Rebuilding US fisheries: progress and problems

Andrew A Rosenberg[1*], Jill H Swasey[2], and Margaret Bowman[3]

The Magnuson-Stevens Fishery Conservation and Management Act of 1996 requires an end to overfishing and the rebuilding of depleted fishery resources. Now, 9 years later, the progress towards rebuilding overexploited marine fisheries in the United States is reviewed here. Despite the statutory mandate, overfishing and depletion of important fish stocks remains a widespread problem in the US. Sixty-seven fish stocks are currently under rebuilding plans mandated by law. Overfishing, where the fishing mortality rate exceeds the level that should support the maximum sustainable yield (F_{MSY}), continues in 45% of the stocks managed in rebuilding plans. Seventy-two percent of these stocks are still considered overfished, with measurable abundance remaining depleted below a predetermined threshold according to the standards set by the National Marine Fisheries Service and the Regional Fishery Management Councils. Only three stocks have been rebuilt to levels that should produce maximum sustainable yield. However, fish stock abundance appears to be increasing in 48% of the stocks under rebuilding plans. The clearest cause of the lack of progress in rebuilding is the failure of many plans to reduce exploitation sufficiently to end overfishing.

Front Ecol Environ 2006; 4(7): 000–000

The problem of overexploitation of fisheries has been well-documented globally, showing a widespread pattern of severe resource depletion occurring over centuries, but particularly during the past 50 years (Jackson *et al.* 2001; Myers and Worm 2003; Pauly and Maclean 2003; Millennium Ecosystem Assessment 2005). Over the past decade, there has been a concerted effort in national and international fishery policy to end overfishing and recover overfished resources (FAO 1995). In the United States, a very strong statutory mandate to end overfishing and rebuild depleted fishery resources came into effect with the Magnuson-Stevens Fishery Conservation and Management Act of 1996 (NOAA 1996; Safina *et al.* 2005). The law sets out specific timelines for action to rebuild depleted fisheries, establishes requirements for the rebuilding management plans, and requires accountability for implementing plans in a timely manner.

In a nutshell:

- Nine years after the Magnuson-Stevens Act's fisheries rebuilding mandate was introduced, less than 5% of fish stocks requiring rebuilding have been rebuilt, while 82% are experiencing overfishing and/or are overfished
- Overfishing is still occurring in 45% of the fish stocks that are supposed to be recovering under rebuilding plans, so that fishing pressure is still too high to allow stock recovery
- The biomass of 48% of stocks is increasing, suggesting that the basic premise of fishing theory appears to hold: if overfishing ends, stocks will begin to recover
- Understanding the connection between overfishing and our failure to rebuild more fish stocks is fundamental to strengthening the Magnuson-Stevens Act

Here we review the implementation of the rebuilding provisions of the Magnuson-Stevens Act. We consider the record of implementation based on a plain reading of the law's requirements and the public record of action by the responsible entities set out in the law, including the Secretary of Commerce (Secretary), NOAA's National Marine Fisheries Service (NMFS), and the eight Regional Fishery Management Councils created by the Act.

We address three basic questions fundamental to reviewing the program: (1) Have the effects of overfishing been reversed? In this, the 9th year since the mandate, fewer than 5% of fish stocks subject to rebuilding plans have been rebuilt and only 13% are no longer experiencing overfishing or are overfished (ie they are no longer depleted due to previous overfishing). However, biomass appears to be increasing in 48% of the stocks. From our review of all federal rebuilding plans, the basic premise of the theory of fishing holds that if overfishing is ended, stocks will begin to recover. (2) Why is rebuilding failing to occur for so many stocks? Nearly half of the stocks for which there are rebuilding plans are still subjected to overfishing, so that fishing pressure is still too high to allow stock recovery. In many cases, rebuilding timeframes have been extended, plans have not been adjusted even when catches are clearly too high, and there have been other delays in implementing effective controls on fisheries. (3) What are the barriers to greater

[1]*Ocean Process and Analysis Laboratory, Institute for the Study of Earth, Oceans and Space, University of New Hampshire, Durham, NH 03824 *(andy.rosenberg@unh.edu); [2]MRAG Americas Inc, 65 Eastern Avenue, Unit B2C, Essex, MA 01929; [3]Lenfest Ocean Program, Pew Charitable Trusts, 1025 F Street NW, Washington, DC 20004*

success in rebuilding fisheries? Ending overfishing immediately is fundamental to rebuilding these resources. Too often, effective reductions in fishing pressure are subject to protracted political debate, while the resource continues to decline. It is essential that the fisheries are protected until an adequate rebuilding plan is in place and if a plan isn't working, adjustments must occur rapidly to prevent further depletion.

The mandate to end overfishing and rebuild

In the law, Congress found:

> "Certain stocks of fish have declined to the point where their survival is threatened, and other stocks of fish have been so substantially reduced in number that they could become similarly threatened as a consequence of (A) increased fishing pressure, (B) the inadequacy of fishery resource conservation and management practices and controls, or (C) direct and indirect habitat losses which have resulted in a diminished capacity to support existing fishing levels" (NOAA 1996).

The Magnuson-Stevens Act requires the following four steps: (1) The Secretary (through the NMFS) shall annually evaluate all fisheries to determine if they are being overfished (ie overexploited, overfishing is occurring) and/or the fishery is in an overfished condition (ie depleted due to past overfishing) based on objective and measurable criteria. Congress and the Regional Fishery Management Councils are to be notified of those stocks in need of rebuilding. (2) The relevant Regional Fishery Management Council responsible for a stock where overfishing is occurring and/or is in an overfished condition shall, within one year, prepare a plan to end overfishing and rebuild the resource. If the Council fails to do so, the Secretary must develop such a plan within 9 months. (3) The plan must end overfishing and rebuild the resources in as short a time as possible, given the biology of the resource and considering the needs of fishing communities. The rebuilding time period is not to exceed 10 years, unless the biology of the fish, environmental conditions, or international agreements dictate a longer time frame. (4) Rebuilding plans shall be based on the best science available and be reviewed by the Secretary for adequate progress at least every 2 years. If adequate progress to end overfishing and rebuild the resource is not made, then revisions shall be made.

Developing management measures for rebuilding is always contentious, because the need to reduce fishing pressure usually requires the implementation of additional restrictions on businesses and individuals engaged in fishing. However, the process is clear: identify, plan within the time frame, and regularly review progress. In fisheries science and in law, it is clear that the fundamental control variable is the exploitation rate or fishing mortality rate for a given stock – that is, the proportion of the stock removed each year due to fishing. Other variables concerning which fish are harvested (eg age, size, gender) are also important in relation to the overall exploitation rate. Thus, ending overfishing requires the reduction of fishing pressures to, at most, the level that would give maximum sustainable yield (F_{MSY}).

Similarly, the goal of rebuilding should be apparent: to rebuild a given fish stock to at least the abundance (usually expressed as biomass) that can support, in the long-term, maximum sustainable yield.

Have the effects of overfishing been reversed?

Under the requirements of the Magnuson-Stevens Act, 74 commercially or recreationally important fish stocks have been identified at some point by the NMFS as requiring rebuilding (NEFSC 2005; NMFS 2005). Sixty-seven stocks have been included in rebuilding plans already (Table 1), while the remaining seven stocks have only recently been identified as overfished and rebuilding plans are currently being developed. An additional four stocks have been identified as experiencing overfishing, but are not yet overfished (ie depleted). For these four stocks, plans are required to end overfishing, although rebuilding per se is not required.

Of the 67 stocks, three (Atlantic sea scallop, Pacific whiting, and Pacific lingcod), or less than 5%, have been rebuilt to the biomass levels that are expected to support maximum sustainable yield, the goal of rebuilding. Less than 14% percent of the stocks are no longer experiencing overfishing or remain in an overfished condition. The majority of stocks undergoing rebuilding continue to be overexploited (45%; ie with fishing pressure in excess of F_{MSY}) and/or their population biomass remains overfished (72%; ie depleted below reference levels; Figure 1a).

As a consequence of the continued overexploitation of many stocks, and the often very long rebuilding plan timelines created by the Councils (see below for further explanation of rebuilding timelines), most stocks that should be rebuilt around the country are still in poor shape. Consideration of plans by Council (Figure 2) indicates the scope of the problem. Only three stocks have been declared rebuilt, one in New England and two in the Pacific. New England and the South Atlantic lead in numbers of stocks that require rebuilding. The Mid-Atlantic and the Pacific lead in recovering stocks. Clearly, developing effective rebuilding plans is a complex process and there are numerous case-specific circumstances concerning each fishery that affect the successful development and implementation of a rebuilding plan. Here we focus on the overall results, because the success of the program ultimately depends on the actual rebuilding of exploited stocks, not in the process itself.

Why is rebuilding failing for so many stocks?

For 45% of the stocks under rebuilding plans, overfishing

Table 1. Status of stocks requiring rebuilding

Regional Fishery Management Council (FMC)	Stocks requiring recovery	Rebuilding plans	Overfishing is occurring[3] Y	N	ND[5]	Overfished[4] Y	N	ND[5]	Stocks rebuilt
New England FMC	19	18	10	8	1	14	5	—	1
Mid-Atlantic FMC	7	5	1	5	1	3	4	—	0
South Atlantic FMC	14	14[1]	11	3	—	11	2	1	0
Caribbean FMC	3	3	1	2	—	3	—	—	0
Gulf of Mexico FMC	8	8	4	4	—	6	2	—	0
Western Pacific FMC	1	1	—	—	1	1	—	—	0
Pacific FMC	9	9	—	9	—	5	4	—	2
North Pacific FMC	4	4	—	4	—	4	—	—	0
Highly migratory species	9[2]	5	7	2	—	7	2	—	0
TOTALS	**74**	**67**	**34**	**37**	**3**	**54**	**19**	**1**	**3**

[1] Ten plans are pre-SFA and have not yet been updated.
[2] Includes Large Coastal Shark Complex; within this complex 15 species are overfished. An additional two have recovered from a previously overfished condition.
[3] The fishing mortality rate in the most recent year, according to the stock assessment, is greater than the reference rate of mortality set by the Council and NMFS as defining overfishing.
[4] The current biomass level is below the threshold level set by the Council and NMFS as defining an overfished stock. By regulation, the NMFS sets a reference point of one half the biomass that would support maximum sustainable yield to determine whether a stock is depleted such that rebuilding is required. This biomass reference point is not the target of rebuilding plans but it is intended to serve as guidance on status of resources as is the exploitation rate that is expected to produce maximum sustainable yield.
[5] Current status not determined

The table includes all stocks that are reported by the NMFS to be in need of a rebuilding plan and those that are currently managed under rebuilding plans (NEFSC 2005; NMFS 2005). Statuses reported here are for all stocks requiring recovery, those currently included in a rebuilding plan and those awaiting plan development.

is still occurring (Figure 1b). In some cases, overfishing has persisted more than 5 years into a supposed rebuilding plan. For 7% of the stocks, biomass has continued to decrease since the rebuilding plans were implemented, but for 45% there is insufficient information to determine biomass trends under the rebuilding plans.

Biomass is increasing in 48% of the stocks under rebuilding plans, reflecting real progress as a result of the program, albeit in less than half the cases. In 37% of the stocks, biomass is increasing and fishing mortality rates are decreasing. In other words, the clear principle of rebuilding holds: fishing pressure must be reduced in order to recover these resources.

These numbers indicate that the fishery rebuilding efforts have not been very successful over the past 9 years. Most stocks have the potential to be rebuilt within 10 years (Safina *et al.* 2005), so this lack of demonstrable progress is disappointing. Unfortunately, despite the statutory mandate to rebuild in as short a time as possible, not to exceed 10 years except under special circumstances, the actual rebuilding time frames implemented have almost invariably been a decade or longer (Figure 3). To make matters worse, 15 plans (mostly in New England) reset rebuilding deadlines back to year one when the plans were revised, instead of using the existing time frame. This can be a mechanism for extending rebuilding time frames well beyond the plain language of the statute. Taking into account the true time frames of the plans (not the reset times), only two plans currently in place have a rebuilding time frame of less than 10 years

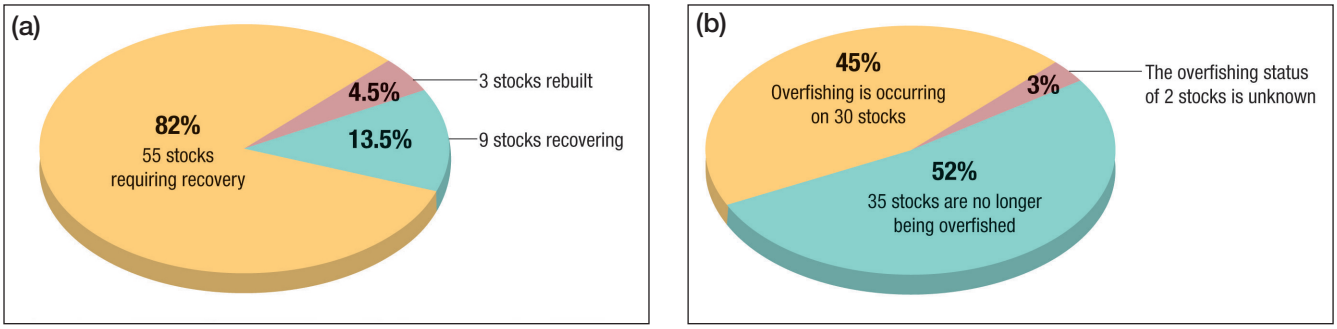

Figure 1. *(a) Status of fish stocks under rebuilding plans. Rebuilt stocks have been determined by the NMFS to be capable of producing maximum sustainable yield. In recovering stocks overfishing is no longer occurring (ie where the fishing mortality rate of a stock is less than or equal to F_{MSY}) nor are they considered overfished (ie where the biomass of a stock is greater than or equal to the overfished status reference point set by the NMFS, typically 50% B_{MSY}). Those requiring recovery are still experiencing overfishing and/or are overfished. Note that for one rebuilt stock, the Atlantic sea scallop, overfishing is now occurring again. (b) Status of fishing pressure on stocks under rebuilding plans. Overfishing is generally defined as the current fishing mortality rate being greater than the rate expected to produce maximum sustainable yield.*

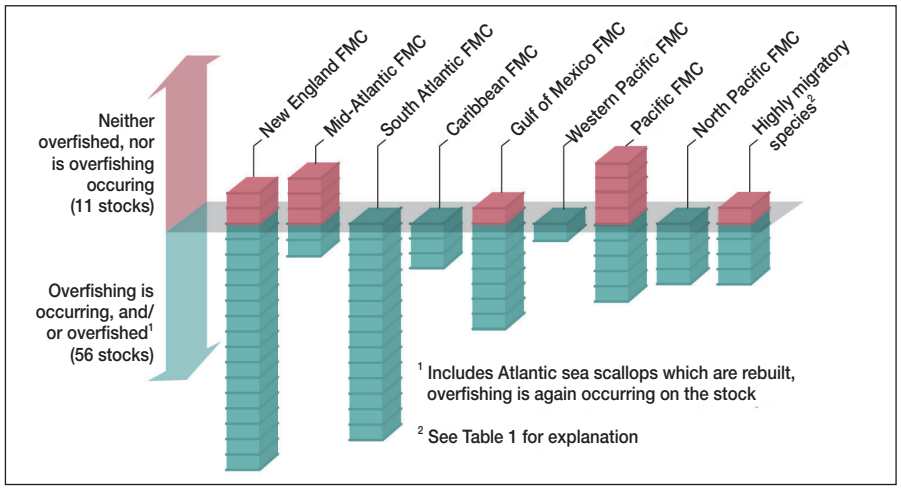

Figure 2. *Stock recovery by regional council. The number of overexploited stocks (56) is one greater than in Figure 1(a) because the recovered Atlantic sea scallop stock is once again being overfished. Those that are neither being overfished nor are in an overfished condition on this graph include the two stocks that have rebuilt and are not currently overfished. Note that highly migratory species are managed directly by the NMFS, not through the council system. Within the highly migratory species division is the Large Coastal Sharks complex, which includes 15 species in need of recovery; an additional two (sandbar and blacktip sharks) are no longer overfished.*

(9 years for bluefish; the 5-year plan for northeast spiny dogfish has expired, but the directed fishery is closed). Twenty-one plans (31%) currently have the 10-year maximum, while 36 (54%) have a time frame extending beyond a decade, due either to the exception for biological conditions or to a reset 10-year rebuilding time. An additional eight timelines are undefined.

■ Overcoming the barriers to successful rebuilding

The US rebuilding program is impressive in concept and scope. Upholding the principle of the Magnuson-Stevens Act to ensure that the capacity to produce the maximum sustainable yield is conserved is the first major step towards sustaining marine ecosystems. Along with broader ecosystem protection from human impacts, the effort to end overfishing and rebuild fishery resources is an important component of a more effective system of management for the oceans according to the principles laid out by the US Commission on Ocean Policy (USCOP 2004). According to the analysis presented here, however, problems in implementation remain. Principal among these is the failure, in far too many cases, to end overfishing itself, an imperative for rebuilding. A related factor is the establishment of long rebuilding time frames, resulting in delays in reducing fishing pressures.

The fundamental factors leading to a failure to rebuild can be illustrated by some of the stocks currently under rebuilding plans. For many stocks, including snowy grouper, South Atlantic black sea bass, and cod, fishing mortality rates are extremely high despite recovery plan implementation (Figure 4). Examples of successful rebuilding are also available, and these underline the importance of implementing large decreases in fishing mortality rates quickly (Figure 5). Sustained rebuilding can be achieved when fishing mortality rates are reduced to below or at least close to reference levels. The examples chosen here illustrate these basic points without regard to the details and specific circumstances surrounding the development and implementation of the rebuilding plans. While the same patterns occur in many other stocks, these examples provide a few clear instances of such patterns.

In several cases, plans have even been revised one or more times, without managing to reduce overfishing to below the reference level. As a consequence, stock biomass has not rebounded. In effect, management has not been held accountable for the most basic provision of a rebuilding plan, that fishing mortality should be greatly reduced and that the plan needs to be monitored to redress any problems.

An additional cause underlying the lack of demonstrable progress in rebuilding overfished resources appears to be the absence of consistent monitoring and revision of the plans that are not showing signs of progress. The trend in fishing mortality rate is unknown for 51% of the

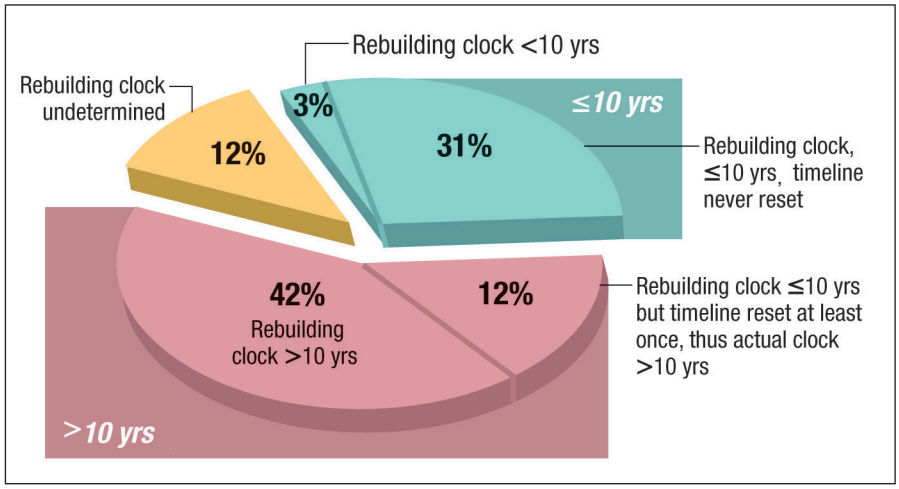

Figure 3. *Timelines for rebuilding. The term "rebuilding clock" refers to the planning horizon contained in the implemented rebuilding plan. The majority of plans employ a time frame greater than 10 years, contrary to that set in the statute.*

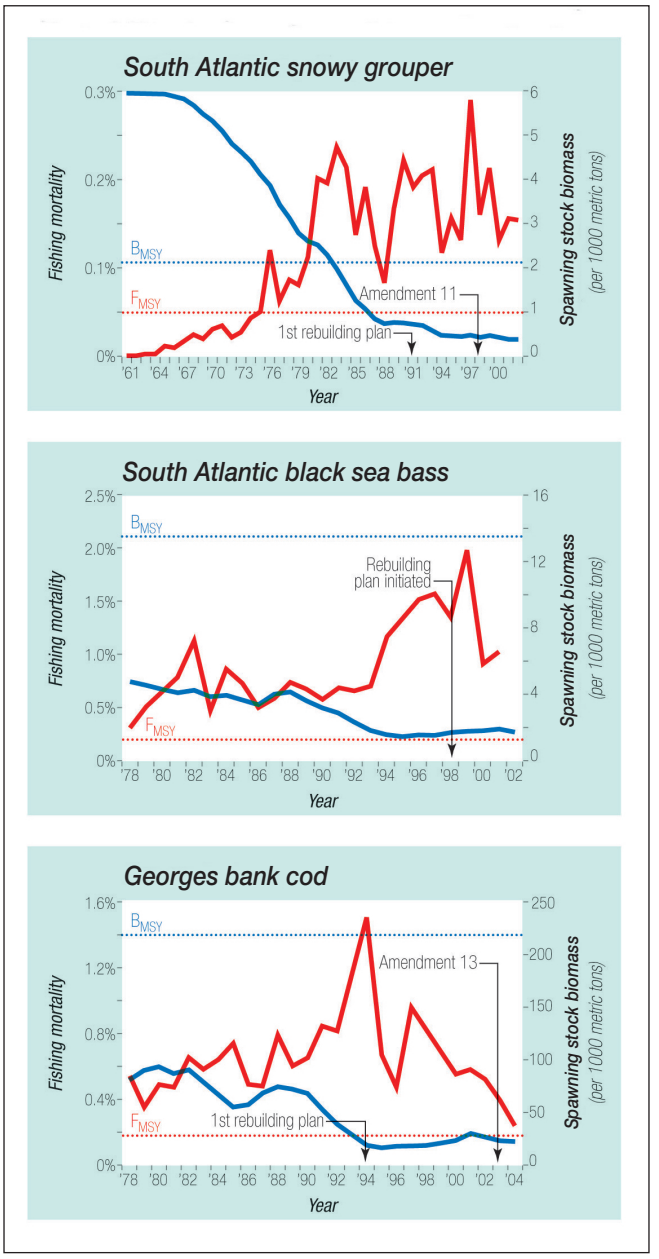

Figure 4. *Examples of stocks showing little or no rebuilding progress. Snowy grouper and black sea bass are managed by the South Atlantic FMC. Georges Bank cod are managed by the New England FMC. Solid red lines show the fishing mortality rate on each stock. Solid blue lines indicate stock biomass on a relative or absolute scale. The dotted lines of corresponding colors indicate the reference levels used to determine overfishing or rebuilt status. The dates when rebuilding plans were implemented and revised are also indicated.*

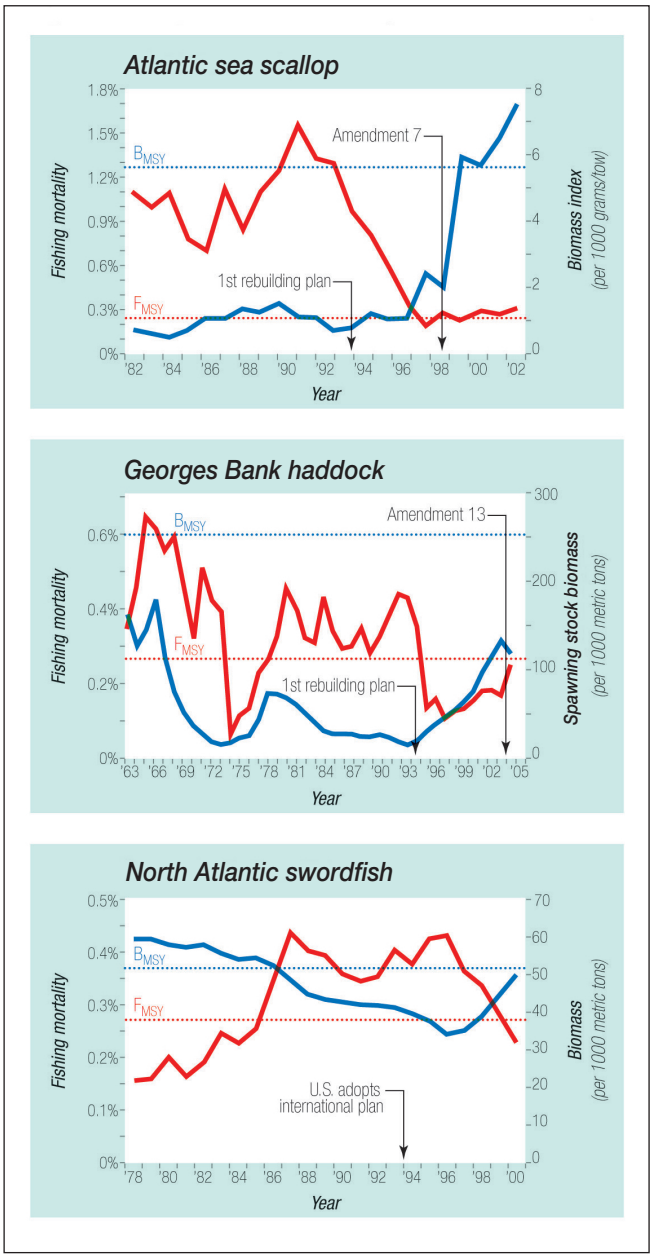

Figure 5. *Examples of stocks showing rebuilding progress. Atlantic sea scallops and Georges Bank haddock are managed by the New England FMC. North Atlantic swordfish is a highly migratory species managed directly by the NMFS. Note that the decreases in fishing mortality rates are followed by increases in biomass. See Figure 4 for legend details.*

stocks under various plans, although in some cases this is because of very recent implementation. Similarly, in 45% of stocks the trend in biomass is unknown. This may be evidence that the scientific information is unable to keep up with the management plans, and there is certainly a strong case to be made for more resources to improve and extend the ability to provide scientific advice for fishery management. However, the fact that overfishing is persisting in nearly half (45%) of the stocks under rebuilding plans indicates that even when there is advice on overfishing and stock status, management has not been held fully accountable for the lack of rebuilding success.

The continued overfishing of so many resources ostensibly under rebuilding plans indicates that the approved plans themselves are failing nearly half of the time. Those developed by the Regional Councils must be approved by the Secretary, through the NMFS. So, it is fair to ask, why is the Secretary approving plans that so often fail to address overfishing?

One reason is that the Secretary may only approve or reject a Council-developed plan; once submitted, Council plans cannot be modified by the Secretary. Rejecting a plan results in a default situation (ie no action to rebuild). The Secretary's decision thus rests on whether a plan is better than nothing, rather than on the best actions for the fishery over the long term. It should be noted that the Secretary does have the authority to develop a plan absent a Council recommendation, although this has been done only very rarely. Since the Act sets up a Council process it is expected that the Councils should develop management plans, rather than the Secretary. Based on the fact that Secretarial plans are rare, it is clear that most decisions are made regarding Council-developed plans that are submitted for approval.

The US Commission on Ocean Policy recommended that a conservative default management plan be implemented for overfished fisheries, while a comprehensive rebuilding plan is developed (USCOP 2004). Creating a strong conservation action that will remain in place while the plan is being developed can prevent further depletion of the resource and shorten rebuilding times overall. Examples of such actions could include an immediate large reduction in fishing pressure through catch limits, closed areas, or closed seasons. Furthermore, this creates a strong incentive for those charged with developing a rebuilding plan to complete the process as quickly as possible.

Clearly, the course of rebuilding will be variable, depending on environmental conditions and other factors. However, it should be clear that progress must be made at each step. While the productivity of a fish population cannot be fully controlled, we can and should have much better control over mortality rates caused by fishing. There must be a performance standard in place for both fishing mortality and for rebuilding, with rapid updates if the targets are not met.

There is often strong pressure from the fishing community to phase in reductions in fishing pressure slowly. In theory, this gives businesses time to adjust to the new restrictions. Unfortunately, it also means that the stocks are further depleted, sometimes severely, before rebuilding can begin, resulting in many more years of reduced yields. The overall economic impact is likely much greater as a result of a long continued decline and delay in rebuilding than from a short-term reduction in catch in order to rebuild populations quickly (Sumaila and Suatoni 2006).

In summary, the US has a very strong fisheries law with clear requirements to end overfishing and rebuild overfished resources. The program has been broadly implemented as a result of major efforts by scientists and managers throughout the country. Rebuilding fisheries is a difficult prospect, but an important one. The depletion of these public resources has long-lasting effects on coastal communities, consumers, industry, and the nation as a whole. Our results indicate that, after nearly a decade, the outcomes of the rebuilding program are disappointing. In order to rebuild resources, overfishing must be ended quickly and kept to low levels – unfortunately, not the norm so far. There is a need for more comprehensive and timely scientific information but, most of all, the program must become results oriented, not process oriented. It is true that there are complications pertaining to each fishery, but it is the results in the water that must be the ultimate measure of the program's success, and a great deal remains to be done.

Acknowledgements

This research was initiated and supported by the Lenfest Ocean Program. M Mangel and J Wiedenmann helped conceive this project. All material used in this study are in the public domain, available from the National Marine Fisheries Service and Regional Fishery Management Councils. We would like to thank the staff of the Councils, Fishery Science Centers, and the NMFS for their assistance in providing reports, documents and supplemental information. Invaluable expertise was provided by R Cronan (graphics) and C Collins (editorial support).

References

FAO (Food and Agriculture Organization). 1995. Code of conduct for responsible fisheries. Rome, Italy: Food and Agriculture Organization of the United Nations.

Jackson JBC, Kirby MX, Berger WH, *et al.* 2001. Historical overfishing and the recent collapse of coastal ecosystems. *Science* **293**: 629–38.

Millennium Ecosystem Assessment. 2005. Millennium ecosystem assessment synthesis report. Washington, DC: Island Press. www.maweb.org.

Myers RA and Worm B. 2003. Rapid worldwide depletion of predatory fish communities. *Nature* **423**: 280–83.

NEFSC (Northeast Fisheries Science Center). 2005. Assessment of 19 northeast groundfish stocks through 2004. Groundfish assessment review meeting; 2005 August 15–19; Woods Hole, MA. Silver Spring, MD: NOAA.

NMFS (National Marine Fisheries Service). 2005. Annual report to Congress on the status of US fisheries – 2004. Silver Spring, MD: NOAA.

NOAA (National Oceanic and Atmospheric Administration). 1996. Magnuson-Stevens Fishery Conservation and Management Act. Silver Spring, MD: NOAA. Technical memorandum NMFS-F/SPO-23.

Pauly D and Maclean JL. 2003. In a perfect ocean: the state of fisheries and ecosystems in the north Atlantic Ocean. Washington, DC: Island Press.

Safina C, Rosenberg AA, Myers RA, *et al.* 2005. US ocean fish recovery: keepers, throwbacks, and staying the course. *Science* **309**: 707–08.

Sumaila UR and Suatoni L. 2006. Economic benefits of rebuilding US ocean fish populations. Vancouver, Canada: The University of British Columbia. Fisheries Centre working paper #2006–04.

USCOP (US Commission on Ocean Policy). 2004. An ocean blueprint for the 21st century. Washington, DC: US Commission on Ocean Policy. www.oceancommission.gov.

