Article Ray Hilborn

Moving to Sustainability by Learning from Successful Fisheries

There are two diverging views of the status and future of the world's fisheries. One group represented largely by academic marine ecologists sees almost universal failure of fisheries management and calls for the use of marine-protected areas as the central tool of a new approach to rebuilding the marine ecosystems of the world. The scientists working in fisheries agencies and many academic scientists see a more complex picture, with many failed fisheries but also numerous successes. This group argues that we need to apply the lessons from the successful fisheries to stop the decline and rebuild those fisheries threatened by excess fishing. These lessons are stopping the competitive race to fish by appropriate incentives for fishing fleets and good governance. The major tool of resetting incentives is granting various forms of dedicated access, including community-based fishing rights, allocation to cooperatives, and individual fishing quotas. Many of the failed fisheries of the world occur in jurisdictions where central governments are not functional, and local control of fisheries is an essential part of the solution.

INTRODUCTION

For more than a century, the status and future of fisheries has been a contentious issue in the scientific and management community, where two warring views prevail. Thomas Huxley's (1) of unending surplus:

... that the cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea-fisheries, are inexhaustible; that is to say that nothing we do seriously affects the number of fish. And any attempt to regulate these fisheries seems consequently ... to be useless.

and Ray Lankester's (2) more conservative appraisal:

It is a mistake to suppose that the whole ocean is practically one vast store-house, and that the place of the fish removed on the particular fishing-ground is immediately taken by some of the grand total of fish, which are so numerous in comparison with man's depredations as to make his operations in this respect insignificant.

These serve as bookends to pronouncements on fish productivity, with Lankester the one who proved to be right.

These debates continued well into the second half of the twentieth century when we still assumed that fishing did not affect recruitment. As recently as 1983, Gulland (3), in discussing the importance of stock and recruitment, stated, "more commonly the number of recruits is effectively independent of the adult stock size over most of the observed range of stock size."

In the last two decades, this view has changed greatly. Within the fisheries management community, the concern that overfishing reduces subsequent recruitment has become the primary focus of regulation, spurred by the increasing number of data sets showing declining recruitment at low stock sizes (4, 5).

There is now broad recognition that the western inheritance of "freedom of the seas" and open access to fisheries are largely incompatible with sustainable management. Gordon (6) noted the overinvestment and inevitable ensuing decline of fisheries more than half a century ago. That many fisheries continue to be overexploited and in decline is not for lack of scientific understanding but, I believe, is primarily a result of competing pressure for sustained employment and continuation of fishing communities, as well as poor governance.

It is almost universally recognized that the future of sustainable fisheries lies with much less fishing effort, lower exploitation rates, larger fish stocks, dramatic reduction in by-catch, increased concern about ecosystem impacts of exploitation, elimination of destructive fishing practices, and much more spatial management of fisheries, including a significant portion of marine ecosystems protected from exploitation. I believe this vision is broadly shared within the fisheries management and the ecological communities.

However much we find agreement on where we want to go, there is a great divide between ecologists and fisheries scientists on how to get there. This divide begins with vastly different perceptions on exactly what the state of fisheries is at present.

The Great Divide: Ecologists and Fisheries Scientists' Views of the Future of Fisheries

Worm et al. (7) projected that all of the world's wild fish stocks would be collapsed by 2048. These authors defined a stock to be collapsed if its catch in any year fell below 10% of the highest recorded catch and, using world catch statistics from 1950 largely compiled by the Food and Agriculture Organization (FAO), calculated the number of fish stocks that were collapsed in each year. In 2003 they estimated that 29% of stocks were collapsed.

The projection of the demise of all the world's fisheries by 2048 garnered great attention in the US and UK media. Although this projection was ridiculed by most fisheries scientists, it does highlight the deep divide between the community of fisheries scientists who work in the arena of fisheries management and the ecological and environmental communities.

In the last decade, quite a few alarmist papers have appeared in the journals *Science* and *Nature,* highlighting the decline of fisheries and the threats of fishing to marine communities. Casey and Myers (8) described the near extinction of barndoor skates due to fishing and by implication the extinction risk posed by current fishing practices. Pauly et al. (9) described the global pattern of declining mean trophic levels in the catch of marine fisheries, giving this process the name "fishing down food chains," suggesting the cause was sequential depletion of high predators, working down to lower trophic levels until there is nothing left in the oceans to eat but jellyfish. Hutchings (10) argued that fish stocks generally do not recover from collapse even when fishing is reduced. Watson and Pauly (11) suggested that the world's total catch of fish was declining rather than increasing due to systematic distortion of China's landings, and Myers and Worm (12) argued that all the large pelagic fish had been depleted by 90% by 1980.

This litany of disasters has been accompanied by intense publicity and led to the general perception among readers of *Science, Nature,* and major newspapers that all the world's

fisheries are poorly managed, that fisheries science and management have failed, and that dramatic new solutions are needed.

Closer inspection of this litany of papers shows them to be either outright wrong or serious distortions of reality. The status of barndoor skates has been reviewed in the US (13) and Canada (14) and found to be not only not headed towards extinction but not even overfished. Essington et al. (15) showed that mean trophic levels in most aquatic ecosystems do not decline because there are no large fish left. On the contrary, the catch of high trophic level fish is still rising, but an even faster increase in lower level fish causes the mean trophic level to decline. We have not run out of the high trophic levels yet. Closer inspection of the stocks Hutchings (10) looked at reveals that the vast majority of stocks that have not recovered are still fished very heavily. Although fishing pressure may have been reduced, it is still much too high. The latest data from the FAO show that world fish landings are not declining significantly and are most likely roughly stable. Numerous rebuttals of the Myers and Worm paper (16–18) have shown their conclusions to be absolutely and totally wrong, and a recent paper in *Science* (19) has shown that in 2004 the stocks of the major tuna fisheries of the Pacific Ocean are depleted by 10 to 70%, a far cry from 90% by 1980.

The rebuttals and refutations of the litany have not received the same profile in scientific journals as the original articles; *Science* refused to even review the Essington et al. rebuttal of fishing down food chains. None of these refutations has made the front page of the *New York Times, Washington Post,* or BBC television news. However, within the community of fisheries scientists working for fisheries agencies and most academic scientists with a specialty in fisheries management, these results, as with the absurdity of the Worm et al. (7) prediction of no fish by 2048, are well known.

This is not to say that there is not wide recognition within the fisheries management community that many of the world's fisheries are seriously overexploited or heading that way and that overfishing is indeed a serious problem. The following quote (20) reflects this recognition:

We see two very different paths fisheries may take in the future. One is that fishing pressure may remain high. Attempts to extract the maximum yield from fisheries will continue to lead to intense harvesting, and sequential depletion of major fisheries will result. Economics will cause fishing pressure to move lower down the food chain, so that fish species that are currently largely discarded will dominate the catch. Alternatively, we envision a future in which the race for fish is eliminated by appropriate institutional incentives, fishing pressure is reduced, stock abundance generally increases, and most depleted stocks recover. Commercial fisheries will strive for stability and profitability rather than maximization of yield.

The key element in this divide is that the fisheries community does recognize the difference between fisheries that are well managed and those that are not while the ecological community does not, instead seeing only problems and ignoring or discounting management systems that lead to ecological, social, and economic success.

The divide between the two communities is equally great when it comes to solutions. There is broad consensus that we need to move to much lower exploitation rates in most fisheries and equal consensus that removing subsidies that encourage fishing effort is part of the solution. We can agree on where we want to go, but we disagree on how to get there.

The ecological community almost unanimously recommends marine-protected areas as a central part of the solution, while the fisheries community sees stopping the competitive "race to fish" as the principal ingredient in success. The primary tool to stop this race to fish is to change incentives from those that encourage fishing fleets to expand to more and bigger boats (21) to those that encourage sustainability and stock rebuilding. The tools most often cited as key to setting appropriate incentives are now often called "dedicated access" and include community quotas and allocation, fishing cooperatives that internally allocate fish, territorial fishing rights for communities, groups or individuals, and individual allocation of catch quotas.

The divide is perhaps best illustrated by the similarities and differences in two major reports done in the US. The Pew Foundation, which has been the main source of funds for high-profile papers in *Science* and *Nature,* issued its report (22) on directions for US fisheries, which was strongly influenced by the same ecological community that provided most of the science advice. At roughly the same time, the US government (23) produced a report on directions for US fisheries, with most of the science advice from people working in the fisheries community. Both reports recognized serious concerns about the impacts of fishing, pollution, and land use on fisheries, and both recommended reducing fishing effort and adopting a broader ecosystem view of fisheries management. However, they differed in the tools to use to get to the desired location. Pew's report was predicated on strong top-down control, pushing for stronger legislative mandates for stock rebuilding and less representation of commercial interests in the US Fisheries Management Councils. The government report placed a strong emphasis on incentives through dedicated access, whereas incentives and dedicated access are not even mentioned in the Pew report.

The theme of this paper is that, although the majority of the world's fisheries have yet to transition to ecologically and socially sustainable management, many fisheries have, and we need to look at the lessons from these fisheries to know how to move forward.

DEFINING SUCCESS

Before we can learn from successful fisheries, we must define what we mean by success, and here success is synonymous with objectives of fisheries management. Traditionally, we have looked at four categories of objectives: biological, economic, social, and political. The biological objective, commonly found in legislation and international agreements, is the traditional maximum sustainable yield (MSY) that produces as much harvest as possible in the long term. In recent years there has been an additional emphasis on protection of nontarget species, particularly charismatic ones, such as whales and dolphins, and on protection of ecosystems. Economic objectives consider economic efficiency or "rent" as the desired outcome of fisheries management. Social objectives seek to spread employment and income among many participants in the fishery and the production of food and maintain traditional communities.

These objectives are often in conflict. As seen in Figure 1 (24), the relationships between the amount of fishing effort and objectives are contradictory. Maximization of jobs calls for the highest sustainable fishing effort, whereas maximization of ecosystem benefits necessitates 0 fishing mortality. The divide between ecologists and fisheries scientists is spelled out in these objectives. Ecological training places a high value on intact ecosystems, which leads to the push by ecologists for marine-protected areas. The fisheries community has traditionally been legislated to use MSY as an objective, while political pressure has often pushed fishing efforts even higher to preserve and create jobs and maintain fishing communities.

A relatively new and formal definition of fisheries success involves the principles of the Marine Stewardship Council (MSC), an international body originally formed jointly by the

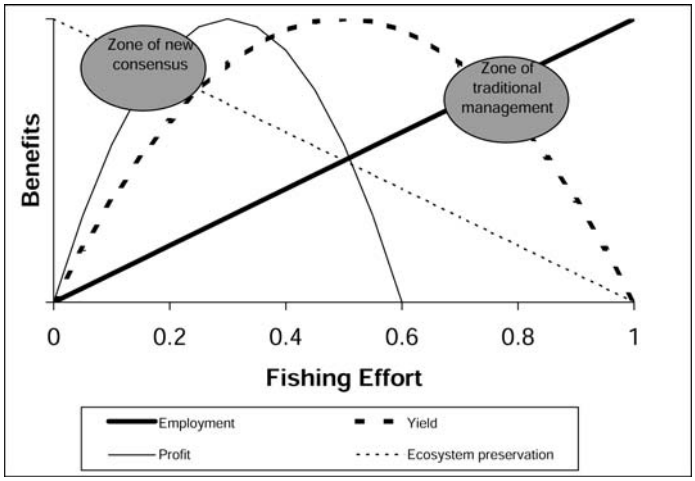

Figure 1. Benefits to different objectives in relation to fishing mortality rate. Reprinted from (24) with permission.

WWF and Unilever to accredit fisheries as being "sustainable and well managed" (25). The MSC looks critically at the condition of the fish stock, the impact on the environment, and the management system in place. As of 2005, 14 fisheries around the world have been certified by MSC, including many of the fisheries most commonly cited as being well managed. However, the MSC criteria do not include any economic or employment objectives. For instance, Alaskan salmon was one of the first fisheries certified at a time when these fisheries were in great economic trouble, employment and participation had declined dramatically, and livelihoods were threatened.

This illustrates the complexity of success: there can be biological success without economic and social success. Each approach demands different tools. Although fisheries management has been primarily concerned with the biological management of stocks, essentially finding ways to control fishing effort at a level that supports MSY, economic performance is usually controlled from outside the management agencies through such programs as tax policy, subsidies on vessel construction, and unemployment insurance.

A beautiful illustration of the great divide between perception and objectives is the New Zealand orange roughy fishery. This fishery is often cited as a failure, and indeed the Australia orange roughy stock has now been declared "threatened." Figure 2 shows the trajectory of the New Zealand orange roughy stocks. Almost all stocks have been fished down to, or below, the level that will produce MSY. However, when addressing the question of whether the fishery production was at or near MSY, researchers (26) found that only 8% of potential biological yield was being lost due to overfishing, and after an economic analysis the authors concluded that the management of the fishery was close to economically optimal (Fig. 3).

SUCCESS OR FAILURE: THE CALIFORNIA CURRENT ECOSYSTEM

The California current ecosystem illustrates many of the failures and successes of fisheries management (27), as well as the divide between ecological and fisheries perception. Figure 4 shows the history of exploitation of the major groups in the ecosystem that had seen the sequential exploitation and depletion of sea otters, fur seals, elephant seals, grey whales, and sardines, all before 1950. Since then, foreign and domestic fisheries have exploited a wide range of stocks, and at present seven species of groundfish managed in federal waters are declared overfished and salmon in California are on the threatened list. It is an ecosystem that to some typifies the continued degradation of an ocean ecosystem,

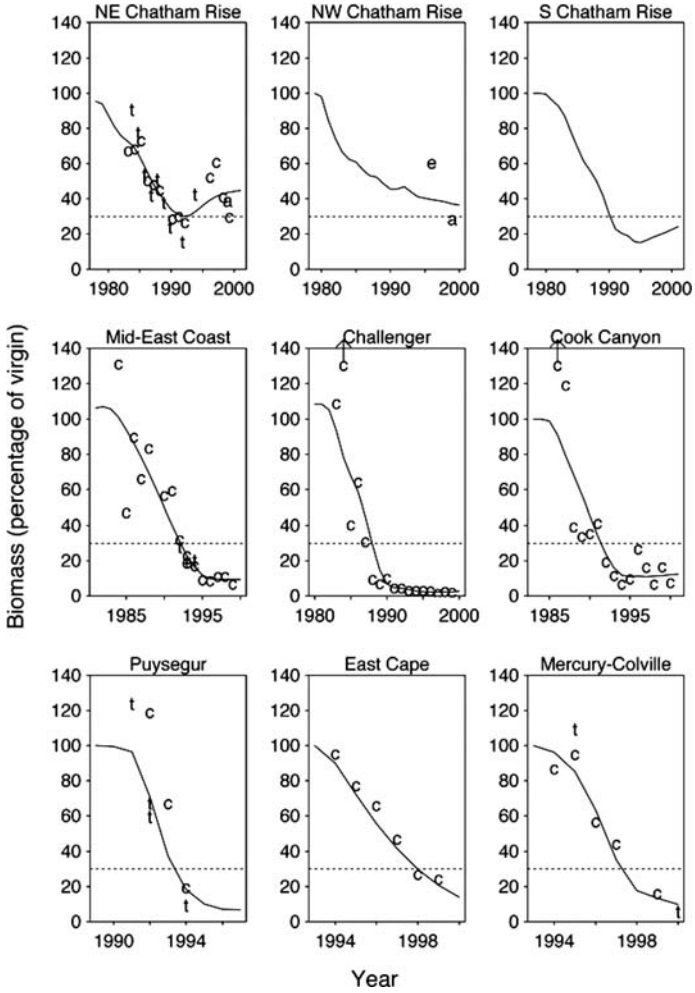

Figure 2. Trends in orange roughy stocks in New Zealand.

leading to state legislation under the Marine Life Protection Act that mandated establishing a system of marine reserves to protect it.

Using the Worm et al. (7) metric of stock collapse, we see a pattern similar to that seen in the whole world, with a linear extrapolation showing that by 2048 all but 33% of the stocks will have collapsed (Fig. 5).

But when we look at this ecosystem in more detail, our perception shifts. The initial overexploited and collapsed stocks were largely marine mammals that are all recovering or at least returned to significant abundance. Grey whales are now at their pre-exploitation level of abundance; fur seals, sea lions, and elephant seals are rapidly growing; and sea otters have returned in good numbers (28).

Among the major fisheries, sardines, the icon of 1950s collapses, have recovered. All the seven stocks listed as overfished by the Pacific Fisheries Management Council (PFMC) are small and when combined constitute only about 1.5% of the total unexploited biomass. Certainly they are overfished, but they are not an important part of ecosystem function. The loss of yield due to overfishing in federally managed fisheries is negligible.

Far greater is the loss in yield due to discarding caused by the two-monthly vessel limits for trawlers, as well as the restrictive limits placed on quotas of healthy stocks to avoid by-catch of overfished stocks. Hilborn et al. (29) estimated that if the PFMC wanted to assure that no stocks were overfished, 90% of the potential yield would be lost because exploitation rates would need to be very low to assure no overfishing at all in the face of natural environmental fluctuations.

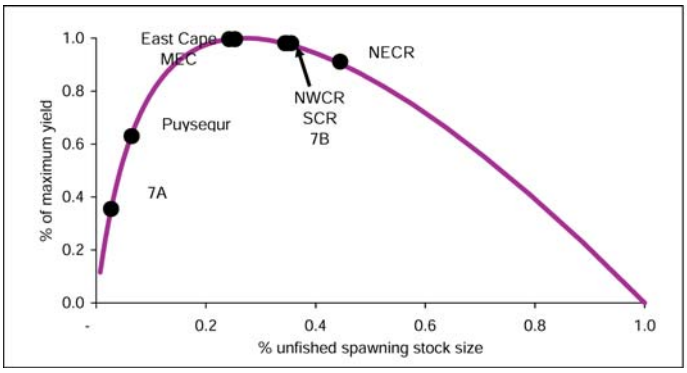

Figure 3. Location of different New Zealand orange roughy stocks on the yield curve. Reprinted from (26) with permission.

The analysis of the California current ecosystem illustrates many of the problems in Worm et al.'s definition of collapse. Although collapsed stocks constitute 29% of all stocks in 2000, they are mostly small, only 8% of the historical landings from the ecosystem. Among the stocks classified as collapsed, the largest is jack mackerel (*Trachurus symmetricus*), which represents one-third of the historical landings of all the collapsed stocks but is not considered overfished by the PFMC. The fact that landings are less than 10% of the historical high reflects changes in markets, management practice, and fluctuating abundance. The second largest collapsed stock is bonito (*Sarda chiliensis lineolata*), which fluctuates greatly in abundance and has collapsed three times in the last 50 years by Worm et al.'s metric. These two stocks alone constitute 50% of the historical catch of collapsed stocks. Clearly, the definition of Worm et al. of collapse has little relation to the biological status of the stock.

There is, nevertheless, a broad perception that the California current fisheries are in trouble. Part of this may be that the general public knows little, if anything, of the large fish stocks in the ecosystem, because the primary contact is through recreational fishing on small inshore stocks that may indeed be more depleted than the numerically more important stocks. Once California abalone were an important sport-dive fishery, but by now they are severely depleted. Because there is no abundance-based measure of the status of the inshore stocks, individual perception may fall under the orange roughy syndrome, i.e., fully exploited stocks are much less abundant than pristine stocks. California sport fishermen will have seen their fishing success with all stocks decline as the fishery developed. Someone who sees a 70% decline in abundance and catch rate will likely not regard that fishery as well managed, even if the stock is now at the level that produces MSY.

From a perspective of yield, one must consider the federally managed fisheries a great success. No significant components of the ecosystem are overfished, and fishing mortality has been dramatically reduced on all overfished stocks. One of the first species listed as overfished, lingcod, recovered rapidly and is no longer so considered. The ecosystem is numerically and trophically dominated by the highly variable pelagics (sardine, jack mackerel, anchovy) and Pacific whiting. The current levels of fishing on these stocks will certainly keep their abundance lower than the pristine state, but the ecosystem as a whole retains its basic structure.

The biological success of this system is due to the implementation of the Magnusson-Stevens Act and its provisions. Although this is a top-down management system, we should emphasize that it (like all US federal fisheries) is managed by a regional body (the PFMC) with very significant representation of fishing industry groups.

It is worth noting that the general biological success in this ecosystem has not brought an economically healthy fishery or fishing community. Employment and profitability have plummeted, and the strong conservation measures imposed to try to rebuild the overfished groundfish stocks have cost much yield from healthy stocks. Although many of the fisheries in this ecosystem are managed with limited entry, none has any true form of dedicated access, and there is a long way to go before the incentives are truly well aligned with long-term conservation and economic profitability.

THE FISHERIES' PRESCRIPTIONS OF SUCCESS

In a series of workshops run by FAO (30, 31), the following key elements of sustainability in world fisheries were defined:

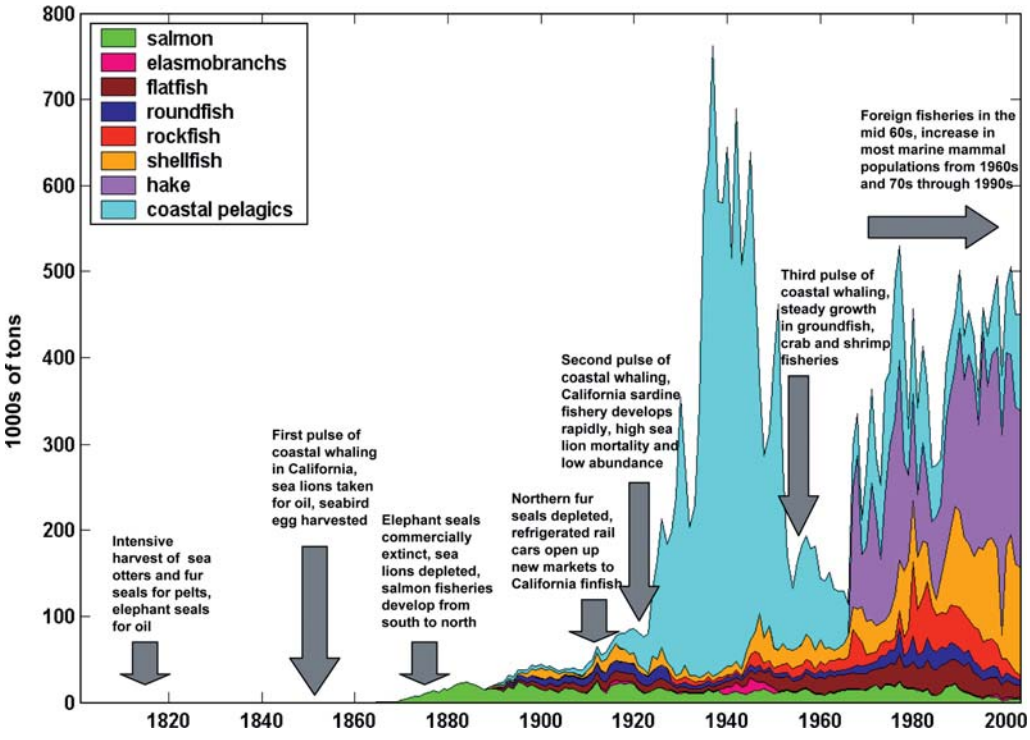

Figure 4. Trends in catch in the California current ecosystem. From Field et al. Reprinted from (27) with permission.

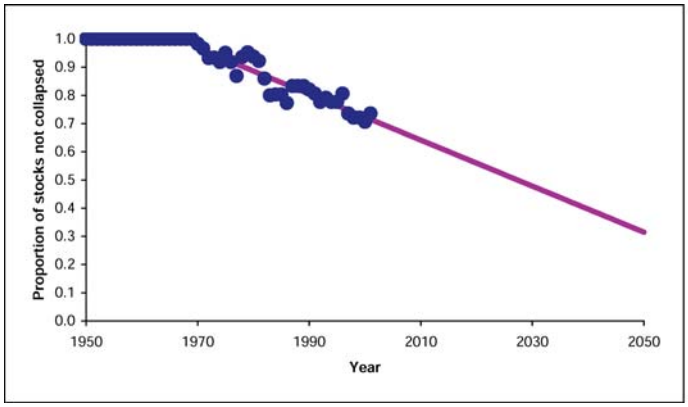

Figure 5. Trends in collapsed stocks in the California current ecosystem using the Worm et al. definition of collapse.

Good Governance

The key to sustainability of a fishery is good governance. Many of the world's fisheries are managed in a nonsustainable fashion because there exists no real governance, the governance system requires the consensus of too many, or the system is corrupted by bribery. Successful fisheries management systems enjoy governance that is deemed transparent by the participants with a scale of decision making appropriate to the fisheries being managed and in which the regulated stakeholders feel represented in the process.

Appropriate Incentives

Fishermen respond to the incentives of the system; in open-access, or "Olympic," systems, the race to fish demands more and bigger vessels and pressures management agencies for larger catches. In dedicated access fisheries, fishermen cannot catch more fish with more or bigger boats, and so the incentives favor reducing costs, higher quality product, and better information to improve management of the fishery. The most important incentive is dedicated access.

The most important form of marine conservation used in Palau, and in many other Pacific islands, was reef and lagoon tenure. The method is so simple that its virtues went almost unnoticed by Westerners. Yet it is probably the most valuable fisheries management measure ever devised. Quite simply, the right to fish in an area is controlled and no outsiders are allowed to fish without permission. (32)

Although true territorial tenure is being re-established in the Pacific (33) and has been quite successful in Chilean artisanal fisheries (34), western countries have not been so accepting. There, tenure most often assigns individual or community rights to specific levels of catch, expressed in individual transferable quotas or the formation of cooperatives, such as the Alaskan floating processor fleet for pollock.

Reducing Demand for Limited Resources

Quite often, there is a mismatch between fishing capacity, demand, and the productive capacity of the resource. Successful fisheries have found ways to better match the demand to the productive capacity of the resource, using removal of subsidies and appropriate incentives as tools. Unfortunately, reducing demand for resources almost always results in lower employment and thus conflicts with governmental fisheries policy.

Elimination of Poverty and Providing Alternatives

In many regions of the world, fishing is one of the few forms of employment open to the very poor. Pauly (35) called this problem Malthusian overfishing. As populations grow and the agricultural resources per capita decline, the pressure on marine resources increases. Although it is difficult and complex, elimination of poverty is an important step to sustainable fisheries, and it is no coincidence that many of the world's well-managed fisheries are found in countries with little poverty and many alternative forms of employment.

Improving Knowledge of Complex Ecosystems

Some of the nonsustainable fisheries can be attributed to poorly understood, complex ecosystems, whereas most well-managed fisheries are characterized by well-funded data collection programs to provide information on the resource being managed.

Interactions of the Fisheries Sector with Other Sectors and Environments

Fisheries management agencies are usually only one player in a potential success story, and their well-intentioned efforts are often subverted by other government agencies through subsidies or poor environmental regulations that badly affect fish or fish habitat, especially in fisheries that strongly depend on critical coastal habitat.

Tools of Sustainable Management

A set of recommended tools and approaches that are broadly supported within the fisheries community (21) emerged from the FAO workshops. In order of importance, given by FAO, these are:

- Rights: The granting of secure rights to resource users (individually or collectively) for use of a portion of the catch, space, or other relevant aspects of the fishery.
- Transparent, participatory management: The granting of a meaningful role to stakeholders in the full range of management (e.g., planning, science, legislation, implementation).
- Support to science, planning, and enforcement: Providing the resources necessary for all aspects of management of the fishery.
- Benefit distribution: Using economic tools to distribute benefits from the fishery to address community and economic sustainability.
- Integrated policy: Planning fisheries, including setting explicit objectives that address all the dimensions of sustainability and the interactions among the factors of unsustainability.
- Precautionary approach: Application according to FAO guidance.
- Capacity building and public awareness rising: Development and application of programs to better inform policy makers and the public at large about main fisheries issues.
- Market incentives: Using market tools in situations in which they are appropriate for addressing factors of unsustainability.

MOVING TOWARDS SUSTAINABILITY: APPLYING THE LESSONS

There is no single prescription for moving currently unsustainable fisheries toward sustainability. The appropriate method will depend greatly on local circumstances. The prescription for a wealthy industrialized country will be very different from that for a poor country with weak government institutions. Even within a single country, such as the US, the prescription will

differ greatly from region to region and from fishery to fishery. Sustainability for a small-scale, largely sedentary fishery will be achieved very differently than for a large-scale industrial fishery, to say nothing of the myriad of special problems in international fisheries.

Wealthy Countries with Strong Central Governments

Wealthy countries with strong government institutions can certainly achieve biological sustainabilty by the classic legal mechanism of simply enforcing major reductions in catch. As we saw in the California current ecosystem, this approach does not necessarily lead to economic or social sustainability: too many fishermen and processing plants will suffer dramatic declines in catch. Plant closures, unemployment, bankruptcies, distress sale of boats, and community disintegration inevitably follow. Such severe social disruptions of a fishery that is squeezed by major reductions in catch can be mitigated by a form of dedicated access with its associated increase in value and assets to the fishermen.

Reductions in fishing effort do not necessarily mean reductions in catch because effort comes in many guises. Fewer boats can catch as much and even more once the stock has had time to rebuild.

Therefore, many of us see the incentives of dedicated access as the key for moving from a high–exploitation rate fishery of high effort-low abundance-low profit that strives to squeeze the last sustainable fish from the system (21, 36), to the world of lower effort, higher abundance, and higher profit. In countries with strong management infrastructure, this combination of top-down reduction in catches and proper incentives can work and has worked in quite a few fisheries in the US, Canada, Iceland, and Australia.

Small-Scale Fisheries and Countries Without Strong Central Governments

In countries without strong central management structures, decentralization and locally controlled dedicated access appears to be the best way to make the transition to biological and economic sustainability. The territorial fishing rights in the Chilean artisanal fisheries and the redevelopment of village control over fishing in the western Pacific are two good examples.

Solving the problems of countries with no functioning governmental structure is beyond the scope of fisheries management. If the country is in chaos, fisheries managers can do little on a national scale. Corruption is equally destructive. If senior government officials allow foreign fleets or unlicensed fishermen to fish in their waters, there is little hope of sustainability. However, management can succeed on a local scale because a functioning form of local governance, such as traditional custom or local councils, is possible even without an effective national government. In this case, enforcement and protection of the local dedicated access become vital to success. A potent threat to local control are industrial fleets based in larger cities. Unless such fleets can be excluded, local dedicated access becomes meaningless.

The key to moving forward without an effective national infrastructure is local control of exclusive access by local fishermen.

International Fisheries

No consideration of the paths to sustainability can be complete without international fisheries. The existing governance regimes for high seas fisheries have failed totally. Despite the existence of numerous regional management organizations (RMOs) as mandated by the UN fishing agreements, none of them regulates high seas fisheries to any effect. RMOs fall into two groups: those who have effectively banned fishing of their target species on the high seas (the International Whaling Commission and the North Pacific Anadromous Fisheries Commission) and those whose regulations are ineffective at preventing the fishery from going to natural "bionomic" equilibrium. In these fisheries, catches are limited by economics rather than regulation.

The failure of the RMOs is directly due to the fact that under existing international law, any country can develop a new fishing fleet for high seas fisheries. If an RMO were to maintain a stock biomass at profitable levels, other countries would see incentives to enter the fishery. Immediately, the incentives for existing fishing nations to maintain high stock abundance will disappear, and their only hope for survival and possible profit is to rely on their superior experience in catching and marketing to make it uneconomic for new entrants while there remains some profitability for their fleets.

The governance of the RMOs precludes in itself any effective management because most require consensus or at least super majorities to implement effective catch regulations. Even when catch regulations are implemented, RMOs usually have limited if any monitoring and enforcement power and normally rely on national governments to monitor and enforce their own fleets. Several recent cases have shown such self-enforcement to be illusory.

The common threads running through the successful and profitable fisheries are some form of secure and limited tenure or access to the fishery, a monitoring and enforcement system that allows those who have access to be confident it is not being significantly infringed by interlopers, and a scientific and data collection system that provides reliable and timely data.

Existing RMOs boast none of these. There is no exclusive access, there is no confidence that others will not enter the fishery, and the data collection schemes rely on national reporting with generally very limited coverage by observers, so that most catch reporting is done by the vessels themselves.

The following proposal outlines how we might move to a system that would encompass the necessary criteria. It draws heavily on suggestions made by Crothers and Nelson (37). It necessitates significant modification in existing international law and practice and would undoubtedly be opposed by many, if not most, existing high seas fishing fleets. However, it would provide significant benefits for most of the countries of the world, provide a framework for sustainable management of high seas resources, and enable existing high seas fleets to continue to operate and indeed make profits.

The steps are as follows:

i) A UN treaty declaring the living marine resources beyond the 200-mile limits the common property of mankind and prohibition of any harvesting on the high seas outside the guidelines listed below. All nations of the world would be encouraged to sign this treaty, with the financial incentives below providing significant inducement.

ii) Access to high seas fisheries would be limited to vessels paying access fees to an international fund that would pay for the management and enforcement of the fishery, and return excess revenues to the signatory nations of the international treaty setting up the international regime. The level of the access fees could be determined either by competitive sealed bids or by independent bioeconomic analysis. If access fees were not sufficient to pay for management and enforcement of a particular fishery, the fishery would not take place.

iii) All vessels fishing on the high seas would have 100% satellite tracking (vessel monitoring system) coverage at all

http://www.ambio.kva.se

times and 100% observer coverage from an international body of observers.

iv) Independent scientific panels would set the allowable harvests for these fisheries to maximize the revenue to the nations subscribing to the treaty.

These steps would assure that the renewable high seas resources were managed so that the people of the world gained from potential profits and that the stock biomasses would be maintained at the high levels associated with profitable fisheries. The vessel monitoring system and observer coverage would provide assurance that the management regime was being enforced and that the data required to determine allowable harvests were available.

Could we move from where we are now to such a system? By providing direct financial benefits to all signatory nations, any nation now not fishing on the high seas would have obvious financial benefits. In theory it is the nations and fleets that now fish the high seas who would be disadvantaged. However, the lessons of the recent past are that the only real profitability on the high seas has come from the development of new fisheries; once fisheries mature, the profits are gone, and the major high seas fisheries of the world are clearly struggling. A nation or company with a large high seas fishing fleet might indeed see that its long-term expected profits under a scheme in which significant access fees were being charged could be more profitable than the current default, in which all high seas fisheries are at or close to the level of no profits.

Without such fundamental changes in high seas governance, I see the only hope for long-term sustainability of high seas fish stocks in rising oil prices. The existing legal framework for high seas fisheries is utterly inadequate to protect them.

CHALLENGES

Although I believe we can say with some confidence that there is a wide range of incentive-based tools available to move fisheries towards more sustainable states, there do remain a number of interesting challenges in the scientific and administrative arenas that have largely been unaddressed. In addressing each of these challenges, we need to look to places where success has been obtained and learn from it rather than necessarily seek new untried solutions.

Sustainable Approaches to Stock Fluctuations

The first challenge is finding sustainable solutions to natural and anthropogenic fluctuations within ecosystems. Species fluctuate in abundance, and four or five decades ago most fishing fleets exploited a range of stocks. The fishermen of the California current ecosystem fished a mixture of salmon, crab, shrimp, and other fish. Similarly, the fishermen of Newfoundland exploited cod, lobster, crabs, harp seals, and other stocks. As fisheries agencies discovered the need to regulate fishing effort, license limitation and other forms of limited entry became the primary tools. This forced fishermen to specialize. Fewer and fewer individuals or boats had the legal right to fish multiple stocks, and thus more became vulnerable to fluctuations in abundance of their target stock. Although the landed value of fish products in Eastern Canada has consistently risen through the 1990s despite the collapse of groundfish, those licensed to fish groundfish were put out of business because they could no longer switch to crab and lobster.

There is a great opportunity to restructure fisheries as we know them from single-species–dedicated access to multispecies-dedicated access systems and perhaps best at the community rather than the individual level, making the fishing communities themselves more sustainable as they switch between species when those fluctuate in abundance. The territorial fishing rights of Chilean artisanal cooperatives is one example of such multispecies-dedicated access.

Ecosystem Cultivation: Is There a Role?

Biological diversity is desirable to both ecologists and fisheries scientists because it contributes to sustainability within a species (38), as well as within an ecosystem (7). As part of the shared vision I described earlier, I see broad agreement that we generally want to maintain the basic structure of ecosystems being exploited to allow for different species and/or stocks to boom and bust as environments change. One of the primary principles of the MSC's is that fishing does not transform ecosystems.

If we look to terrestrial ecosystems, we find that cultivation and monoculture yield the most. You do not maximize productivity of prairies by growing native grasses, but instead plow the land and plant crops. In some aquatic systems, too, cultivation brought dramatic increases in productivity. Shellfish farms come to mind. Exotic species introductions have transformed many freshwater systems and led to much more valuable production (e.g., salmonids in the Great Lakes, Nile perch in Lake Victoria). Furthermore, although the long-term sustainability of these introductions is certainly questionable, we do need to ask if cultivation is an option for management of the world's fisheries.

Many shrimp and prawn fisheries can be thought of as cultivated ecosystems. Competing or predatory species are often eliminated early, and bottom trawling may in fact stimulate productivity of the shrimp and prawn populations. Given that many of these fisheries have persisted for decades, this is certainly a prima facie case that such a fishing practice is sustainable. If it is, should we allow such a practice as part of sustainable fisheries management? It would seem that some form of spatial management would be appropriate, devoting some areas to cultivated fishing while protecting other areas in a much more natural state. This subject has certainly been addressed by agencies that allow leasing sites for shellfish farms but has not been directly addressed in most marine fisheries.

Use of Bottom Gear and Destructive Fishing Practices

Bottom trawling is a highly contentious form of fishing, and many nongovernmental organizations are pushing for its elimination. This is unlikely to happen in the near future because a very significant portion of world fish catch comes from bottom trawling and the trawling groups have considerable political power in many countries. The National Research Council (39) conducted a major study of the intensity of bottom trawling and showed that some areas (e.g., Gulf of Mexico, Georges Bank) are trawled multiple times a year, while in other areas (e.g., the west coast of the US), a relatively small portion of the bottom is trawled. Although Watling and Norse (40) argue that trawling is comparable to clear cutting, the analogy is fallacious because most of the area trawled in a given year had been trawled the year before, whereas few logging companies cut down the same area year after year.

There is little doubt that bottom trawling dramatically transforms bottom types that have considerable vertical structure, and recent moves in the US and New Zealand to close large areas of their exclusive economic zone to any future trawling recognize the desirability of protecting these habitats. However, in soft-bottom habitat, it is less clear if trawling is destructive, or if, on the contrary, it stimulates production of target species. Interestingly, none of the major studies of trawling has asked whether it stimulates ecosystem productivity and which species benefit and which are harmed. In the US we

do seem to be moving towards a zoning system that protects some areas from trawling and keeps others open, but much of the basic science of the impact of trawling has yet to be performed.

SUMMARY: MOVING TOWARDS SUSTAINABILITY BY LEARNING FROM SUCCESSFUL FISHERIES

My key argument is that there are a range of proven tools available for moving from nonsustainable to sustainable states. Many lessons have been learned from success and failure, and the lessons from the successes need to be applied to fisheries that have yet to make the transition to sustainability. Although incentives appear to be the strongest tool, there are no general solutions because the type of incentives will differ from fishery to fishery. A prerequisite to success, however, is effective governance. Without it, any attempts at sustainability will fail.

This brings us back to the divide between fisheries scientists and ecologists. Ecologists almost universally prescribe protected areas as the central tool in moving to sustainability (7, 41). Fisheries scientists are very suspicious of this prescription (42), foremost because protected areas are not a central feature of successful fisheries and because protected areas are simply a patch to the problem of overexploitation (29) that does not address the basic causes, including the race to fish. Fisheries scientists certainly see protected areas as an important part of the toolkit and have used closures of spawning and juvenile rearing areas as a common element of traditional fisheries management.

One of the most widely advocated approaches to natural resource management is adaptive management (43), which, when stripped to its bare elements, is learning by trial and error that is well thought out. Over the last century there have been trials in thousands of fisheries around the world, and there are numerous lessons to be learned from the successful ones. The future of fisheries sustainabilty will depend on our ability to understand the key elements of these successes and apply them well.

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