Policies to enhance long-term sustainability of marine fisheries

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Executive Summary

Historically, marine management policies have been unable to ensure sustainable, economically viable fishing practices. These policies have been ineffective in regulating technological advancements in fishing, and flawed policies have contributed towards hastening the use of harmful technologies. As a result, several once-major fishing stocks are overfished or collapsed, resulting in both severe environmental degradation and large economic losses. This paper proposes a series of initiatives to encourage the fishing industry to adopt sustainable fishing practices and provide support to maintain healthy, profitable commercial fish populations.

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Introduction: The Fishery Crisis

The world's oceans have long been a vital source of food and other resources. Economically, too, fishing is an extremely important industry, with fish worth US$4.2 billion landed in the U.S. in 2007. However, poor management policies and lax enforcement have placed a growing strain on many of the fish populations relied upon by the fishing industry. Some species, like bluefin tuna, are approaching collapse. The independent International Commission for the Conservation of Atlantic Tunas (ICCAT) estimates that in 2008, 60,000 tons of bluefin tuna were caught, four times higher than the commission's recommended maximum catch of 15,000 tons [1]. Conservation groups have called for an immediate halt to all bluefin fishing to stave off extinction. In the Pacific, the Northwest chinook salmon season was almost completely shut down after fisheries officials counted a 90% decline in spawning fish over the last few years. The economic loss to California alone is estimated to be around $255 million [2].

While these are the most recent species to be dangerously threatened, there have been similar collapses in the past, causing the loss of millions of dollars of revenue as well as tens of thousands of jobs. For example, the yearly oyster yield from Chesapeake Bay is now 80,000 bushels, compared with 9 million in the 1870's [3]. In 1992, the once-numerous Atlantic cod, a species famed for its ubiquity, had declined to less than one percent of its population size 30 years prior. Canada was forced to declare a moratorium on cod fishing, leaving 40,000 people without jobs [4]. More than a decade later, cod fishing stocks are still unable to recover.

Clearly, these economic losses are significant. Furthermore, fishing jobs from a particular fish stock are generally concentrated in a few locales, and these communities often have few other sources of income. As a result, the effects of a fish stock collapse create a focused, severe socio-economic blow. For example, 30,000 of the 40,000 jobs lost in Canada to the cod collapse were in the province of Newfoundland and Labrador [5]. When the moratorium took effect, more than 1 in 20 people lost their jobs. Because the job loss estimate only included jobs directly tied to the cod industry, the actual fraction of jobs lost was likely much higher. Not surprisingly, the population of the province has steadily declined since, and entire towns have been abandoned.

Catastrophic population collapses are not the only threat to fisheries. Less severe overfishing, which may not immediately cause collapses, drains breeding populations and lead to an overall decline in catch totals over subsequent years. In 2003, the Pew Oceans Commission reported that, of 304 studied U.S. fish stocks, 93 stocks were overfished [6]. The state of another 120 major stocks was unknown. The UN World Bank and the UN Food and Agriculture Organization report that, worldwide, poor fisheries policies and the resultant overfishing cause the loss of an estimated $50 billion a year [7].

Certainly, overfishing is not the sole culprit threatening marine populations. Coastal fisheries are often damaged by general environmental influences as well. Yearly fluctuations in weather and climate can greatly affect fish populations. Human environmental changes also play an extremely large role. Coastal development, runoff from upstream industries, dam building, and many other human factors have degraded vital breeding sites in estuaries and rivers. In some areas, such as off the mouth of the Mississippi in the Gulf of Mexico, human factors contribute to a yearly hypoxic "death zone" that kills indiscriminately. Overfishing, however, exacerbates these environmental stresses on fish populations. While healthy populations can survive natural and man-made environmental stresses, the combination of environmental changes and overfishing can push a fish stock into collapse. This paper will thus focus on methods to regulate overfishing and encourage healthy fishery practices.

Flaws in current fisheries policy

Many factors have contributed to the current overfished state of fisheries. Fisheries management is currently plagued by poor policy, often compounded by overly complicated regulatory systems and a lack of scientific information about marine ecosystems. Traditional fishery management policy uses several regulatory mechanisms, such as catch quotas to limit the total fish brought into harbor, fishing seasons to limit when fish may be caught, and geographical restrictions on certain fishing methods, such as banning the use of bottom-trawlers in some ecologically sensitive areas. However, these methods share several distinct weaknesses, and in some cases actually encourage harmful fishing practices. I describe three of the main weaknesses below.

1. Failure to control bycatch and bykill
2. Inability to quickly adapt to technological innovations
3. Encourages inefficient technological investment

1. Failure to control bycatch and bykill

Catch quotas and other regulations that limit the amount of fish landed, or brought to market, do not consider the fact that much of what is hauled onto most modern fishing vessels is not considered salable. Modern nets and trawls gather everything in their paths, including undesired fish, other organisms, and miscellaneous debris along with the fishers' target species. This incidental catch is called bycatch, and it constitutes a significant part of every haul. Shrimp trawls, for example, are estimated to catch an estimated 5 to 15 kilograms of bycatch for every kilogram of shrimp harvested [3]. Importantly, some of this bycatch consists of commercially valuable fish—to other fisheries. Juvenile red snapper is one of the major bycatch fish for shrimp trawls, which threatens the commercial red snapper fishing industry.

Bycatch is not limited to net-based fishing. Long-line vessels will also regularly catch fish other than their target prey. Unfortunately, because catch quotas refer only to the amount of fish kept, bycatch is discarded overboard. The lack of bycatch regulation also makes it economically advantageous to keep only the most valuable species of fish. Less valuable species are discarded, in a process known as "high grading." By the time bycatch animals are sorted from the desirable species, they are mostly dead or dying, creating bykill, which is rarely measured and mostly unregulated. This increases the environmental impact of fishing beyond those measured.

Ghost fishing is another cause of bykill. Many nets, traps and other fishing gear are lost at sea. Because the nets are made of highly durable, synthetic materials, they viable and functioning long after they have been lost. Studies have shown that these nets can continue to catch and kill animals for more than a year, further contributing to unproductive catches [8].

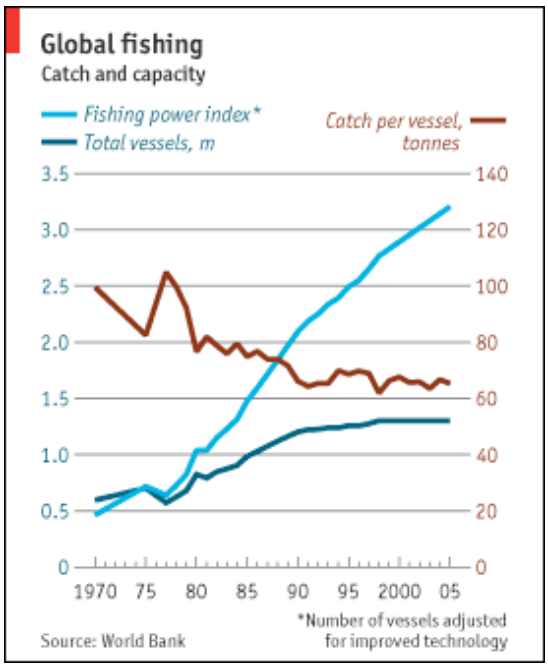
Fishery managers have taken some steps to reduce bycatch. In particular, some regulatory commissions require fishing vessels to use nets designed to reduce bycatch, especially of endangered species such as dolphins or sea turtles. However, the use of catch quotas in their current form nevertheless encourages wasteful harvest technologies, only partially tempered by layers of regulation to protect a few specific species.

2. Encourages inefficient technological investment

Traditional fishery management rules, such as catch quotas and limited fishing seasons, combined with fleet subsidies, have resulted in a rapidly intensifying race between fishers to

catch as much as allowed in as little time as possible. This has created fishing fleets capable of catching far more fish than are allowable under catch quotas, known as overcapacity.

This arms race between fishers creates an artificially induced demand for investment in technology development that are directed towards catching more fish, and more quickly, with no benefit to fishers or the sustainability of fish populations. Over the last twenty years, fishers' investments into greatly improved technology have not increased the overall amount of fish caught (See chart)[7]. Technology investment and development would be far more beneficial if it were directed towards other goals, such as the reduction of bykill.



3. Inability to quickly adapt to technological innovations

Traditional management policies are unable to keep up with advances in fishing technology, and instead must play "catch-up" to regulate new techniques after they have already been prevalent. For example, deep-sea trawling was developed during the 1960's. Despite general agreement on its capacity for widespread destruction, deep-sea trawling still occurs without regulation in many parts of the ocean [9]. Purse-seine fishers are now leaving radio-tagged logs to float on the oceans for several months. The logs gather swarms of small fish, which in turn draw juvenile bluefin tuna and other marine animals. This technique allows fishers to catch even highly depleted and scattered populations of fish with little effort, but it has not yet come under regulation.

Rapid policy decision-making is partly hindered by the lack of scientific studies on the impact of new technologies and fisheries. The live food fishery, which catches fish alive for transport to supermarkets and restaurants, was thought to have begun on the West Coast in the 1970's, yet even now there are no statistics for its impact on fish populations in California [3]. Without knowing the potential economic and environmental impacts of an industry, fishery councils and other policy decision-makers are unable to determine whether regulation is even necessary, much less what types of regulation are appropriate.

Some of these flaws in fisheries management are slowly starting to be addressed. The 2007 Magnuson-Stevens Reauthorization Act (MSRA) calls for a wide variety of new policies to better manage fishery stocks. Among these are calls to reduce the overcapacity of fishing fleets, to develop equipment that reduces bycatch, and to adopt individual fishing quota (IFQ) programs in fisheries nationwide [10]. However, these steps are insufficient to address the mis-incentives that drive current overfishing. While the MSRA is a vital step towards reforming fishery policy, it needs a great deal of supplementation to encourage long-term sustainable fishing practices that are acceptable to fisheries' many stakeholders.

Policies to encourage sustainable fishing practices

To address the flaws I have described above, I propose four mutually supportive initiatives to develop and maintain productive fish populations.

1. Establish a series of small marine reserves in active fishing grounds to serve as a refuge for healthy breeding populations.
2. Provide economic incentives to encourage sustainable fishing practices.
3. Redirect science investment more strongly into marine ecology.
4. Direct fishery councils to base policy decisions on science findings.

1. Fishing reserves

Fishing, by definition, requires the harvest of large, economically valuable specimens. However, recent studies have shown that large, older fish are also the most reproductively productive individuals in a population [11]. It is difficult to exclude such individuals from catches, nor would it be economically feasible for the fishers to do so. Additionally, these large specimens are also the targets for sport and recreational fishers and thus extremely valuable to multiple industries. However, to maintain a viable breeding population of these individuals, it is necessary to establish reserves in which these populations can be protected. Currently, very little of the United States' marine territory is protected by reserves. In 2003, less than 1 percent of US oceans was designated as off-limits for all disruptive activities, compared to 4.6 percent of US terrestrial territory[6]. There has been some progress on this front. A few no-take reserves were recently established off the coasts of California and Florida, but a larger network is required to protect the many commercial species in the Gulf of Mexico and New England.

To create refuges for commercially fished populations, the United States needs to establish a series of small marine reserves scattered throughout the various regions where fishing occurs. Such small reserves have been previously established for environmental studies, and were observed to provide a large ecological benefit to surrounding areas as well. In New Zealand, the Leigh Marine Reserve, only 2 square miles in size, significantly improved lobster catches in the area. Population size increased 10% per year within the reserve, and straying lobsters were caught by traps placed just outside the borders. After several years with the reserve, four of five commercial fishers in the area supported establishment of additional reserves [3]. These reserves have also been used in other nations, with positive effect.

One difficulty of establishing no-take fishing reserves is the cost affiliated with enforcing its boundaries. While in some established reserves, increases in tourism can help offset these costs, they are unlikely to be significant in reserves established further offshore or where marine tourism is sparse. Much of the enforcement can be relatively cheap by installing position-tracking devices on commercial and charter fishing vessels, a current practice around some reserves. However, to guard against illegal fishers, funding will need to be appropriated to pay for personnel to patrol the fishing reserves, similar to those hired in national parks and forests. Fortunately, the MSRA has coincidentally provided a solution. Part of the MSRA calls for a reduction in the size of fishing fleets, through vessel buyback programs. I propose that some of the displaced fishers from this overcapacity reduction program can be retrained to patrol the fishing reserves. They would already qualify for retraining assistance under the MSRA, and thus some funding is already available for this use. Additionally, some of the repurchased vessels can be modified and reused as patrol vessels, instead of being simply destroyed. After several years, increased fishery productivity will increase tax revenues and help offset the cost of enforcement.

Further, positive experience with fishing reserves will encourage self-enforcement among fishers. At the Leigh Reserve, four of five commercial fishers, having seen first-hand the advantages of a no-catch reserve, stated they would act to prevent poaching [3].

One of the most significant advantages of marine reserves is their role as insurance against catastrophic population collapses. If poor management or unregulated fishing activity damages fish populations outside the fishing reserve, the reserve can still serve as a "seed population" for recovery efforts. However, small reserves cannot protect against larger influences on fish population, such as any that might affect the general ecological environment. One major weakness is susceptibility to water temperature changes, or to chemicals introduced from terrestrial industries. Addressing such issues requires a larger response, beyond the scope of this paper, that balances the needs of both fishers and other coastal communities, as well as the many upstream communities that may affect marine environments at river mouths.

2. Economic Incentives

The MSRA attempts to address the problem of bycatch by introducing bycatch quotas, which limits the amount of bycatch that can be hauled out of the sea by a vessel. However, like quotas to fish landed, bycatch quotas are faulty regulators of catch intakes. Quotas force fishers to meet a minimum and add an additional regulation to the many rules that already constrain fishers. At best, this would add financial stress to fishers as they make required investments in equipment to reduce bycatch. At worst, the quota becomes a mis-incentive that encourages fishers to cheat the quota, much like bycatch discard and high-grading developed in response to fish catch quotas. Further, quotas provide no incentive for fishers who are able to reduce bycatch levels to those below the quota. In contrast, I propose several policies to reduce bycatch and bykill: Implementing a bycatch tax, providing incentives for net retention to reduce ghost fishing, and widespread implementation of ITQ programs.

A bycatch tax, similar to carbon taxes proposed to regulate greenhouse gases, rewards fishers for reducing bycatch. By taxing fishing vessels for bycatch discarded at sea, fishers will have a strong financial incentive to reduce total bycatch, by whatever solutions are most feasible to their methods and target species. By using a graded scale of taxes per weight of bycatch, with higher taxes beyond a certain target bycatch level, regulators can encourage bycatch reduction to at least the standard set as the current quota. However, reductions in bycatch totals beyond this level would be financially rewarded by a further reduction in the amount of bycatch tax paid, and thus encourage fishers to adopt new technologies developed to reduce bycatch. Further, this tax reflects the reality that everything harvested from a country's coastal regions represents resources removed from the ecosystem, and provides a method for placing an economic value on bycatch. To minimize financial strain that would occur if fishers were immediately required to pay taxes on bycatch, delayed implementation of bycatch taxes would give fishers several years in which to adopt the equipment necessary to reduce bycatch.

To reduce the amount of bykill, especially that lost to "ghost fishing" from lost fishing gear, I propose a set of subsidies to discourage the loss of fishing gear. For example, in current practice, when fishing nets are caught on underwater outcroppings, they are often cut loose to free the fishing vessel. If fishing councils or the government place a reward for returning damaged nets, possibly in the form of partial subsidies for new nets, fishing vessels will be encouraged to develop methods to retrieve damaged and otherwise useless nets, preventing them from persisting in the ocean where they can continue to catch and kill fish and other marine life. Many fishing vessels already use tracking devices to retrieve nets set at sea; thus, the technology

is available to allow fishing vessels to track and potentially retrieve torn and lost nets. One possible criticism of this system is that many ghost nets are tangled hundreds of feet below the ocean's surface, and extremely difficult for fishing vessels to retrieve. In this case, a smaller reward might be given for reporting such nets for later retrieval. Additionally, the government, likely the NOAA, should fund research into developing nets and traps with shorter persistence in the natural environment, such that lost gear does not persist and continue to function in the environment for months or years.

Individual transferable quotas, or ITQs, are a well-established method to reduce overfishing. Fishing resources, like many other natural resources, suffers from the tragedy of the commons, where the lack of ownership rights encourages stakeholders, in this case fishers, to compete with each other to gain the greatest harvest possible. However, in the long term, all fishers would receive a greater benefit if they harvested less than the maximum they can catch to maintain healthy breeding stocks. ITQs grant fishers long-term fishing rights to a certain percentage of the total allowable catch (TAC) in specified fisheries. Because TACs are set yearly, dependent on the health of the target populations, long-term access rights encourage fishers to cooperate to maintain a self-replenishing fish population. These ownership-like privileges encourage fishers to prevent overfishing and catch under-reporting, and further provide an incentive for them to apply their ingenuity not towards gaming the system, but towards managing their fish populations appropriately. Studies have shown that fisheries under ITQ management have a much lower rate of overfishing [12].

The MSRA states that fishery councils *may* establish ITQ-based fishery management systems, but with few exceptions, does not require it. Fishery policy should actively encourage ITQ management through public outreach to fishers, and where feasible, require local fishery councils to implement ITQ programs. There are some caveats associated with ITQ programs, which have worried some industry observers. One major issue is that ITQ programs tend to concentrate into a few holders. However, the MSRA has addressed this concern by limiting the percentage of access that can be held by any individual. Further, the current implementation of limited access privileges, as described in the MSRA, requires all such privilege holders to be those who "substantially participate" in the fishery, to protect against outside investors artificially raising costs of ITQs. ITQ programs do require significant observer supervision, to ensure that fishers are catching the amount of fish they are allowed under their individual quota, and to ensure that non-ITQ holders are not illegally harvesting from the fishery. As a result, initial funding may be required to hire and train additional observers for ITQ fisheries.

3. Redirecting science investment toward marine research

The MSRA calls for focused research into specific areas of interest, such as in the development of new equipment to reduce bycatch. While these topics are extremely important, they do not address the fundamental lack of knowledge in fishery science and marine ecology. Only over the last few years did fishery scientists begin to incorporate ecological webs and environmental health into their models of fish populations, though this is now recognized as fundamentally necessary towards predicting future fish yields. Studies suggest that the cod collapse has permanently changed the ecosystems where the species once dominated, which has allowed the influx of invasive species and prevented recovery [13]. If this information had been available earlier, it may have spurred earlier regulatory action to stave off collapse.

Another recent discovery was that certain commercially fished populations serve additional, economically or environmentally important functions. Oysters, for example, are now

known to serve as highly efficient pollution filters, which can help clean up excess fertilizer nutrients and other contaminants from coastal environments. This knowledge would help policymakers place a more accurate value on oyster populations, and allow regulations to be developed appropriately.

Additional research would also inform current fishery management efforts. The resurgence of salmon in the Fraser River in Canada would not have been possible without studies that identified individual, watershed-specific salmon stocks, and the unique timing of migration specific to each one. Unlike conservation efforts in the Columbia River, begun at the same time, the use of basic research into salmon ecology in the Fraser River allowed the resurgence of salmon populations there, at a much lower cost than failed efforts in the Columbia River. Over the course of approximate five decades, the United States spent approximately $3 billion on restoration efforts in the Columbia Basin, compared to $21.3 million in the Fraser River. However, Fraser River sockeye runs increased over that period from 3.3 million to 7.8 million fish on average per year, while the Columbia River run in 1993 was counted at less than half a million fish, an approximately 95% drop from historical runs of 8 to 10 million [14].

Because much of fishery policy is crippled by the lack of studies on the effects of new technologies and fisheries, increasing funding for such studies would allow fishery councils and other policy makers to make more informed decisions. Studies on the ecological impact of new fishing technologies is vitally important to allow policy to respond and adapt to changes in the industry and the marine environment. Furthermore, increased research funding will allow fishery scientists to measure what benefits accrue from newly implemented policies as described in this proposal or in the MSRA.

Increased funding for marine ecology would likely have unpredicted side benefits as well. For example, the effectiveness of small marine reserves on neighboring regions was observed first outside small reserves established by marine scientists to protect experiments. Increased funding in this area would undoubtedly lead to large advances in understanding the ecology and interactions in between fish populations and their environments.

Currently, however, marine ecology is poorly funded, especially compared to research in comparable areas. Federal funding for oceans research is at $755 million [6], compared to more than $2 billion for USDA-funded research [15]. Additionally, the National Oceanic and Atmospheric Administration reports that there will be a nationwide shortage of fishery scientists over the next ten years [16]. There have been recent proposals to increase research funding and science training by the current administration. A portion of NSF funding each year should be reserved for training and research funding for the marine sciences.

4. Science-based policymaking

One of the great successes of the Fraser River salmon management was due to the management commission's willingness to accept scientific findings and change their policies based on research results. One major example of this occurred when the commission cited research to block the building of the Moran Dam on the mainstem of the Fraser River. The commission did not block all river developments; other dams were built on upper tributaries. However, by keeping the main river clear, conservation efforts allowed spawning runs to continue, with the final result that the salmon population rebounded with few attempts at artificially stimulating population growth. In the end, policymakers determined that the value of salmon conservation was greater than that of the power generated by mainstem dams. Unfortunately, such science-based decisions are rare in current decision-making.

In determining the composition of fishery councils, the MSRA calls for a minimum of 3 members from various fishing industries, and 1 scientist. Prior fishery councils have also been dominated by the fishing industry. While the fishing industry does have the largest stake in fishery regulation, this group composition naturally encourages the short-term interests of the fishing industries, especially with respect to policies that may decrease immediate yields. As a result, fishery scientists' recommendations for total sustainable catches were often ignored or inflated when fixing quotas. For example, despite the ICCAT's recommended 2008 bluefin quota of 15,000 tons, the European Union set their legal quota at 28,000 tons [1]. The same has been true for other fish species as well. Simply requiring fishing councils to heed scientists' catch recommendations would do a great deal to alleviate current overfishing strain on populations.

To encourage a longer-term view on fishery management, Congress may need to mandate changing the composition of fishery councils. This would likely be a politically charged process and simply reducing the seats granted to different fishing industries is not the most feasible solution. The three fishing industries named for representation in the MSRA: commercial, recreational, and charter fishers, have separate interests that must be addressed. It may be easier to require other specialist members on each fishery council. Fishery councils must deal with many different factors and outside interests that affect the fisheries. For example, marine environments are increasingly sought for resource extraction (such as off-shore oil rigs) and coastal development, and councils would benefit from the addition of an economist or statistician with insight into the effect of external influences on fishing populations and management. Such an addition would also help balance the council to a longer-term management view.

The policies proposed here will help encourage long-term sustainability of fisheries in the United States. Additionally, the policies described here are synergistic with each other. Economic incentives can both encourage and direct scientific research and the maintenance of marine reserves, while further research may inspire new policies in marine management and inform efficient placement of marine reserves. Healthy management in the long-term interests of all stakeholders will address existing flaws in fishery management and help preserve a key natural resource that benefits all.

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