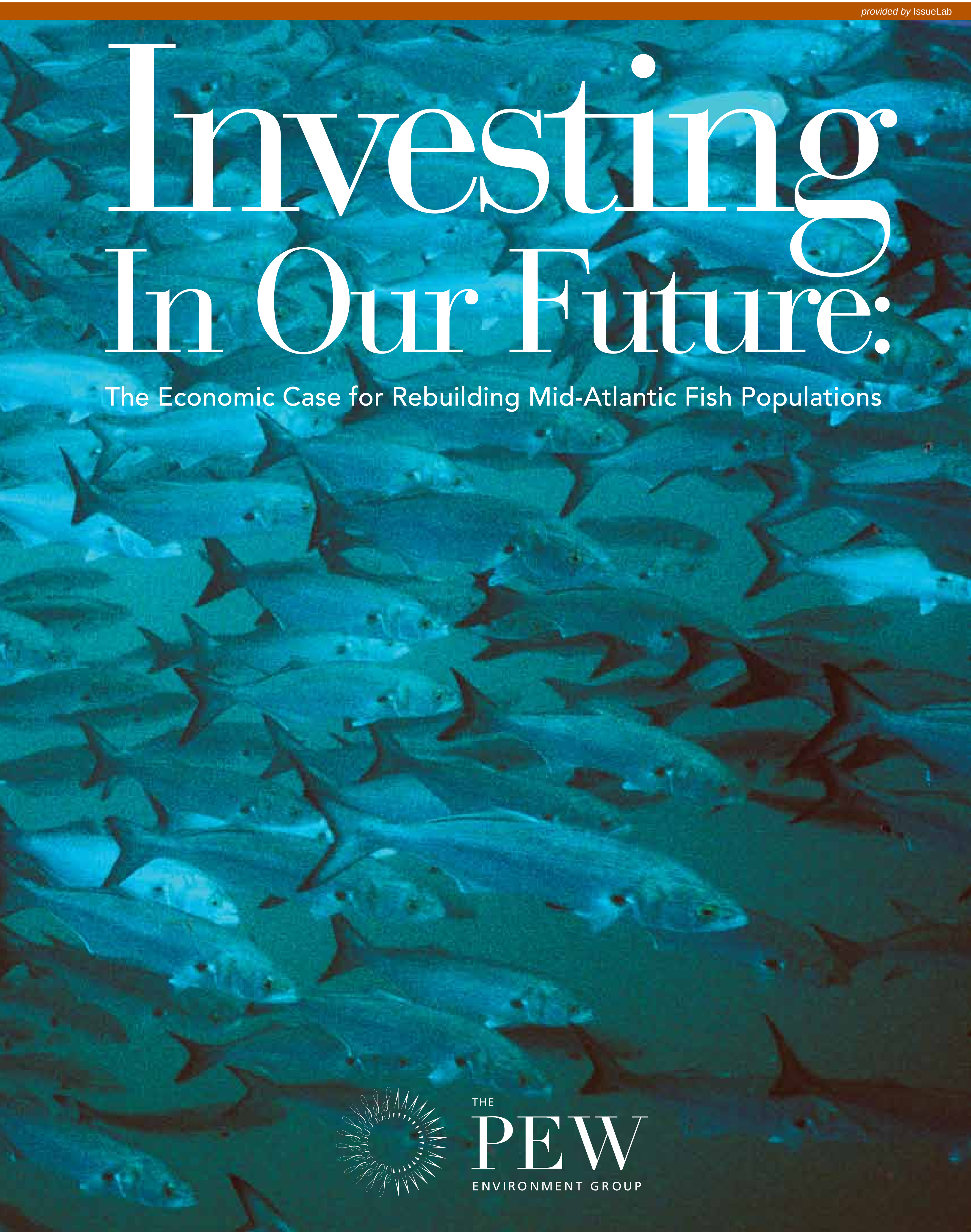

Investing In Our Future:

The Economic Case for Rebuilding Mid-Atlantic Fish Populations

THE PEW ENVIRONMENT GROUP

This report was prepared by Dr. John M. Gates, Professor Emeritus of Economics and Environmental and Natural Resource Economics at the University of Rhode Island. He holds a Ph.D. in economics from the University of California, Berkeley. He has extensive experience in the field of fisheries economics and has written dozens of peer-reviewed journal articles over the past three decades, publishing in such journals as *Marine Resource Economics, Journal of Applied Economics, Marine Policy,* and *American Journal of Agricultural Economics*.

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EXECUTIVE SUMMARY

Rebuilding depleted fish populations must be a priority, both for the health of our ocean ecosystems and our coastal communities. The Magnuson-Stevens Fishery Conservation and Management Act, the primary law that governs our ocean fisheries, supports this by mandating an end to overfishing and rebuilding depleted fish populations within 10 years, if biologically possible.

Delayed rebuilding has significant costs. Failure to immediately address overfishing and allow fish populations to rebuild as quickly as possible forgoes current economic benefits and may result in more costly regulations in the long–term. While delay imposes considerable costs, there are also important benefits to be gained from rebuilding. Previous studies found that rebuilding just 17 depleted fish populations would increase the economic value of these fisheries from $194 million to $567 million dollars.

This report provides new analysis of the potential economic benefits of rebuilding, focusing on four depleted fish populations in the Mid-Atlantic: summer flounder, black sea bass, bluefish and butterfish. The study estimates direct economic benefits by comparing status quo management scenarios with scenarios where populations would have been rebuilt by 2007.

If the four species had been rebuilt by 2007, commercial landings would increase by 48 percent, resulting in an additional $33.6 million per year (in 2007 dollars) in direct economic benefits in perpetuity. In the recreational sector, rebuilding these four fish populations would increase landings by 24 percent more per year than status quo management, with an economic value of approximately $536 million per year (in 2007 dollars) in perpetuity.

In sum, for both commercial and recreational fishing sectors, rebuilding populations of black sea bass, bluefish, butterfish and summer flounder by 2007 would have generated an additional $570 million per year in perpetuity in direct economic benefits. During a 5 year period, the accrued total would total $2.85 billion in economic benefit, a substantial contribution to the Mid-Atlantic economy and its coastal communities.

In sum, for both commercial and recreational fishing sectors, rebuilding populations of black sea bass, bluefish, butterfish and summer flounder by 2007 would have generated an additional $570 million per year in perpetuity in direct economic benefits. During a 5 year period, the accrued total would total $2.85 billion in economic benefit, a substantial contribution to the Mid-Atlantic economy and its coastal communities.

These direct economic benefits would have potential secondary impacts in the region through increased income, sales and jobs for related businesses such as bait and tackle shops, lodging and restaurants. Thus, the estimates reported here are conservative and the actual benefits are likely to be more expansive. These results provide analytical evidence that there is both significant value in rebuilding fish populations and foregone economic benefits from delaying rebuilding.

INTRODUCTION

Ending overfishing is a critical first step to ensuring healthy fish populations, but for depleted populations, it is not enough. Rebuilding depleted populations must also be a priority, not just for the sake of conserving fish populations but also for improving economic conditions in coastal communities. The Magnuson-Stevens Fishery Conservation and Management Act (MSA) mandates an end to overfishing and the rebuilding within 10 years of depleted populations to levels able to support maximum amount of fish that can sustainably be caught, if biologically possible.[1] Congress chose 10 years based on input from experts on population dynamics during the 1996 reauthorization of the MSA. While those scientists estimated that most marine species could rebuild within five years, Congress chose a longer time frame (10 years) to minimize social and economic costs.[2]

Promptly rebuilding diminishes biological, ecological and economic costs to the fishery. Biologically, delayed rebuilding may impede the ability of a species to recover, as seen in New England where cod have failed to rebuild after reductions in fishing pressure were slowly phased in.[3] In contrast, haddock has rebounded after fishing pressure was reduced quickly.

> "The longer managers allow overfishing, the more depletion undermines subpopulations' diversity, resilience, and adaptability; risks ecosystem structure and functioning; reduces chances for eventual recovery; and raises social and economic costs."[4]

While there are other factors that influence a fish species' ability to rebuild, fishing pressure is an important and strong constraint. Ecologically, delayed rebuilding can have negative impacts that reverberate throughout the ecosystem, affecting prey and predator relationships and weakening the ecosystem's ability to respond to other pressures such as climate change.

Economically, delayed rebuilding means lost opportunities for fishermen to catch the maximum amount of fish that can sustainably be taken from a population. It also means fewer jobs and less income. Failing to quickly address overfishing and allow populations to rebuild as rapidly as possible may lead to severe regulations that are longer in duration and thus more costly.[5] Delays also raise the potential for population collapse. Although the costs caused by delaying rebuilding are telling, the benefits that can be gained from rebuilding are equally important. While there has been a dearth of analysis regarding such benefits, there have been a few studies that estimate the substantial gains from rebuilding.

BENEFITS OF REBUILDING

Sumaila and Suatoni (2005) estimated the economic benefits (potential value calculated in 2005 dollars) of rebuilding 17 valuable U.S. fish populations and found great potential to increase net present value. They compared rebuilding scenarios to recent catch and found rebuilding resulted in about three times more value in 2005 dollars than status quo. Specifically, rebuilding just 17 depleted populations resulted in an increase from $194 million to $567 million in 2005 dollars, although this is likely an underestimate given that the study only analyzed direct economic benefits from increased fishing opportunities.[6]

An earlier study, part of the 2003 Final Supplemental Environmental Impact Statement for the Final Amendment 13 to the Northeast Multispecies Fishery Management Plan, the New England Fishery Management Council estimated a potential cumulative value of rebuilding New England groundfish to be roughly $300–$500 million in 2003 dollars relative to status quo.[7] Outside these and a few other reports and assessments, there has been little research on the benefits of rebuilding or the costs of delaying rebuilding.

In order to expand on this previous work, this study analyzed the economic benefits of rebuilding four depleted fish populations according to their fishery management plans. It modeled catch projections for summer flounder, butterfish, black sea bass, and bluefish under two scenarios: the actual catch that occurred up until 2007 (status quo–Scenario 1), and the catch that would have resulted from following a projected rebuilding plan based on the target fishing mortality rate (rebuilding target–Scenario 2). These two scenarios were then compared for an estimate of the benefits that could have resulted if the rebuilding plan had been followed. The indicator used to assess economic benefits is landed value plus reductions in trip costs in the commercial sector and willingness-to-pay in the recreational sector, measures that will be explained in more detail in the next section.

Methodology and Results

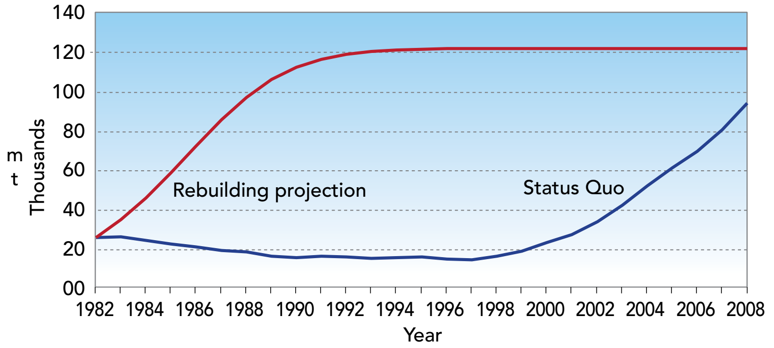
A retrospective analysis of each species (summer flounder, butterfish, black sea bass and bluefish) was conducted. These species were chosen because they were under rebuilding plans at the beginning of 2009 when the analysis was done.[8] Data on population size (biomass), fish killed as a result of fishing (fishing mortality) and the rate at which unwanted or illegal fish are discarded at sea (bycatch) for each species was obtained from Mid-Atlantic Council staff and Council documents including fishery management plans. These data were used to project population size over time with a model that included estimates for r (intrinsic population growth rate) and K (the maximum population size or carrying capacity).[9]

The analysis simulated and compared two population size projections for each species. Scenario 1, the status quo, followed what actually happened in the populations from the base year to 2007. The base year was 1994 for black sea bass and bluefish and 1982 for butterfish and summer flounder.[10] These timeframes are not analogous to the exact rebuilding timeframes in each species' fishery management plan; rather, the time periods used were based on the catch and landings data that were available.[11] Scenario 2, the projected rebuilding plan, followed what would have happened if the population had been managed so that the fishing rate was kept at the rebuilding level, allowing the population to rebuild to its target size and able to support the maximum amount of fish that can be sustainably caught each year.[12]

The study estimated and compared the catch and landed value for both recreational and commercial sectors associated with each of these scenarios for each species and then aggregated across all species. In some fisheries there are rather substantial differences between the amount of fish caught by fishermen and fish brought back to the dock and landed. This difference is the amount of fish discarded at sea and the number that survives affects rebuilding rates and biomass levels (see appendix); direct economic benefits for the commercial sector are only derived from that portion of the catch that is landed and sold. A management strategy that is able to reduce discards would show larger economic returns from rebuilding (likely significantly larger), as there is an economic loss associated with discards that don't survive. Even if no discards survived, it would be preferable from an economic perspective to achieve conservation by reducing fishing mortality, keeping all the catch, and reducing discards, so that the maximum sustainable landed value can be obtained and the population rebuilt as soon as possible.

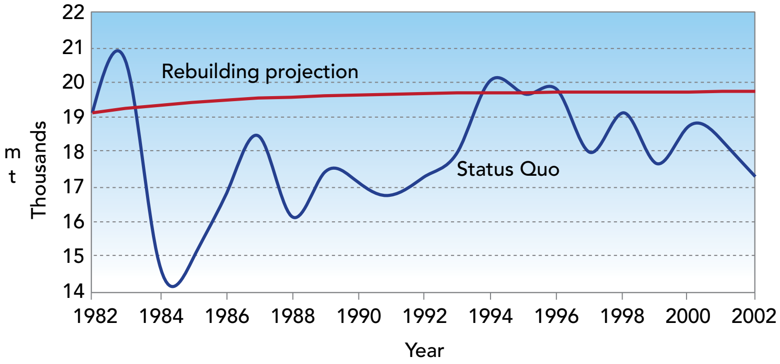
To measure the direct economic benefits from rebuilding, the analysis used value of landed fish plus reductions in trip costs as the indicator in the commercial sector; for the recreational sector willingness-to-pay estimates were used. Specifically, the study assessed the *change* in landed value plus the *change* in trip costs to measure the economic benefits.[13]

Figure 1. Summer Flounder Population Size for Status Quo and Rebuilding Scenarios: 1982–2007



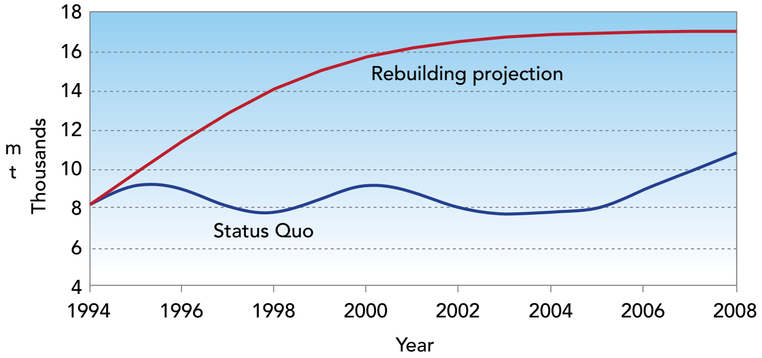
The blue line shows population size under actual management; the red line shows the population size if the target fishing mortality had been realized.

Figure 2. Butterfish Population Size for Status Quo and Rebuilding Scenarios: 1982–2002



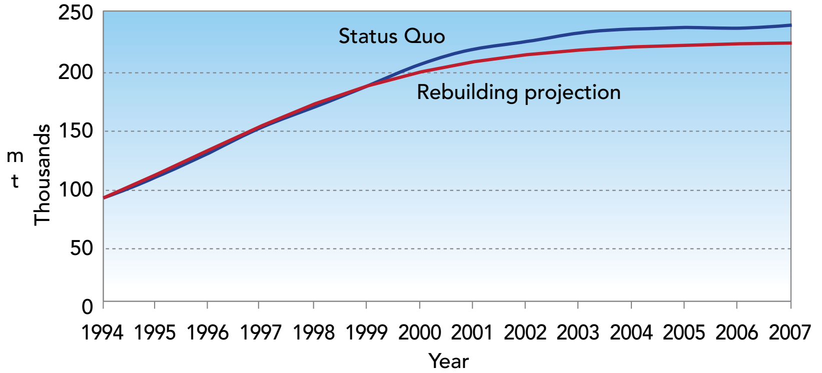
The blue line shows the population size under actual management; the red line shows the population size if the target fishing mortality had been realized.

Figure 3. Black Sea Bass Population Size for Status Quo and Rebuilding Scenarios: 1994–2007



The blue line shows the population size under actual management; the red line shows the population size if the target fishing mortality had been realized.

Figure 4. Bluefish Population Size for Status Quo and Rebuilding Scenarios: 1994–2007



The blue line shows the population size under actual management; the red line shows the population size if the target fishing mortality had been realized. The lines are similar because bluefish remained on track during its rebuilding plan.

Landed values and economic benefits are reported in the form of equivalent annuities, which is a measure of the value in dollars per year. To calculate these values, the analysis took the benefits foregone each year during the rebuilding period from the base year to 2007 and compounded them to 2008. The resulting value is the lump sum value of rebuilding in dollars which is then converted to equivalent annuities or value in dollars per year extending into the future indefinitely.[14] For the conversion, the lump sum value was multiplied by a discount rate of 2.8 percent to obtain the equivalent annuities in 2007 dollars. The result represents how much is gained each year, in perpetuity, as a result of rebuilding.[15] All results reported in tables and charts in this report are in the form of 2007 dollars per year (equivalent annuities).

DIRECT ECONOMIC BENEFITS

To estimate direct economic benefits (Table 1), the commercial and recreational sectors were assessed separately. To calculate annualized values for catch, landed weight and landed value the study compared the status quo scenario and the rebuilding target scenario. These values were then aggregated across species so that the change in net benefits from the status quo could be estimated. The analysis is comparative and assesses the change from status quo; it is not a measure of total net benefits. Table 2 presents a summary of the results.

Comparing intended rebuilding paths to what actually occurred in the four fisheries shows commercial landings would increase by 48 percent or 7,864 mt per year under the rebuilding scenario. The commercial landed value for all four species was $55.3 million per year under the status quo scenario, while under the rebuilding scenario projected revenues would be about $88 million per year in 2007 dollars. Comparing the status quo scenario with the rebuilding scenario in the commercial sector (shown in Figure 5), the gain in annualized landed values is about 59 percent ($32.6 million more per year), if one assumes that there are no changes in the number of trips taken or in costs associated with fishing.

Direct economic benefits were calculated from the commercial sector as the additional revenues from landings plus the reduction

TABLE 1. Estimates of Direct Economic Benefits from Rebuilding

	Additional $ per year
Gain in Annualized Commercial Landed Value	$32,600,000
Annualized Trip Cost Savings	$978,000
Annualized Recreational Willingness–To–Pay	$536,000,000
Total Direct Benefits	$569,600,000

TABLE 2. Combined Catch, Landings and Landed Value

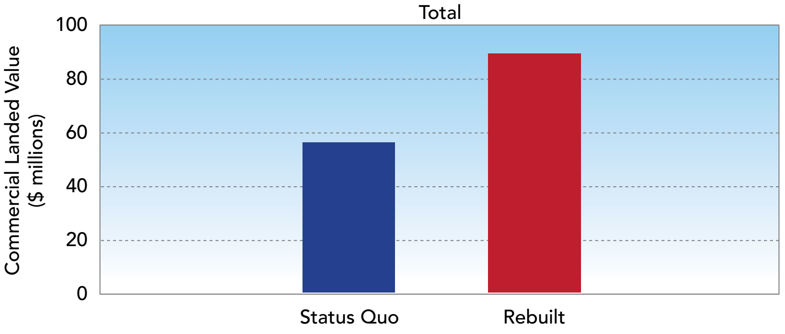
Total	Status Quo	Rebuilding Target	Change	% Increase
Commercial				
Catch	21,287 mt/yr	30,765 mt/yr	+9,478 mt/yr	45%
Landings	16,510 mt/yr	24,374 mt/yr	+7,864 mt/yr	48%
Landed Value	$55,315,365	$87,964,321	$32,648,956	59%
Recreational				
Catch	37,937 mt/yr	46,734 mt/yr	8,747	23%
Landings	28,655 mt/yr	35,423 mt/yr	6,731	24%
The combined total catch, landings and landed value for commercial and recreational fishing for four species in the Mid-Atlantic. The gain and percent increase from rebuilding compared to status quo is presented.				

in trip costs associated with lower fishing mortalities.[16] If the rebuilding scenario had been followed and the populations rebuilt as planned, the commercial sector would have realized a near doubling of ex-vessel annualized revenues. However, regulations to achieve reductions in fishing effort usually result in fewer trips taken, meaning that trip costs are reduced in proportion to fishing mortality. Assuming a cost reduction equivalent to 3 percent of revenues,[17] a cost savings of $978,000 per year might be realized by following the rebuilding scenarios.[18] Thus the total benefit from revenue and trip cost savings is an increase of $33.6 million per year in perpetuity under the rebuilt scenario.

For direct economic benefits from the recreational sector, willingness-to-pay estimates were used from a previous study by Hicks *et al*, the most recent one available.[19] The 1994 study by Hicks *et al.* asked respondents their willingness-to-pay for a one fish increase in success rate per recreational visit and estimated an aggregate value.[20] Since rebuilding the four mid-Atlantic species under study would bring an increase in landings of 24 percent or 6,768 mt more per year than status quo, the economic value of this increase would be based on how willingness-to-pay changes due to the increase in catch.

To calculate this change, the change in pounds of fish caught per recreational visit between the status quo and rebuilding scenarios was divided by the average weight of a fish (estimated from the Hicks study[21]) for each year in the rebuilding period to obtain the change in number of fish caught per visit. This value was then multiplied by the Hicks' willingness-to-pay estimate for a one fish per visit increase in success rate in 2007 dollars (this

Figure 5. Combined Annualized Commercial Landed Value (in millions) for 4 Mid-Atlantic Species under Status Quo and Rebuilt Scenarios



The blue bar represents the value ($) per year for the combined landings of summer flounder, black sea bass, bluefish, and butterfish under status quo management; the red bar represents the value ($) per year in perpetuity for landings under a scenario where the populations are rebuilt by 2007.

value was converted from 1994 dollars to 2007 dollars using the Consumer Price Index). This calculation was done for each year of the rebuilding period and then financial formulas were applied (*i.e.*, calculating lump sum and equivalent annuities or value in dollars per year) to the time series of willingness-to-pay estimates. These calculations determined that the economic value of rebuilding in the recreational sector, measured as the willingness-to-pay for enhanced success rates, would be approximately $536 million per year in perpetuity.[22] This assumes that average willingness-to-pay has not changed over time. More detail on this methodology is provided in the technical appendix.


Photo credit : Herb Segars/gotosnapshot.com

Summer flounder are found from North Carolina to Maine. These fish stay in bays and estuaries during the summer, migrating offshore in autumn where they spawn; water currents carry larvae back to the coast to develop. Sexually mature by age two, females live to 20, while males live until 10.

Otter trawl is the principal fishing gear in the commercial fishery, which is allocated 60 percent of the total allowable catch, leaving 40 percent for recreational fishermen. However, the recreational rod and reel fishery has caught a large portion of the total catch, sometimes exceeding the commercial landings. Recreational catch peaked in 1983 at 12,700 mt and then declined, ranging from 3,800 mt to 7,100 mt between 1996 and 2005.

SPECIES

Summer flounder

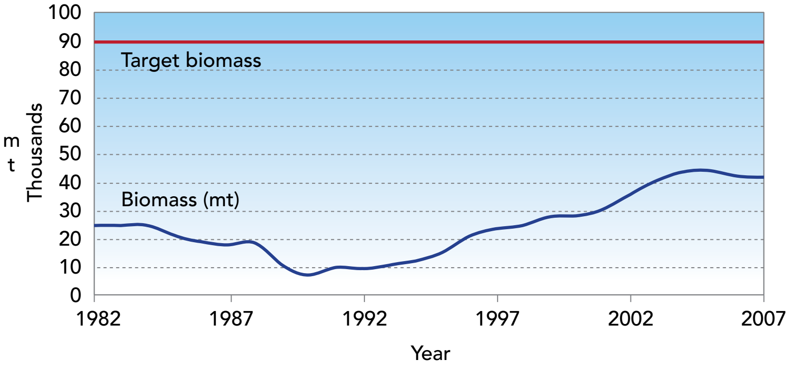
(Paralichthys dentatus)

Of the four species assessed, summer flounder is the highest value commercial fishery, with the most to gain and the most to lose. Managed cooperatively by the Mid-Atlantic Fishery Management Council and the Atlantic States Marine Fisheries Commission, the summer flounder is currently under a rebuilding plan which calls for it to reach its target population size by January 1, 2013, as required by Section 120(a) of the Magnuson-Stevens Fishery Conservation and Management Act.

In 2007, summer flounder was not considered overfished (population size depleted to unsustainably low levels) or subject to overfishing and its spawning biomass or amount of fish able to reproduce was approximately 95.6 million lbs., or about 72 percent of the 132.4 million lb. rebuilding target—slightly short of being rebuilt. This is an improvement from the late 1980s and early 1990s when the population had reached record low abundance levels. This decline affected the age structure of the population by reducing the number of older fish. Under a management plan for almost 20 years and with fishing regulations that have gradually reduced quotas to sustainable levels, the last decade has seen an expansion in the amount of summer flounder (biomass) and a more normal distribution of the population's age structure. The amount of fish able to reproduce has also increased from a low of 7,017 mt in 1989 to an estimated 43,363 mt in 2007. This increasing trend in biomass is shown in Figure 6.

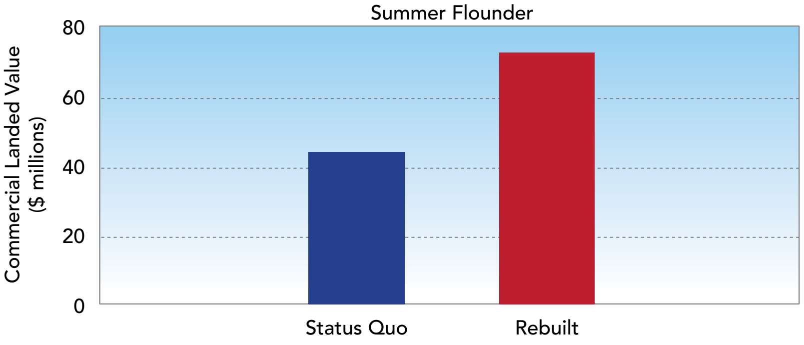
The gains of rebuilding summer flounder sooner (in 2007 as opposed to the 2013 status quo deadline) and achieving the target rebuilding path are significant, as shown in Table 3. Annualized commercial landings would have been 6,184 mt more per year if the intended rebuilding plan had been achieved, allowing for the maximum amount of fish that could have sustainably been taken in 2007, compared to what actually transpired (Figure 7). This translates into a possible 66 percent increase in commercial landed value or a $28.9 million

Figure 6. Trends in Summer Flounder Biomass: 1982–2007



Summer flounder biomass from 1982 to 2007 show a general upward trend, a result of management measures starting with Amendment 2 to the fishery management plan implemented in 1993.

Figure 7. Annualized Commercial Landed Value for Summer Flounder



The blue bar represents the value ($) per year for commercial landings under status quo management; the red bar represents the value ($) per year in perpetuity for landings from rebuilding the population by 2007.

TABLE 3. Summer Flounder Catch, Landings and Landed Value

Summer Flounder	Status Quo	Rebuilding Target	Change
Commercial			
Catch	7,583 mt/yr	13,958 mt/yr	+6,375 mt/yr
Landings	7,356 mt/yr	13,540 mt/yr	+6,184 mt/yr
Landed Value	$43,943,165	$72,863,640	$28,920,475
Recreational			
Catch	5,055 mt/yr	9,306 mt/yr	+4,250 mt/yr
Landings	3,994 mt/yr	7,351 mt/yr	+3,358 mt/yr

Summer Flounder catch and landings (in mt per year) and landed value (in $ per year) for status quo and rebuilt target scenarios and the difference between the two scenarios.

gain per year. There would also have been an 84 percent increase in recreational landings under a rebuilding scenario.

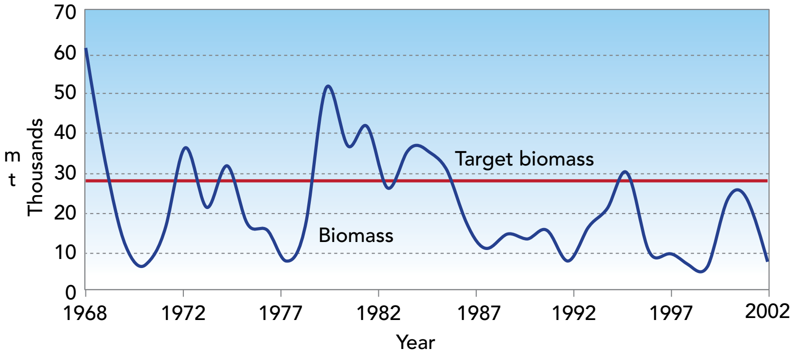
Butterfish
(Peprilus triacanthus)

A 2004 stock assessment determined that the butterfish population was at an unsustainably low level in 2002 with a biomass of only 7,800 mt, well below the threshold level of 11,400 mt,[23] but that overfishing was no longer occurring. Additionally, the age distribution was truncated to three years from a historical average of six years. Most troubling, scientists estimated that discards of butterfish caught unintentionally in the *Loligo* squid fishery were twice the level of annual commercial landings. The Mid-Atlantic Fishery Management Council has developed a rebuilding plan as part of Amendment 10 (which is not yet a final rule) along with a cap on the amount of butterfish caught incidentally in the squid fishery. The rebuilding plan estimates that the population will be rebuilt in five years, but it could be rebuilt in less time if reproduction rates are high and the proposed fishing rate is not increased. Figure 8 shows the fluctuations in butterfish

Photo credit : Herb Segars/gotosnapshot.com

Small and bony, **butterfish** grow quickly and rarely live more than three years. It is managed as a unit from Cape Hatteras to the Gulf of Maine, migrating according to water temperature, moving north in summer as temperature increases. There is no recreational fishery and commercial landings have declined since 1985, reaching a record low of 432 mt in 2005. In addition, butterfish are caught incidentally in other fisheries where they suffer high levels of mortality.

Figure 8. Trends in Butterfish Biomass: 1968–2002



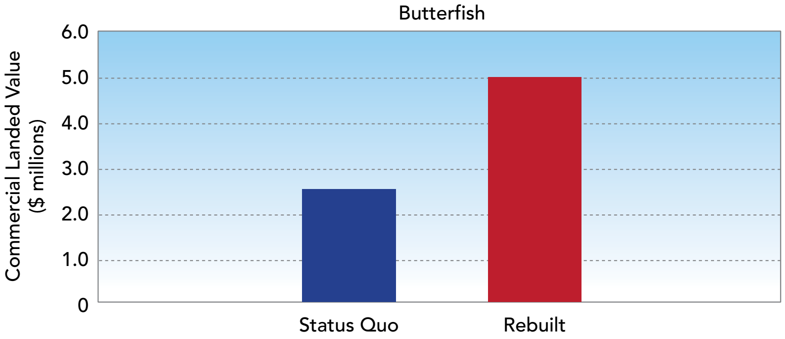
Butterfish biomass from 1968 to 2002 reflects a general downward trend with the population depleted to an unsustainable level in 2002.

TABLE 4. Butterfish Catch, Landings and Landed Value

Butterfish	Status Quo	Rebuilding Target	Change
Commercial			
Catch	4,918 mt/yr	6,680 mt/yr	+1,762 mt/yr
Landings	1,672 mt/yr	2,271 mt/yr	+599 mt/yr
Landed Value	$2,497,587	$4,974,728	$2,477,141

Butterfish catch and landings (in mt per year) and landed value (in $ per year) for status quo and rebuilt target scenarios and the difference between the two scenarios.

Figure 9. Annualized Commercial Landed Value (in millions per year) for Butterfish.



The blue bar represents the value ($) per year for commercial landings under the status quo scenario; the red bar represents the value ($) per year in perpetuity for landings for the rebuilt scenario.

biomass that have resulted from variable reproduction, though on average the population size has declined since the early 1980s.

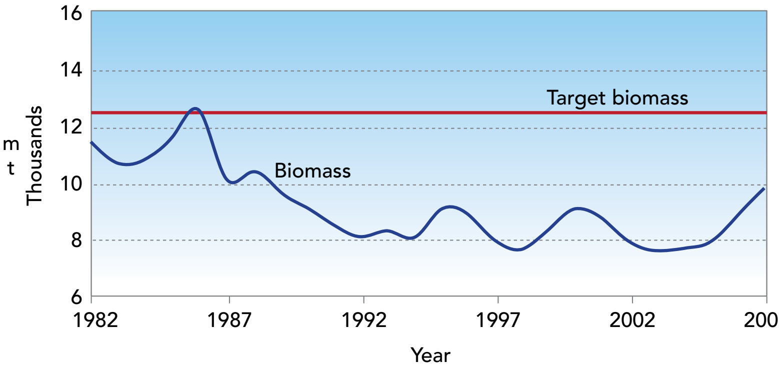
Since there is no recreational fishery for butterfish, all direct economic benefits are found in the commercial sector. Under a rebuilt scenario, landings would be 599 mt higher per year than the status quo scenario (Figure 9), a gain of roughly $2.5 million per year, or 99 percent (Table 4). The large difference between landings and catch reflects the high amount of unintentional catch or bycatch that occurs in the *Loligo* squid fishery. Butterfish are typically caught unintentionally due to the small mesh size gear used for squid and the fact that butterfish and *Loligo* inhabit the same areas year round.

Black Sea Bass

(Centropristis striata)

Black sea bass are managed by the Mid-Atlantic Fishery Management Council and the Atlantic States Marine Fisheries Commission under the Summer Flounder, Scup and Black Sea Bass Fishery Management Plan. There is both a commercial and recreational fishery, each accounting for half of total landings by weight over the past 10 years. The commercial fishery mainly uses hook and line and fishing traps called pots. Commercial landings in 2005 were 1,310 mt, up from a low of 566 mt in 1971, but still well below a peak of 10,000 mt in 1952.

Figure 10. Trends in Black Sea Bass Biomass: 1982–2007

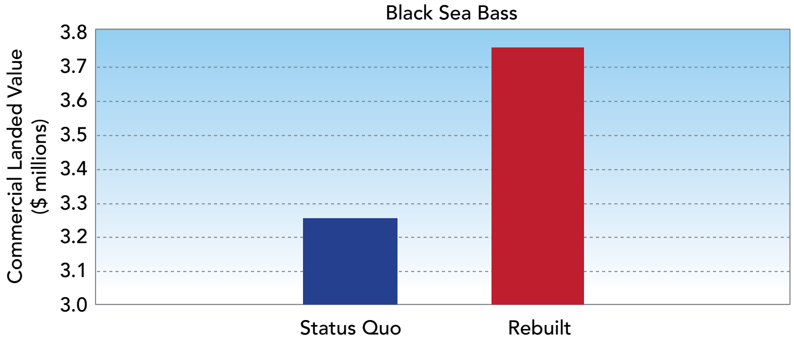


Black sea bass biomass trends from 1982 to 2007. Coastwide quotas, allocated into quarterly periods, were put in place in 1996.

Photo © Marilyn & Maris Kazmers / SeaPics.com

Black sea bass are found from the Gulf of Maine to Gulf of Mexico, living near bottom structures and reef habitats. They move seasonally, migrating offshore in the winter and spawning in coastal waters in the spring. They are caught in a trawl fishery along with summer flounder and scup. Black sea bass begin life as females and change into males between two and five years of age, causing the proportion of males in the population to increase with size and age.

Figure 11. Annualized Commercial Landed Value (in millions) for Black Sea Bass



The blue bar represents the value ($) per year for commercial landings under status quo management; the red bar represents the value ($) per year for landings if the population had been rebuilt by 2007.

In early 2009, fishery scientists determined that black sea bass was subject to overfishing, but that the population size was not depleted to an unsustainably low level. The population has rebounded from its historic lows. Currently at 92 percent of the spawning biomass goal of 27.6 million pounds, it is scheduled to be rebuilt in 2010. However, information about the black sea bass population is limited, and more information is needed on the effect of sex changes on the reproductive potential of the population. There is also considerable uncertainty regarding the level of natural mortality. Estimates of trends in population size, shown in Figure 10, show an average decrease since the mid 1980s, but an increase within the last few years.

The commercial sector of the black sea bass fishery is projected to have a landings gain of 261 mt per year under a rebuilt scenario (Figure 11), an increase in value of $499,756 per year (roughly 15.4 percent). As with the analysis of the commercial sector, the differences for the recreational sector between the retrospective rebuilding

TABLE 5. Black Sea Bass Catch, Landings and Landed Value

Black Sea Bass	Status Quo	Rebuilding Target	Change
Commercial			
Catch	2,606 mt/yr	3,127 mt/yr	+521 mt/yr
Landings	1,303 mt/yr	1,564 mt/yr	+261 mt/yr
Landed Value	$3,252,852	$3,752,609	$499,757
Recreational			
Catch	2,712 mt/yr	3,255 mt/yr	+543 mt/yr
Landings	2,034 mt/yr	2,441 mt/yr	+407 mt/yr
Black Sea Bass catch and landings (in mt per year) and landed value (in $ per year) for status quo and rebuilt target scenarios and the difference between the two scenarios.			

and status quo scenarios are significant (Table 5). Comparing the two scenarios, the gain in annualized landed values is about 20 percent or a 407 mt increase per year. The monetary value of this increase in landings was calculated later using willingness-to-pay estimates for the sum of gains from recreational landings for all four species.

Bluefish
(*Pomatomus saltatrix*)

Recently declared successfully rebuilt in the *2008 Status of U.S. Fisheries* report issued by National Marine Fisheries Service, bluefish proves that rebuilding a depleted fish population to a sustainable level is an achievable goal.[25] Under a nine year rebuilding plan implemented in 2001, bluefish's fishing mortality rate was controlled to allow the population to rebuild. In 2004, bluefish was no longer considered to be at an unsustainably low level or subject to overfishing, and the amount of fish in the population had risen to 104,136 mt, an increase from the historic lows in the mid-1990s (Figure 12).[26]

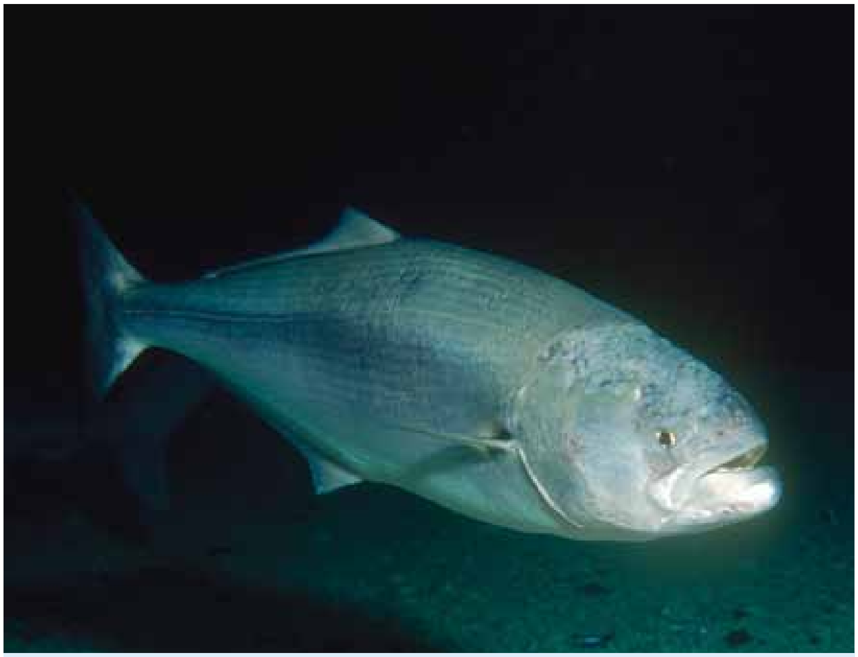
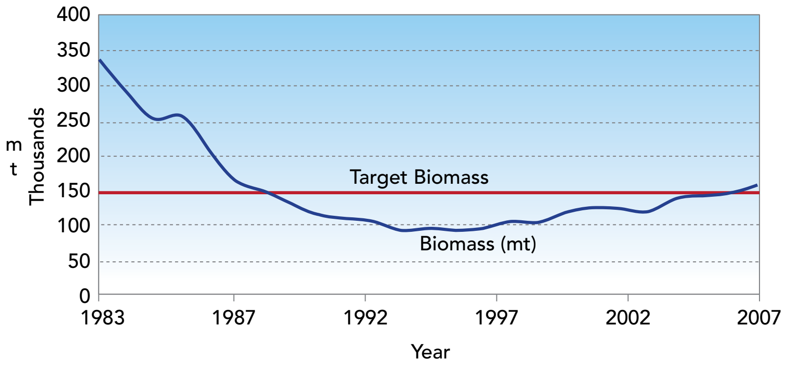


Photo credit : Herb Segars/gotosnapshot.com

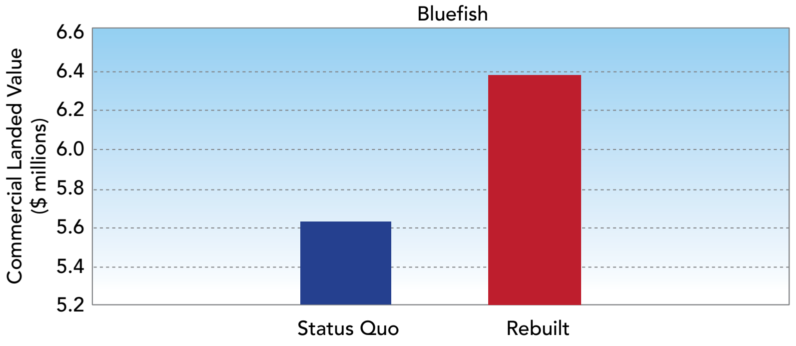
Bluefish is a migratory predator found in coastal waters from Florida to Maine, but it is mainly caught by recreational fishermen off the Mid-Atlantic States from New York to Virginia. It is managed jointly by the Mid-Atlantic Fishery Management Council and the Atlantic States Marine Fisheries Commission under a fishery management plan implemented in 1990. The recreational fishery is allocated 83 percent of the annual quota, while the commercial fishery has 17 percent, based on the historical trends of recreational landings that account for 80–90 percent of total catch.[24]

Figure 12. Trends in Bluefish Biomass: 1982–2007



Bluefish biomass trends from 1982 to 2007 show the population steadily declining until reaching a low in 1993. Levels gradually rebuilt to the target biomass (reached in 2008) after a fishery management plan was implemented in 1990.

Figure 13. Annualized Commercial Landed Value (in millions) for Bluefish.



The blue bar represents the value ($) per year for commercial landings under status quo management; the red bar represents the value ($) per year in perpetuity for landings under the rebuilt scenario.

Since the actual population size trajectory is very close to the intended rebuilding plan, the difference in the two scenarios is not as significant as for other profiled species (Figure 13). Specifically, a comparison of the two scenarios, shown in Table 6, reveals that there is an annualized gain in commercial landings of 820 mt per year under the rebuilding scenario which amounts to a value of $751,585 per year, or a 13.4 percent increase. On the recreational side, estimated annualized landings increase by 3,003 mt per year, a 13.3 percent increase.

TABLE 6. Bluefish Catch, Landings and Landed Value

Bluefish	Status Quo	Rebuilding Target	Change
Commercial			
Catch	6,179 mt/yr	6,999 mt/yr	+820 mt/yr
Landings	6,179 mt/yr	6,999 mt/yr	+820 mt/yr
Landed Value	$5,621,760	$6,373,345	$751,585
Recreational			
Catch	30,170 mt/yr	34,174 mt/yr	+4,004 mt/yr
Landings	22,627 mt/yr	25,630 mt/yr	+3,003 mt/yr

Bluefish catch and landings (in mt per year) and landed value (in $ per year) for status quo and rebuilt target scenarios and the difference between the two scenarios.

CONCLUSION

If populations of summer flounder, butterfish, black sea bass and bluefish were rebuilt by 2007, an additional $570 million per year in perpetuity in direct economic benefits would have resulted. This potential benefit is the combination of a $33.6 million per year increase in commercial landed value (including trip cost savings) and a $536 million per year increase in the value of landings to the recreational sector (estimated as increased willingness-to-pay for visits). Put another way, the foregone benefit of rebuilding is $570 million per year in 2007 dollars. Over a five-year period the accrued total would reach $2.85 billion in economic benefit, a substantial contribution to the mid-Atlantic economy and its coastal communities.

These direct economic benefits would have potential secondary impacts in the region assuming increased income, sales and jobs in associated businesses such as bait and tackle shops, although, these cannot be meaningfully added to direct benefits and are difficult to assess due to confounding variables. Still, it is important to note that the primary, direct benefits are a conservative estimate and the benefits may expand beyond the sums estimated here. Furthermore, this study is only a partial economic valuation of rebuilding; it does not include the value to processors and retailers of rebuilding. A full economic valuation of rebuilding would require a combination of direct use value (revenues and costs), indirect use value (sales, jobs, and income, *etc.*) and non-use value (the value of preserving the resource for future generations and the value of knowing the resource exists), an extensive undertaking that is constrained by data limitations and is beyond the scope of this study.[27]

In addition, these economic estimates are premised on population recoveries which, in turn, presume that appropriate fisheries management measures are enacted, enforced and sustained. If measures are not maintained, the success and benefit of rebuilding will dissipate; providing further evidence that adopting science-based rebuilding plans and regulations that achieve the required reductions in fishing mortality are critical to rebuilding valuable fish populations as soon as possible.[28]

Importantly, this study provides analytical evidence that there is value in rebuilding fish populations and foregone economic benefits from delaying rebuilding. In 2003, the Pew Oceans Commission concluded that “rebuilding U.S. fisheries has the potential to restore and create tens of thousands of family wage jobs and add at least $1.3 billion to the U.S. economy.”[29] That assertion is supported by this report’s finding of an increase of $570 million per year estimated for just four species in the mid-Atlantic region.

APPENDIX: TECHNICAL SUMMARY OF ECONOMIC METHODOLOGY

Biomass Growth Functions

Biomass growth functions describe the response of biomass to changes in parameters and to fishing mortality.

Growth equation: $G(B)$ where
B = biomass

Particular cases of G are:

$G(B) = rB-(r/K)B\beta$
the Bernoulli equation

When $\beta = 2$ this equation is reducible to:

$G(B) = rB(1-B/K)$

and is referred to as the Schaeffer or Gordon equation.

The more general case in which $\beta \neq 2$ is labeled, in fisheries, is the Pella-Tomlinson equation.

Another form is the Gompertz growth function:

$G(B) = rB\ln(K/B)$.

These are all two parameter curves with parameters r and K, where K = carrying capacity and r = "intrinsic" growth rate.

Biomass Difference Equation

$B(t+1) = B(t) + G(B(t)) - C(t) + S(t)$; $C(t)$ = catch; $S(t)$ = surviving discards.

Or

$\Delta B(t) = G(B(t)) - C(t) + S(t)$;

Steady state is attained when $\Delta B(t) \rightarrow 0$; catch plus surviving discards equal growth:

$C-S = G(.)$; the time subscript being irrelevant in steady state.

$C- S = rB-(r/K)B\beta$ for the Bernoulli equation.

All points along this curve are steady state equilibria. These equilibria may be stable or unstable, depending on the parameterization.

Discards and survivors

Suppose the discard rate is d. Then discards = dC. Suppose the survival rate of discards is s. Then survivors are:

$S = sdC$

so, in steady state:

$C(1-sd) = rB-(r/K)B\beta$ for the Bernoullli equation, or

$C = (r/(1-sd))B(1 - B/K)$

Let $\alpha = r/(1-sd)$,

$C = \alpha B(1 - B/K)$

which makes it clear that the effect of surviving discards is analogous to a larger intrinsic growth rate, since $\alpha > r$ for $sd > 0$. This effect makes sense intuitively.

To find the "Maximum sustainable yield" (MSY), differentiate with respect to B and equate the result to zero:

$dC/dB = \alpha-\beta(\alpha/K)B\beta-1= 0$;
solving for B:

$Bmsy = (K/\beta)\gamma$ where
$\gamma \equiv 1/(\beta-1)$.

Note that surviving discards have not affected the Bmsy, but the rate of approach to Bmsy is accelerated. For the Schaeffer-Gordon special case in which $\beta = 2$, this reduces to
$Bmsy = K/2$.

Production Function or Catch Equation:

$C = H(F,B) = B(F/Z)(1-e-Z)$;
$Z = F + M$; M = natural mortality.

Landings versus Catches:

$L = (1-d)C = (1-d)H(F,B)$

maximum sustainable yield is:

$Cmsy = H(Fmsy , Bmsy)$

$Lmsy = (1-d)Cmsy$

For the special Schaeffer-Gordon case in which $\beta = 2$, the steady state or sustainable yield curve is a homogeneous quadratic and as such is perfectly symmetric about a midpoint which is the MSY.

Estimates of Growth Parameters:

Data on biomasses, fishing mortalities and rates of discard and survival of discards were obtained from staff at the Mid-Atlantic Fishery Management Council. For each species, a growth equation was fitted to the data to estimate r (intrinsic rate of growth) and K (carrying capacity). For most species the growth function was logistic. However, for butterfish it was the Gompertz function.

Table 7 below summarizes the results.

Application of Growth Functions

For each species, four scenarios were constructed. Scenario 1 regenerates the expected outcomes given the observed fishing mortality coefficients during the rebuilding period. Scenario 2 generates the expected outcomes if the target fishing mortalities had been adopted. The outcomes generated included biomass, catch, discards, surviving discards and commercial sector revenues.

The rebuilding periods are discussed in the body of the report. The ending year was 2007 which was the latest data year available. Since past values are being compounded forward to 2007, Future Value (FV) formulas were used and then converted to equivalent perpetual annuities. The more common situation involves future streams that are discounted back to the present (Present Values or PVs), before being annuitized. Equivalent annuities (EAs) were reported because the units of measurement mt/year or dollars/year are more easily understood by the general public than lump sum Present or Future Values in mt or dollars.[30] The lump sum future values of outcomes foregone were converted to equivalent perpetual annuities by multiplying the discount rate (2.8 percent):

$$EA = i*FV$$

Direct Economic Benefits

Direct economic benefits for the commercial sector were calculated as the additional revenues from landings plus the estimated reduction in trip costs associated with lower fishing mortalities. The dominant (commercial) gear type in these fisheries is the bottom trawl. A biomass–weighted reduction in fishing mortality was calculated. Trip costs for bottom trawls in the Mid-Atlantic area were obtained from the Northeast Fisheries Science Center, Social Sciences Branch. The percent reduction in fishing mortality

TABLE 7. Growth equation and parameters used in projecting biomass

	Black Sea Bass	Bluefish	Butterfish	S. Flounder
Growth	Logistic	Logistic	Gomperz	Logistic
r	0.568	0.0599	0.204	0.396
K	25,074	294,102	41,169	169,881
SSQT	0	1.04E+10	1.53E+09	1.63E+08
SSQR	4.51E+07	1.51E+11	6.17E+09	3.33E+09
R^{2}	1	0.93	0.75	0.95
Bmsy/Target Biomass (mt)	12,537	147,051	41,169	84,940

was assumed to approximate the percent reduction in trip costs. The result was equivalent to a 3 percent reduction in revenues. The most extreme reduction in trip costs could be as much as 18 percent, but that seems unlikely. It is very difficult to determine the "correct" reduction in trip costs without a detailed modeling effort for the various gear types and species involved. Often, in multispecies fisheries, the composition of catches has a strong separation by season, area or depth of tow. Technical substitution between species is then quite easy. However, when multiple species are present at the same time and in the same area, substitution possibilities are quite limited.

When there is no market for the services of natural resources, we are forced to try to infer their values by other methods. Direct economic benefits for the recreational sector were estimated using willingness-to-pay estimates by Hicks *et al.* (1999). Unlike landed weight and landed values series, willingness-to-pay studies are done only infrequently. The field data on which their estimates are based dates to 1994. Thus, while this data is rather old, it is near the beginning of the rebuilding period. In the study by Hicks *et al.*, respondents were asked their willingness-to-pay for a one-fish increase in their success rate. An enhanced success rate of one fish is a relatively convenient concept when administering willingness-to-pay survey instruments. At an individual level, different visits will experience increased catches per visit of –2,–1, 0, +1, or +2 fish. That is to say, at an individual level, catches and changes in catch are integer values. But when we calculate an average change in catch per visit, the result is not necessarily integer. For the sake of abstracting from discounting procedures, consider a year (as an example) in which the change in catch per visit is 0.8 fish per visit. If the average fish caught weighs 0.8 lbs., the increased success rate in fish units is (0.8lbs. per visit)/(0.8 lbs. per fish) which equals one fish per visit.

So, drawing on the Hicks' estimate of willingness-to-pay for a one fish increase in success rate we can infer that in this particular year, for each $100 of the Hicks' willingness-to-pay estimate, we would estimate $100 willingness-to-pay from the above (one fish per visit) increase in success rate. We can apply this reasoning for each year in the rebuilding period and then apply our financial formulas to the series of willingness-to-pay in each year. Of course, in some years, the change in catch rate may be negative; especially in early years, since catch rates must initially decrease in order for population growth to exceed fishing induced mortality.

For the willingness-to-pay calculation we assume proportionality: in the aggregate, a half fish increase in success rate per visit results in half the reported willingness-to-pay increase for one fish increase in success rate. Therefore, the primary direct benefit (increased willingness-to-pay) of rebuilding can be estimated as the recreational willingness-to-pay for enhanced success rates. To generate this estimate, the Consumer Price Index (CPI) was used to adjust the Hicks' 1994 estimate to 2007 dollars.

Some caveats on the willingness-to-pay estimates:

1. Limitations of the study.

We have only one observation on willingness-to-pay per visit (for 1994). While there is more recent raw data, there is no more recent complete study of willingness-to-pay in recreational fisheries. Thus, estimates could be considerably different using more recent data. Additionally, during the rebuilding time period assessed, there may have been large changes in the mix or size of species caught that would affect willingness-to-pay per visit. This effect was not accounted for in the present study, as willingness-to-pay was assumed to not have changed over time. Rather, this study calculated the differences in catch per visit before and after rebuilding and related this to the effect of a one fish increase in the success rate per visit.

2. Catch versus landings.

The willingness-to-pay literature most relevant for these fisheries is silent on whether the increased success rate is in terms of catch or landings. There is some evidence that it is the experience of catching the fish is the most important. However, catching a fish is a necessary condition for its landing. The theory of utility maximization that underlies the estimation of willingness-to-pay suggests that it is expected to be at least as responsive to increases in landing success as to increases in catch success. The percentage increase in landings per visit (24 percent) is essentially equivalent to that of catch per visit (23 percent). It seems reasonable, therefore to expect that willingness-to-pay for increased landings would be similar to that for increased catches.

3. The declining size of the fish caught by the recreational sector.

One would expect that declining fish size would diminish the willingness-to-pay of a trip. The NMFS statistics for recreational catch include catch in numbers as well as weight. From this, it is possible to infer average weight per fish. This statistic declined for all the species and states (except North Carolina), between 1981 and 2007. This would perhaps be most important for gamefish such as bluefish. There is nothing that can be done about this in the short run because this size effect was not captured in the willingness-to-pay studies. This study used the 1994 mean weight per fish caught to calculate the change in success rate in number of fish, but if one uses the actual fish size in 2007 the implied increase in number of fish caught would be larger. Thus, the estimate used is conservative (ignoring any size related willingness-to-pay premium, meaning that recreational fishermen may have a higher willingness-to-pay for larger fish), and reasonably comparable to the average size of fish at the time (1994) data was collected for the willingness-to-pay study estimates.

ENDNOTES

1 There are some exceptions: fish species managed under international agreements or where the biology of the fish species or other environmental conditions dictate it be longer (16 U.S.C. 1854, MSA § 304 (e)(4)(A)(ii), P.L. 109-479). In those cases, the rebuilding period cannot be longer than 10 years plus one mean generation of the fish species.

2 C. Safina, *et al.*, 29 July 2005, "U.S. Ocean Fish Recovery: Staying the Course. Policy Forum," *Science*, 309, pp. 707–708.

3 *Ibid.*

4 *Ibid.*

5 K.W. Shertzer and M.H. Prager, 2007, "Delay in fishery management: diminished yield, longer rebuilding, and increased probability of stock collapse," *ICES Journal of Marine Science*, 64, pp. 149–159.

6 U.R. Sumaila and E. Suatoni, October 2005, "Fish Economics: The benefits of rebuilding U.S. ocean fish populations," Fisheries Economics Research Unit.

7 Northeast Multispecies Fishery Management Plan, pages I–xii and I–602 of Amendment 13.

8 Since that time bluefish has been declared successfully rebuilt by the National Marine Fisheries Service in its 2008 *Status of the Stocks* report.

9 The growth function was logistic for all species except butterfish which was Gompertz.

10 The time period used for butterfish was actually 1982 to 2002 as this was the data that was available. However, the results were projected to 2007 to allow for the species to be aggregated and comparable.

11 We chose to use 1982 and 1994 as starting years as opposed to 1998 when the 1996 amendment requirement for rebuilding plans to start would begin because we wanted the longest times series possible in order to better fit the data to the model.

12 The target fishing mortality rate was 0.34 for black sea bass, 0.19 for bluefish, 0.38 for butterfish, and 0.31 for summer flounder.

13 The measure used as the indicator of economic benefit is a form of economic rent or quasirent which is rent plus fixed costs of capital. Without a catch share type program that grants fishing privileges and allows for long run costs to be reduced, full rent cannot be generated.

14 The lump sum value is analogous to the principal on a loan or face amount of an asset; equivalent annuities are analogous to the loan payments or repayment on an asset.

15 To be clear, the present value that is being annuitized in 2007 is the benefits foregone *during the rebuilding period*. However, the differences in benefits after 2007 are not captured. To do so, we augment the equivalent annuities with the annual benefits in 2008 to capture the post–2007 benefit streams. The result is annualized values (perpetual annuities) in 2008 dollars. The fact that rebuilding periods differ somewhat between species is of no consequence because landed values are converted to an equivalent annuity at a common point in time. Further discussion of these measures is contained in the appendix.

16 Since the dominant commercial gear type in the fisheries is bottom trawl, a biomass–weighted reduction in fishing mortality was calculated to approximate the percent reduction in trip costs. Trip costs for bottom trawl in the Mid-Atlantic were obtained from the Northeast Fisheries Science Center, Social Sciences Branch. A cost reduction equivalent to a 3 percent reduction in revenues was assumed.

17 If trip costs are assumed to be 30 percent of revenues (calculated from data obtained from NEFSC on vessel revenue per day and cost per day) and it is assumed that there is an average 10 percent reduction in fishing mortality (calculated as a biomass–weighted average of fishing mortality across the four species), then the cost savings would be 3 percent.

18 These costs are also deflated using the Producer Price Index (PPI) for finfish in order to convert them into 2007 dollars.

19 R. Hicks, *et al.*, 1999. "Volume II: The economic value of New England and Mid-Atlantic sportfishing in 1994," *NOAA Technical Memorandum NMFS-F/SPO-38*, US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

20 Willingness-to-pay studies are done infrequently, so while the field data on which Hicks *et al.* (1999) base their willingness-to-pay estimates is old (1994) it is near the beginning of the rebuilding period and the most recent available. There is more recent raw data available (2006) that could be used for more recent estimates but this was beyond the scope of the current study.

21 These averages are based on 1994 data. If actual fish size in 2007 is used, the implied increase in number of fish per visit would be greater than the one fish per visit estimated. Thus the estimate used is conservative and comparable to the average size of fish in 1994 when the Hicks willingness–to–pay data was collected.

22 The economic benefits to either sector are not broken down by species because it is not economically meaningful to do so.

23 1/2 Bmsy

24 National Marine Fisheries Service, 2009, "Bluefish," *FishWatch—U.S. Seafood Facts,* www.nmfs.noaa.gov/fishwatch/species/bluefish.htm.

25 National Marine Fisheries Service, *2008 Report to Congress: the Status of U.S. Fisheries,* May 2009, www.nmfs.noaa.gov/sfa/statusoffisheries/booklet_status_of_us_fisheries08.pdf.

26 G. Shepherd, 2006, Status of Fishery Resources off the Northeastern US. Bluefish, www.nefsc.noaa.gov/sos/spsyn/op/bluefish/.

27 See J. Krutilla, 1967, "Conservation reconsidered," *American Economic Review* 57, pp. 787–796; H. Goulder and D. Kennedy, 1997, "Valuing ecosystem services: Philosophical bases and empirical methods," In *Nature's services: Societal dependence on natural ecosystems* (ed. G.C. Daily), pp. 23–48. Washington, DC: Island Press; U.R. Sumaila and C. Walters, 2005, "Intergenerational discounting: a new intuitive approach," *Ecological Economics* 52, pp. 135–142.

28 Reductions in fishing mortality are necessary but not always sufficient for sustainable rebuilding to occur due to uncertainty in management and environmental and biological stochasticity. The analyses in this report have been deterministic and do not account for uncertainty, but such an analysis would be useful for future research.

29 Pew Oceans Commission, 2003, *America's Living Oceans: Charting a course for sea change*, p. 5.

30 The FV and PV are financial functions which are available within Excel. Their arguments are the interest rate, the flows to be discounted or compounded, and the number of years in the rebuilding period.

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