"Optimum Yield" in fisheries is far from optimum

Maximum sustainable yield and effective fisheries management

Due to ill-advised amendments to the Magnuson Stevens Fisheries Conservation and Management Act, all federally managed fisheries are required to be at a level that will produce the maximum sustainable yield. This is a requirement in spite of the fact that having "competing" species at this level might be biologically impossible or undesirable for economic or other reasons. The folly of this legislative mandate becomes obvious in an examination of the current situation regarding the "plague" (according to both recreational and commercial fishermen) of spiny dogfish, *Squalus acanthias,* currently impacting many fisheries from South Carolina to Maine.

In specific instances, and the dogfish situation off the Northeast coast provides a sterling example, fishing pressure can—and should—be used as an effective management tool. Given the basic fact that a particular area of ocean can only support a limited biomass of fish, by fully understanding and carefully controlling the makeup of that biomass through selective fishing, the species mix of the fish available for harvest can be optimized, producing a true optimum yield.

Nils E. Stolpe

Maximum Sustainable Yield and effective fisheries management

The Maximum Sustainable Yield (MSY) of a stock of fish is a theoretical level of harvest that will allow the stock to replenish itself continuously. Most simply, the rate of increase of the stock will be balanced by the rate of removal from the stock. When this condition is reached, the conventional wisdom has it, the fishery will be sustainable.

If any assumption can be said to be basic to modern fisheries management, it is that the sustainability of a fishery can be guaranteed by properly controlling fishing mortality. In fishery after fishery in which the population is not at a level that will produce the theoretical MSY, management efforts consist primarily of reducing fishing effort. Implicit in this is the belief that fishing is the most significant factor in determining if a fish stock is at the MSY level or not and is the only variable, that all other sources of fish mortality are negligible relative to fishing mortality and are constant as well.

Obviously this is not the case. On the macro-scale, regime shifts affecting entire ocean basins are accepted as regular occurrences. These profound perturbations have significant consequences for entire ecosystems and on virtually all of the fish stocks in them. On a lesser scale, non-fishing anthropogenic and natural factors can and do affect processes like spawning success and recruitment. These directly affect stock size. And most obviously, big fish eat little fish, so a bumper crop of species X can have a dramatic impact, positive or negative depending on who's eating who, on species Y and Z. These phenomena aren't necessarily regular, predictable or identifiable, yet in fisheries management they are treated as if they are, all being lumped together under Natural Mortality and assumed to be constant.

Maximum Sustainable Yield and the Magnuson Stevens Fisheries Conservation and Management Act -

One of the requirements of the Magnuson Stevens Act, the federal legislation that controls fishing in the US Exclusive Economic Zone, or more accurately one of the implied requirements of the Act, is that all fisheries be at the level that will produce MSY.

The first of the 10 National Standards that are applied to Fishery Management Plans put in place through the provisions of the Act is "conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the OY (Optimal Yield) from each fishery for the U.S. fishing industry."

From the Act (16 U.S.C. 1802, MSA § 3):

> ***104-297***
>
> *(33) The term "optimum", with respect to the yield from a fishery, means the amount of fish which—*
>
> *(A) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;*
>
> *(B) is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and*
>
> *(C) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in such fishery.*
>
> *(34) The terms "overfishing" and "overfished" mean a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis.*

The definition of OY supposedly allows for departures from the MSY. However, as even the casual consideration of the above section of Magnuson indicates, that is not the case, or more accurately, that is only the case when a stock isn't at the MSY level. In that case the stock is considered to be overfished, and if it is considered to be overfished, it must be "rebuilt" to the MSY level by having the harvest level reduced.

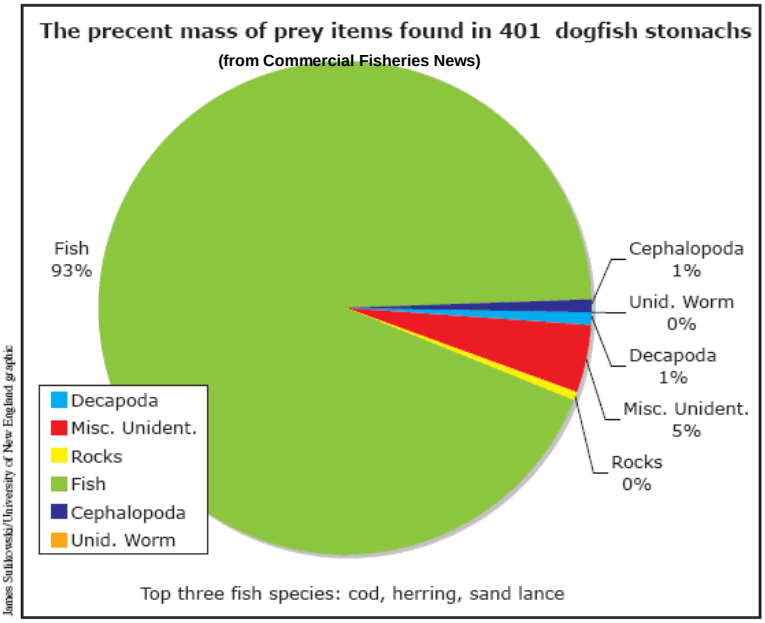
But will having every stock of fish in the U.S. Exclusive Economic Zone being managed at the MSY level be economically, socially or ecologically "optimum?" Will it automatically provide "the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities?" Economically and socially, emphatically no. Is it even possible? ecologically a not so emphatic "maybe." Considering all of the good intentions, all of the effort, all of the pain and suffering and all of the money – both from the public and the private sectors – that is being expended in efforts to reach what are perhaps undesirable and unattainable goals, the results of being tied to the Magnuson concept of OY can be and in demonstrable instances are far from optimum.

Spiny dogfish – the poster fish for mismanagement

> The Food and Agricultural Organization of the United Nations, in its "Global Information System Species Fact Sheet," says of dogfish "*this shark is a powerful, voracious predator that feeds primarily on bony fishes, and is capable of dismembering rather large prey with its strong jaws and clipper-like teeth. Its bony fish prey includes herring, sar-*

dines, menhaden and other clupeids, true smelt (Osmeridae) and their eggs, hake, cod, pollock, ling, haddock and other gadoids, midshipmen, blennies, sand lances, mackerel, porgies, croakers, flatfish and sculpins. It is thought to prey on most available bony fishes smaller than itself, and will often prey heavily on abundant schooling fishes, but newborn dogfish attack herring larger than themselves, as may adults with cod and haddock." Ranging up to four feet in length, spiny dogfish may be larger than all but the very largest of the listed prey species."

The biomass of spiny dogfish off the Northeast coast of the U.S. is conservatively estimated to be in the neighborhood of 500,000 metric tons (that's 1.1 billion pounds). If there's one thing that everyone who is familiar with dogfish agrees on, it's that they are exceedingly voracious. They are notorious for attacking anything that they can catch that's about their size or smaller. They are primarily piscivorous (meaning they prefer a fish diet when available), they grow to three feet or more in length, and they are born as fully functional predators. Needless to say, many regulated species, species almost always more valuable commercially or recreationally than spiny dogfish, end up as their dinner.



How much do those 1.1 billion pounds of dogfish eat? In the 2004 NMFS publication **Biology of sharks and their relatives**, researchers Wetherbee and Cortés report that spiny dogfish consume between 0.4% and 2.6% of their total body weight per day. Assuming the median level of 1.5%, for the population of spiny dogfish off the northeast coast that amounts to 16.5 million pounds a day, or 6 billion pounds a year. *"Relative to the estimated stock sizes of age-1 fish, the mean number of potential recruits removed ranged from 2% (haddock) to 37% (Atlantic cod) for spiny dogfish …. With the minimum estimate, the number of juvenile fish that were eaten was generally much less than 10% of the standing stock. Conversely, with the maximum estimate, the number of juvenile fish that were eaten sometimes represents a notable proportion of the stock of prerecruit fish (e.g., 80% of Atlantic cod in the case of spiny dogfish predation)."* (J.S. Link, L.P. Garrison, F.P. Almeida, Ecological Interactions between Elasmobranchs and Groundfish Species on the Northeastern U.S. Continental Shelf. I. Evaluating Predation, North American Journal of Fisheries Management 22:550–562, 2002)

And what do they eat? Besides cod and haddock, apparently anything they can get in their mouths. A limited amount of research has been done on their dietary habits. Reporting on University of New England researcher James Sulikowski's analysis of the stomach contents of adult dogfish from the Gulf of Maine, Janice Plante wrote in the May, 2008 Dogfish Special Report in *Commercial Fisheries News*, "but in the remaining 340 fish (36% of the fish sampled had empty stomachs), they found – with a few notable exceptions – just about everything: herring, sand lance, flounder, hake, cod, haddock, a few crabs, anemones, worms, and even a couple of rocks, which probably were a byproduct of groveling for crabs. All told, 87% of the stomach contents from these particular Gulf of Maine-caught dogfish consisted of bony fish – with cod, herring, and sand lance being the top three species."

So, if we project the feeding characteristics of dogfish when they're in the Gulf of Maine to when they're elsewhere, approximately 80% of what they eat is composed of bony fish. That's 5 billion pounds of northeastern fish eaten by spiny dogfish every year. And most of those 5 billion pounds is made up of either the species that fishermen target or the prey that the targeted species feed upon. To put that in perspective, in 2007 the total commercial landings in the Mid-Atlantic and New England were less than 800 million pounds. Spiny dogfish are eating over six times as much of the region's fish as the entire commercial fishing fleet catches.

(Note that Professor Sulikowski has also done some preliminary dogfish tracking work with satellite tags and has estimated that the actual spiny dogfish biomass could be as high as 1.9 million metric tons – almost 4 times the "official" estimate.)

There are a number of important fisheries off New England and the Mid-Atlantic in which the harvest levels have been severely curtailed due to supposed overfishing. Many

Proportion of Spiny Dogfish caught in MFS Northeast Bottom Trawl Surveys

Survey	lbs Dogfish	lbs All Species	% Dogfish
Fall '06	69,031	161,234	43%
Spring '06	66,680	107,349	62%
Winter '06	58,943	114,605	51%
Total '06	**194,654**	**383,188**	**51%**
Fall '05	73,321	152,666	48%
Spring '05	46,992	83,465	56%
Winter '05	79,900	121,062	66%
Total '05	**200,213**	**357,193**	**56%**
Fall '04	58,923	145,430	41%
Spring '04	32,341	94,848	34%
Winter '04	89,932	150,237	60%
Total '04	**181,196**	**390,515**	**46%**
Fall '03	32,661	124,099	26%
Spring '03	55,654	133,134	42%
Winter '03	86,862	163,578	53%
Total '04	**175,177**	**420,811**	**42%**
Fall '02	33,668	153,542	22%
Spring '02	49,496	111,770	44%
Winter '02	88,233	164,748	54%
Total '03	**171,397**	**430,060**	**40%**
Fall '01	58,062	128,892	45%
Spring '01	26,321	75,564	35%
Winter' 01	91,686	186,301	49%
Total '01	**176,069**	**390,757**	**45%**
Fall '00	57,018	140,280	41%
Spring' 00	24,961	96,789	26%
Winter '00	45,923	91,674	50%
Total '00	**127,902**	**328,743**	**39%**
Fall '99	34,720	118,596	29%
Spring '99	36,434	87,783	42%
Winter '99	88,268	139,124	63%
Total '99	**159,422**	**345,503**	**46%**

of these species serve as prey for the dramatically increasing spiny dogfish population, and virtually all of them compete with dogfish for one prey species or another. Among them is the complex of New England groundfish, which has been effectively used as a *cause célèbre* by the anti-fishing activists, but others, including summer flounder, are of comparable recreational and commercial significance. Some of these fisheries have not responded to the "traditional" cure for overfished stocks; cutting back on fishing effort. It's indisputable that the huge spiny dogfish population is retarding the recovery of these various other species.

None of this is new information. In fact, in 1996 Steve Murawski, who is now the Director of Scientific Programs and Chief Science Advisor at the National Marine Fisheries Service, wrote "whether species changes on Georges Bank (one of the world's richest fishing grounds located off Cape Cod) are the result of biological interactions among species or are simply the result of differential fishing mortality rates remains conjectural. However, total biomass in the system does seem to have again reached a threshold. The ability to increase the abundance of marketable species may thus be limited by predation from or competition with the elasmobranch species" (Can we manage our multispecies fisheries? Fisheries 16-5:5–13).

The negative impacts of spiny dogfish on other fisheries aren't limited to predation and competition. In fact, it's difficult to find any ocean fishery, recreational or commercial, off the northeast US coast that isn't being directly and increasingly affected. Dogfish consume other fish after they are hooked or captured by a gillnet, their abrasive skins and sharp spines damage other species in the net, they prevent the capture of desirable species by clogging nets, eating bait or getting hooked, they greatly increase the wear and tear on any recreational or commercial fishing gear that they interfere with, and they force desirable species from traditional areas by their sheer numbers and rapaciousness.

The economic impact of this huge biomass of dogfish on recreational and commercial fisheries, while so far unaddressed, must amount to tens of millions of dollars annually. The social impacts, as evidenced by the prolonged and possibly futile efforts to rebuild New England groundfish and their corrosive effects on traditional fishing communities from Long Island to Maine, are staggering, as are the ecosystem impacts.

The billion plus pounds of these notoriously voracious fish are having a greater impact on the fish stocks from South Carolina to Canada than the combined commercial and recreational fishing fleets have had in recent history (and reliable commercial landings records go back to 1950). But as it stands today, the spiny dogfish Total Allowable Catch (TAC) is never going to exceed 10,000 metric tons per year, and that level will only be possible when the total dogfish biomass is officially recognized as being 450,000 metric tons – 990 million pounds (see the penultimate page of Paul Rago's Powerpoint presentation by following the link on the Philadelphia Dogfish Forum page at http://www.fishnet-usa.com/dogforum1.htm).

What can be done about this much less than optimal situation? With the Magnuson Act as it is today, distorted by anti-fishing activists, nothing at all. As long as Magnuson requires that every stock of fish be at MSY, a huge part of the productivity of some of our most productive waters is going to be squandered by preserving an artificially high biomass of a species of low recreational and commercial value.

And this is only one of the most egregious examples of an ever-increasing host of problems for fishermen, for seafood consumers and for the marine ecosystem resulting from an irrational and unrealistic Magnuson requirement .

Managing fishing and the "Natural Balance"

Implicit in the arguments used against the controlled harvest of fish or other living marine resources is the notion that there is an inherent natural balance in the world's oceans that fishing and other anthropogenic activities unnecessarily disturbs. This notion has been successfully, and disingenuously, tied into the concept of sustainability.

As anyone who has had an introductory ocean sciences course, has done even elementary reading in oceanography or any related discipline, or has observed a bit of ocean or an estuary for longer than an hour or so knows, these aren't static systems and never were. Affected by weather, affected by climate, affected by the sun and the moon, affected by the critters living in them and increasingly affected by the domestic, industrial and agricultural effluvium of what is now approaching 7 billion people, about the only thing that is constant about our salt and brackish waters is change—both "natural" and human-induced.

Additionally, we are presently harvesting about a quarter of our animal protein from the oceans, and in all likelihood will be increasing that proportion as the world's population continues to increase.

While the idea of pristine, steady-state oceans is certainly appealing, it's neither possible nor practical, and anyone who believes otherwise is sorely in need of a reality check.

Magnuson could – and should – be amended to allow management decisions to be made in accordance with the definition of OY that is already included in the legislation ("the amount of fish which will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems.") The spiny dogfish biomass could be "fished down" to a more acceptable level, perhaps something on the order of 200,000 metric tons, by temporarily increasing the level of harvest. Once the lower, more desirable biomass was reached, the TAC would be lowered to a level that would maintain the biomass at that sub-MSY level, yielding a sustainable spiny dogfish fishery and allowing other far more valuable fisheries to be rebuilt to MSY levels, something that might well be impossible today because of dogfish predation and competition.

Too much of a good thing?

The biomass estimate for Atlantic herring is higher than that for spiny dogfish, hovering around a million metric tons. Two decades ago the biomass was approximately 10% of that.

Atlantic herring are among the most important forage species in Mid-Atlantic and New England waters. Based on harvesting the exploding population, a commercial fishery has developed over the past decade with large vessels utilizing efficient trawling and seining gear. This "new" herring fishery complements an existing traditional purse seine fishery.

The increase in herring landings this expansion of the fishery occasioned coincided with a decrease in the occurrence of some of the New England groundfish stocks and of migratory bluefin tuna, which support small yet significant hook and line and harpoon fisheries. The growth in herring landings, and the assumed relationship between that growth and decreasing numbers of groundfish and tuna, sparked the development of organized opposition to the newer herring fishery. Among the opponents were traditional New England fishermen and a coalition of "conservation" organizations created, supported and in other ways tied to the Pew Charitable Trusts (see the Oil Slick section of the Fishnet-USA titled Fisheries management – it's time for a new paradigm at http://www.fishnet-usa.com/new_paradigm.html). The goal of these people and groups is ever-increasing restrictions on the newer entrants into the herring fishery, based on the idea that they are catching fish that would otherwise be enriching the productivity of New England waters.

In a presentation to the New England Fisheries Management Council titled "Fishery Production Potential of the Northeast Continental Shelf" on November 20 last year, the National Marine Fisheries Service's Mike Fogarty focused on the ecosystem interactions between Atlantic herring and other species (go to http://www.nefmc.org/actions/index.html - and click on #13, for the audio of his presentation. The Powerpoint presentation is available at http://www.nefmc.org/press/council_discussion_docs/list_of_nov2008_discussion_docs.html). In what was to a large extent the justification for a shift to ecosystem based management, Dr. Fogarty discussed various impacts of the existing and growing herring biomass. As fairly non-selective feeders, herring consume larger zooplankton like adult copepods and larval fish (including larvae of the various groundfish species). They prey on groundfish as larvae and compete with groundfish as juveniles, and a couple of billion tons of herring can do a lot of eating and a lot of competing.

But the potential impacts of this huge herring biomass aren't just restricted to the groundfish stocks. The type of copepods that herring feed on are one of the principal food sources of right whales, and evidence points to an inverse relationship between their abundance and the calving success of this endangered whale. Also, there's evidence of a reduction in the size of the herring at maturity and possibly a lack of condition. This could be having a negative impact on the bluefin tuna that feed so heavily upon them.

Menhaden, in the same family as herring, are another schooling, plankton-feeding species found in great abundance in Atlantic coastal waters and in the Gulf of Mexico. Like Atlantic herring, they are considered a forage species, and like herring, their "protection" (from commercial harvesting) is being sought by anti-fishing activists and recreational fishermen. As a response to a drive to shut down the menhaden fishery in Texas state waters, Omega

Protein, a menhaden fishing and processing company, commissioned the consulting group Ocean Associates, Inc. to review the science relating to the ecological role of menhaden and their management. Ocean Associates' report, "Gulf of Mexico Menhaden: Considerations for Resource Management," bears out much of what Dr. Fogarty reported on regarding the ecological impacts of sea herring. From the Executive Summary:

> *"Recognition by the (Texas Parks and Wildlife) department that menhaden are omnivores is profound, with far-reaching implications that are rooted in the menhaden scientific literature. As omnivores, the juveniles and adults consume the larger phytoplankton (drifting algae) and all the zooplankton (small animals) they encounter. The zooplankton consists largely of animals that spend all or most of their lives carried by currents, eating the algae and each other. However, it also includes meroplankton, "temporary" plankton – eggs and larval and very young juvenile fish, shrimp, oysters, and crabs. Capture efficiency of larger organisms during filtering is high and nearly all that enters menhaden mouths are consumed. However, as any organism that loses a high percentage of its population every day to predation (probably about 10%/day for the first year), the menhaden are most abundant when they are larvae. Menhaden larvae eat mostly zooplankton in directed attacks and have teeth to help them capture their prey, which includes all zooplankton and virtually all fish eggs and larvae found in their presence. As stated by TPWD, menhaden are "a key forage species for many other species in the gulf". Likewise, many other species in the Gulf, during their egg and larval and smallest juvenile stages, are also forage for menhaden. Menhaden adults, swimming at two ft. per second with large open mouths, can each clear zooplankton (including fish and shellfish eggs, larvae, and small juveniles) from over 25 quarts of water per minute.*
>
> *Traditional stomach analyses have not captured the extent of juvenile and adult menhaden's animal diet because of their extremely rapid digestion and their regurgitation of stomach contents during sampling. Putting the sampled animals on ice does not stop digestion, which is complete in a few hours, and quickly works through even the stomach walls and into the flesh. Recent menhaden diet studies using fatty acid composition and carbon and nitrogen isotope ratios, confirm menhaden to be primarily carnivores at all life stages. DNA analysis of already-digested stomach contents in herring (a close cousin) shows that young stages of predatory fish are part of their diet, even though they are quickly rendered invisible by rapid digestion.*
>
> *In a balanced ecosystem, species adapt reproductive strategies to cope with variations in predation and other factors. Since menhaden predators are below virgin levels, unfished menhaden will expand to the limits that food, disease, and habitat will allow. These increased menhaden populations could well spell the demise of shrimp, red drum, blue crab, oyster and other populations whose youngest forms share space with always-hungry, always-feeding menhaden. This is particularly true of species that are at reduced levels, with reduced spawning potential. We wonder if menhaden's extensive predation on, and competition for food with, other species has been considered in this proposal."*

So, it appears, we're in the same situation with the massive stocks of menhaden in the Gulf of Mexico and off the South- and Mid-Atlantic coasts as we are off New England because of Atlantic herring. And what's the response of the managers - whose hands are tied by the inflexibility injected into Magnuson by the successful lobbying efforts of the anti-fishing activists? To restrict fishing even further.

How can yields actually be optimized?

The so-called conservationists involved in fisheries would have us believe that there's some sort of "natural balance" possible in our inshore and offshore waters and that, if fishing is reduced adequately across the board, this mythical balance can be reestablished. That is far from the case.

In their Rousseau-inspired misconception of what the oceans should be, they look at anthropogenic effects as categorically bad, with fishing in general and not harvesting every stock at the MSY level in particular among the worst. This is not necessarily the case. Fishing can be an effective management tool. In the case of species like herring, menhaden and dogfish, allowing – or encouraging – harvest levels above what would be considered "sustainable," and then maintaining the populations at lower than maximum levels by carefully regulating harvest might be all that is necessary to return "overfished" stocks of much more valuable species back to their OY levels.

Take, for example, the current situation regarding the New England groundfish complex. Fishermen have been hit with a seemingly interminable series of harvesting reductions extending back well over a decade. These cutbacks have been so severe that, if the most recent "management" proposal by NMFS is instituted, boats will be allowed to

fish only 20 days a year (see "Sparks fly as feds propose new fishing curbs." by Becky Evans in the 01/15/09 New Bedford Standard Times at http://www.southcoasttoday.com/apps/pbcs.dll/article?AID=/20090115/NEWS/901150373).

This is due to the fact that several of the groundfish stocks haven't been recovering as they were expected to (at least by the managers) following previous drastic reductions in fishing effort. At the same time, as we've seen above, the stock of spiny dogfish, notoriously voracious predators on groundfish and their prey species, have been allowed to increase unrestrictedly. And the even larger Atlantic herring stock could be impeding the groundfish recovery as well.

Reduce the number of spiny dogfish? Of course not. The Magnuson Act won't permit it. Reduce the number of herring? Ditto, but for political rather than biological reasons.

But what if we could? Using such an approach, the economy will benefit, the ecosystem will benefit (through increased biodiversity), and the fishing communities that are dependent on "balanced" fisheries will benefit as well.

And there are other fisheries that are facing ever more stringent harvesting restrictions each year because they aren't performing as the fishing-centric computer models predict that they should. The summer flounder fishery in the mid-Atlantic is one. What's the impact of spiny dogfish on the summer flounder stock?

An EEZ that is being managed to provide the optimal harvest from a complex of interacting species would seem to be preferable to what we have today. The way we're doing it today, our most valuable fisheries are increasingly subject to the depredations of other, less valuable species that enjoy the protection of a management regime that is totally stacked against rational management. If fewer spiny dogfish, fewer Atlantic herring or fewer menhaden will mean an increase in more valuable, more desirable or more threatened species, then why shouldn't the people responsible for fisheries management be provided with the administrative wherewithal to allow this? Legislation mandating that they can't isn't benefitting anyone beyond the few anti-fishing activists who have built careers on saving fish stocks that clearly don't need saving, and it's certainly not benefitting the ecosystem. So why do we have it?

How are the fish of the Northeast U.S. really faring?

While researching this FishNet I came across a spreadsheet that reproduced the Northeast Fisheries Science Center's spring and fall bottom trawl survey results going back to the mid 1980s. Before 1993 these surveys extended into Canadian waters north of the Hague line, but since then have covered the same areas from the Gulf of Maine to Cape Hatteras and essentially the same stations . Hence they provide a reasonable picture of trends in the abundance of those species that dwell on or near the bottom that can be caught with the sampling gear used (a standard otter trawl). The species sampled include dogfish, skates, Atlantic herring, hakes, cod, haddock, pollock, various flatfish, Atlantic mackerel, butterfish, Acadian redfish, goosefish, American lobster and squid.

As the plot to the right shows, the weight of the fish sampled in the two surveys has increased more or less constantly, the total in 2006 being about 70% greater than in 1993. Particularly considering that just about all of the species sampled are marketable, it seems really difficult to acknowledge any New England fisheries "crisis," nor to understand the fact that with so many fishermen—and so many of the businesses that depend on them—in such poor economic shape the only response from the managers being to restrict fishing even more.

It's hard to imagine a more compelling reason for a serious reassessment of our fisheries priorities.