have been steadily fishing down the food web towards lower trophic levels⁹. This is worrying, says Pauly, as the trend will reduce the complexity of marine food webs, which is likely to make ecosystems inherently more vulnerable to damage².

Pauly's Sea Around Us Project, funded by the Philadelphia-based Pew Charitable Trusts, is now using the FAO's data to investigate the impact of large-scale fisheries on

North Atlantic ecosystems. One goal is to map large marine ecosystems that share common fauna and oceanographic characteristics, and to devise policies that can mitigate and reverse stock depletion and habitat destruction.

Out of bounds

Pauly argues that sustainable fishing will only be possible if protected areas are set aside in which no fishing is allowed, where fish are able to reproduce and grow to maturity in undisturbed habitats. Historical evidence provides some support for this view: fish stocks increased substantially during the Second World War, when fisheries in the North Sea came to a standstill. And stocks around Cyprus increased in the mid-1980s after the no-fishing period enforced during the summer breeding season was extended.

Make or break for Europe's fisheries

“The desperate race for fish has to stop,” declared Franz Fischler, the European Union's commissioner for agriculture and fisheries in May, launching a far-reaching proposal

to reform the EU's Common Fisheries Policy (CFP).

Directly and indirectly, Europe's fishing industry employs more than 15 million people. But Fischler wants to reduce the EU's total fishing effort by up to 60% from January 2003. He aims to cut the current fleet of almost 100,000 vessels by 10%, while forcing the remainder to reduce their activity. Subsidies worth 460 million euros (US\$450 million) for 2003–06, currently earmarked for renewal and modernization of vessels, would be redirected to pensions and retraining for fishermen.

By mid-2004, Fischler intends to set up an inspection scheme to tackle illegal fishing and the

misreporting of catches. Sick of the “annual political horse-trading” over national catch quotas, Fischler also wants to introduce management plans lasting several years, in which advice won't be twisted by competing national agendas. And to bring policy-making closer to fishermen, he aims to create regional advisory councils, to which stakeholders can submit their own ideas about fisheries management.

It's a bold plan, and one that fisheries scientists argue is necessary if Europe's fisheries are to escape destruction. Since 1991, more than 70,000 fishermen have been driven out of a job by dwindling stocks and diminishing catches — adult cod are only half as abundant in Europe's fishing grounds as they were in the 1970s. But can the man from landlocked Austria succeed where his predecessors failed, and

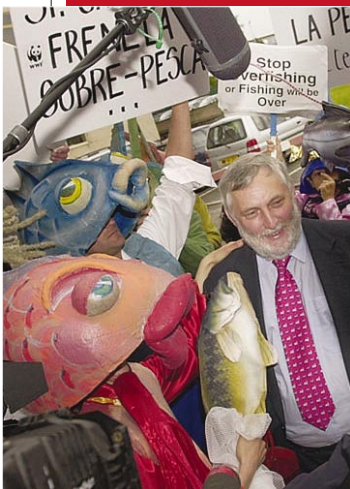
reconcile competing national interests to achieve a sustainable reform of the CFP?

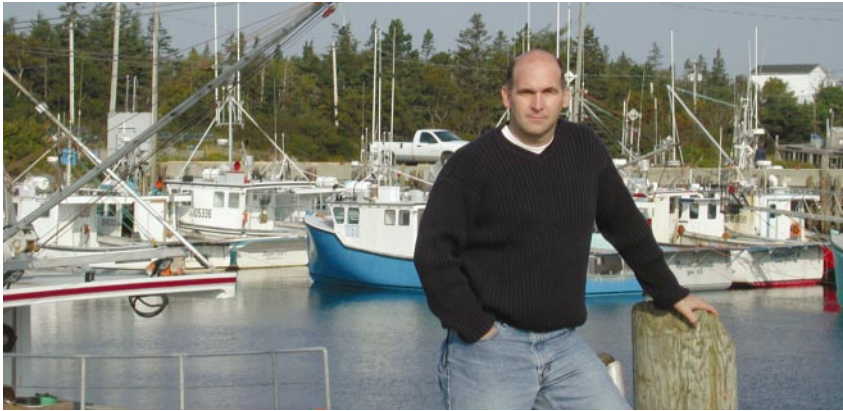
Time and again, efforts to reduce the EU's overexploitation of its fisheries have floundered, mired by opposition from countries with large fishing industries, such as Spain, Portugal and France. And with Fischler's plan still being discussed by the EU's member states, it could yet be blocked or watered down considerably.

If Europe can't get its fisheries in order, its problems seem certain to be exported. With European fishermen increasingly looking farther afield for their catches, the EU is already paying compensation to some West African countries for fishing rights in their coastal waters.

► http://europa.eu.int/comm/fisheries/policy_en.htm

Franz Fischler aims to stop “horse-trading” over fishing quotas in the European Union.





Shared goal: Jean Guy d'Entremont wants to foster trust between fishermen and fisheries scientists.

Most encouragingly, research published last year revealed that marine reserves established off Florida and in the Caribbean Sea have increased catches in surrounding waters¹⁰. In particular, a network of reserves off St Lucia, established in 1995 to preserve important coral reefs, has increased adjacent catches by small-scale fishermen by up to 90%.

Instituting similar policies on a larger scale will require huge changes in the way in which decisions on fisheries management are made, however. Conservation biologists want to see a reversal of the traditional 'burden of proof'¹¹. Rather than erring on the side of avoiding immediate economic pain, they would like to see precautions being taken to avoid damage to ecosystems. "The public, not industry, is the owner of the resources," argues Pauly. "But so far, all forms of fisheries management have been industry-friendly to a misplaced degree."

In the long run, the industry has everything to lose if fish stocks continue to decline. And although most fishermen still tend to regard scientists as opponents who are trying to limit their ability to earn a living, rather than partners in ensuring that their industry has a future, hints of a more productive relationship are beginning to emerge. "Fishermen have realized in the last decade that there is only a limited number of fish in the ocean," says Jean Guy d'Entremont, co-founder of an informal group of Canadian responsible fishermen, and vice-chair of the Fisheries Resource Conservation Council, which advises the Canadian government.

D'Entremont is steeped in the fishing business. He skippered an 18-metre inshore trawler for 7 years, and in 1992 took over his parents' fish-processing company in West Pubnico, Nova Scotia. In his spare time, he taught himself the basics of fisheries science. Seeing all sides of the problem, d'Entremont became convinced that fishermen must become more involved in the scientific assessment of stocks. "Fishermen are the first to touch the fish," he says. "They are the ones who can tell managers and regulators straight from the horse's mouth what's out there in terms of stocks, gear and technology."

To initiate a more productive dialogue, d'Entremont organized two North Atlantic Responsible Fishing Conferences, held in March 2000 in Fraserburgh, Scotland, and in November of the same year in St John's, Newfoundland. These meetings — a third will be held next June in Yarmouth, Nova Scotia — bring fishermen from across the North Atlantic to meet with fisheries scientists and government representatives. Fishermen can swap practical knowledge and expertise — for example, on techniques for reducing incidental catches of non-target species — while sharing their perspectives on fisheries management with policy-makers and those who advise them.

Team effort

The initiative has proved mutually beneficial, d'Entremont argues. Fishermen have brought in data from remote sea areas to assist scientists with stock assessment. And regulators have received valuable feedback on the impact of new management policies on fishing communities. Most importantly, the fishermen who have taken part say that they are now less suspicious of the scientists who advise government regulators. One Newfoundland fisherman says: "Occasionally, fisheries scientists will take the time to ask me specific questions about the fishery."

Initiatives such as d'Entremont's may be particularly relevant in Europe, where competing national agendas make the adoption of sustainable fishing policies even more problematic (see "Make or break for Europe's fisheries", opposite).

Other positive signs include the growing number of nations that are adopting aspects of the FAO's Code of Conduct for Responsible Fisheries, a 1995 document that suggests legal, technical and economic arrangements for national authorities seeking to put their fisheries on a more sustainable footing. Iceland and New Zealand, for instance, have reduced their fleet sizes and are strictly enforcing total allowable catches (TACs).

The same two countries have also led the way in dividing their TACs into individual

transferable catch quotas (ITQs) for each vessel — New Zealand introduced ITQs in 1986; Iceland, after a successful experiment with its herring fishery, applied ITQs across the board in 1990. Without ITQs, fishermen race against one another to land as many fish as possible early in the season. Total catches, as a result, frequently exceed the TAC, and illegal fishing is common. With the security of ITQs, however, individual boats no longer compete as fiercely, so fishermen can spread their harvest over the season and sell any unused portions of their ITQ. The net outcome is that total catches tend to be lower.

These policies, according to analyses by the Organisation for Economic Cooperation and Development¹², have actually increased the profitability of the two countries' fishing sectors. What's more, some stocks that are fished by their vessels are now showing signs of recovery.

But will the fishing industry ever embrace the widespread introduction of large marine reserves? Despite recent progress in building bridges between scientists and fishermen, and the evidence that reserves can boost catches, many experts still can't see it happening. "Just imagine the blockades, riots and the tonnes of fish dumped on ministers' desks if they closed down half of the North Sea," says Shepherd.

Pauly believes that involving the public in the debate will be crucial. Consumer preference for products labelled as eco-friendly, for instance, could be a powerful factor in changing attitudes within the fishing industry — particularly if the public is informed of the consequences for consumer choice if fisheries are not put on a sustainable track. If the fishing fleets refuse to withdraw from large parts of the oceans, argues Pauly, future generations won't have the option of dining on cod or other familiar favourites. Instead, they'll have to make do with jellyfish and plankton. ■

Quirin Schiermeier is *Nature's* German correspondent.

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FAO fisheries statistics

♦ www.fao.org/fi/statist/statist.asp

Stock Recruitment Database

♦ <http://fish.dal.ca/welcome.html>

Sea Around Us Project

♦ <http://saup.fisheries.ubc.ca>

FAO Code of Conduct for Responsible Fisheries

♦ www.fao.org/fi/agreem/codecond/codecon.asp