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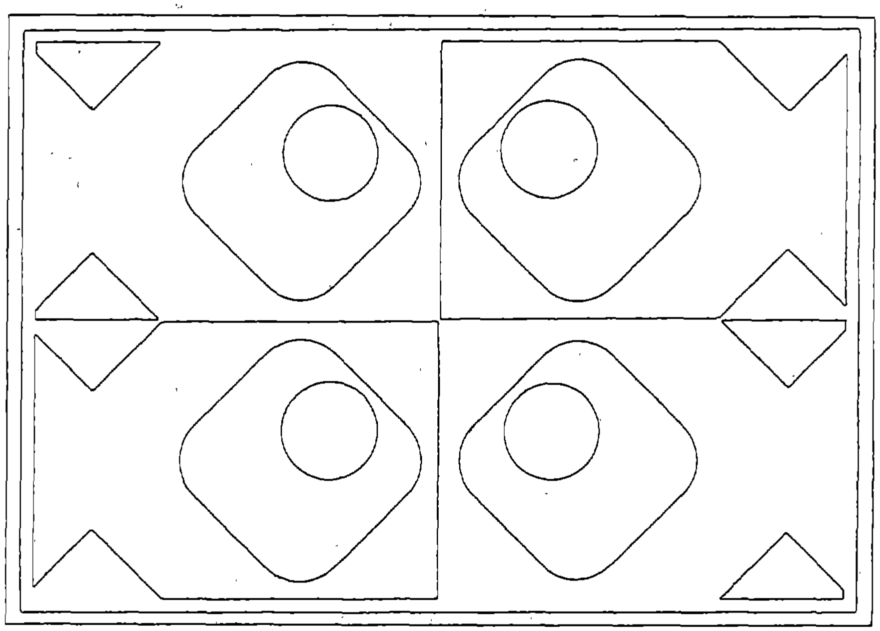
NOAA Technical Memorandum NMFS-NE-108

Status of the Fishery Resources off the Northeastern United States for 1994



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Status of the Fishery Resources off the Northeastern United States for 1994

Conservation and Utilization Division
Northeast Fisheries Science Center

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Table of Contents

Introduction 1
Fishery Landings Trends 9
Aggregate Resource Trends 11
Fishery Economic Trends 19
Fishery Observer Program 35
Species Synopsis 43

Principal Groundfish

1. Atlantic cod 44
2. Haddock 48
3. Redfish 52
4. Silver hake (whiting) 54
5. Red hake 58
6. Pollock 61

Flounders

7. Yellowtail flounder 64
8. Summer flounder (fluke) 69
9. American plaice (dab) 71
10. Witch flounder (gray sole) 73
11. Winter flounder (blackback, lemon sole) 74
12. Windowpane flounder (sand flounder) 79

Other Groundfish

13. Goosefish (angler, monkfish) 82
14. Scup (porgy) 84
15. Black sea bass 86
16. Ocean pout 88
17. White hake 90
18. Cusk 92
19. Wolffish (catfish) 94
20. Tilefish 96

Principal pelagics

21. Atlantic herring 98
22. Atlantic mackerel 100

Other pelagics

23. Atlantic butterfish 102
24. Bluefish 104
25. Spiny dogfish 106
26. Skates 108

Invertebrates

27. Short-finned squid 110
28. Long-finned squid 112
29. American lobster 114
30. Northern shrimp 117
31. Surfclam 119
32. Ocean quahog 121
33. Sea scallop 123

Anadromous fish

34. River herring 126
35. American shad 128
36. Striped bass 130
37. Atlantic salmon 132
38. Atlantic and shortnosed sturgeon 134

Marine mammals

39. Harbor porpoise 137

Common Name Index 139
Scientific Name Index 140

Introduction

The Conservation and Utilization Division of the Northeast Fisheries Science Center (NEFSC), with headquarters in Woods Hole, Massachusetts, annually updates its assessments of finfish and shellfish resources off the northeastern coast of the United States and presents detailed information as needed to administrators, managers, the fishing industries, and the public. This report is based on those assessments and summarizes the general status of selected finfish and shellfish resources off the northeastern coast of the United States from Cape Hatteras to Nova Scotia by summer 1994.

This report is divided into two sections, Aggregate Summaries and Species Synopses. The Aggregate Summaries section includes general descriptions of fishery landings trends, aggregate resource trends, and commercial fishery economic trends. A special section is added this year highlighting the NEFSC's Fishery Observer Program in which trained scientific observers are placed aboard commercial fishing vessels. The Species Synopses section, on the other hand, includes information about the status of 53 individual populations or stocks of some 48 species of finfish, shellfish, and harbor porpoise.

The species described in the Species Synopses section can be grouped under eight headings: principal groundfish, flounders, other groundfish, principal pelagics, other pelagics, invertebrates, anadromous fish, and marine mammals (harbor porpoise). There are several other species of commercial, recreational, and ecological importance that are not included, such as bluefin and yellowfin tuna, swordfish, red crabs, sand lance, sea urchins, menhaden, pelagic sharks, and inshore shellfish (including softshell and hard clams, oysters, and blue mussels). Some of these are migratory species that seasonally move outside the U.S. northeastern fishery conservation zone (FCZ), while others are fisheries that have not been routinely assessed by the Northeast Fisheries Science Center.

Gloucester fish house workers, circa 1945.
O.E. Sette Collection, NMFS/NEFSC Photo Archive

OVERVIEW OF ASSESSMENT APPROACHES

Depending on the nature of the fishery, the type and amount of data from the fishery and from research surveys, and the information required for management, the assessment information reported here may be generated in several different ways. Figure 1 is a diagram of several ways in which catch and survey data, in the lower right and left boxes respectively, can be combined to provide assessment advice, illustrated at the top of the diagram. The simplest approach is when catch data are used to generate indices of abundance, as seen by moving vertically up the right side of Figure 1. A more complex approach is when the catch data are combined with trawl survey data to generate indices of abundance, as seen by moving vertically up the middle of Figure 1.

These approaches are frequently supplemented with knowledge of the animal's life history generated using biological data from sampling the commercial and survey catches. A third approach is to utilize the information about total stock size and population productivity generated under the first two approaches to determine the relationship between productivity and stock size; this is referred to as a "production model." Finally, for those species where the age composition of the catch or of the survey samples can be determined reliably, more detailed analytic assessments can be developed using the information in the age structure of the population and the catches to determine productivity.

The status of information pertaining to the various elements in Figure 1 is diagrammed in Figure 2. The great differences in availability of different types of information (columns) for the many species of interest in this region (rows) suggests why assessments of different species involve different paths in Figure 1. Although research on some of the species has been underway for many years, some items are still not known. As fisheries become more developed, more of the categories need to be filled in to evaluate the effects of fishing on the resource. Much of the biological information (*e.g.*, growth and maturity rate) requires continual updating since many parameters change significantly with the level of exploitation and with changes in the environment.

The different informational paths in Figure 1 result in assessment information having different levels of sophistication and reliability. The actual level of complexity of an assessment is determined by the amount of information available, as indicated in Figure 2, and by the amount of information needed by management. Although there is some overlap, the assessments presented here can be roughly grouped in order of increasing level of complexity into the following categories, each one including features of all simpler levels.

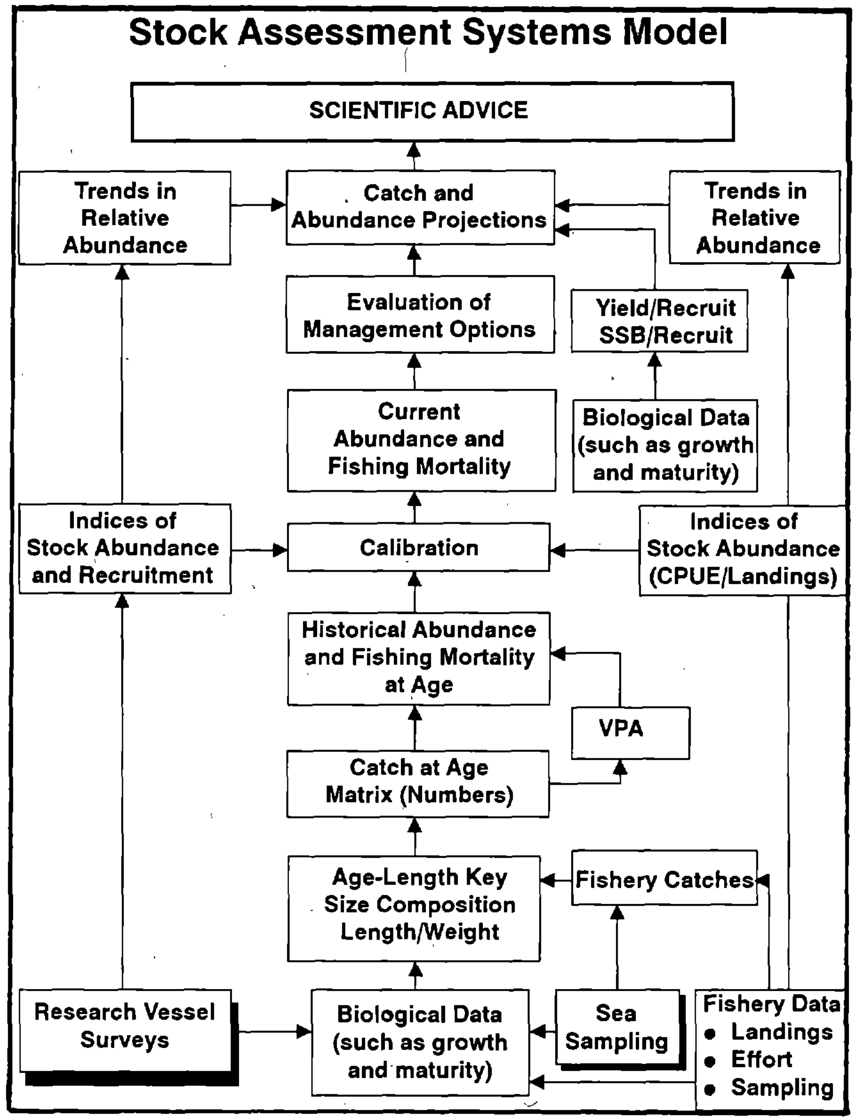


Figure 1. Diagram of alternative ways in which fishery-generated data and research vessel data (lower right and lower left boxes, respectively) are combined to provide scientific advice on the status of the stocks.

KINDS OF ASSESSMENTS

INDEX: assessment relies on an index of stock size from resource survey data or from fishery catch-per-unit-of-effort (CPUE) data.

YIELD: assessment also includes an evaluation of yield tradeoffs for different levels of fishing mortality and ages of fish caught, (*e.g.*, yield-per-recruit analysis).

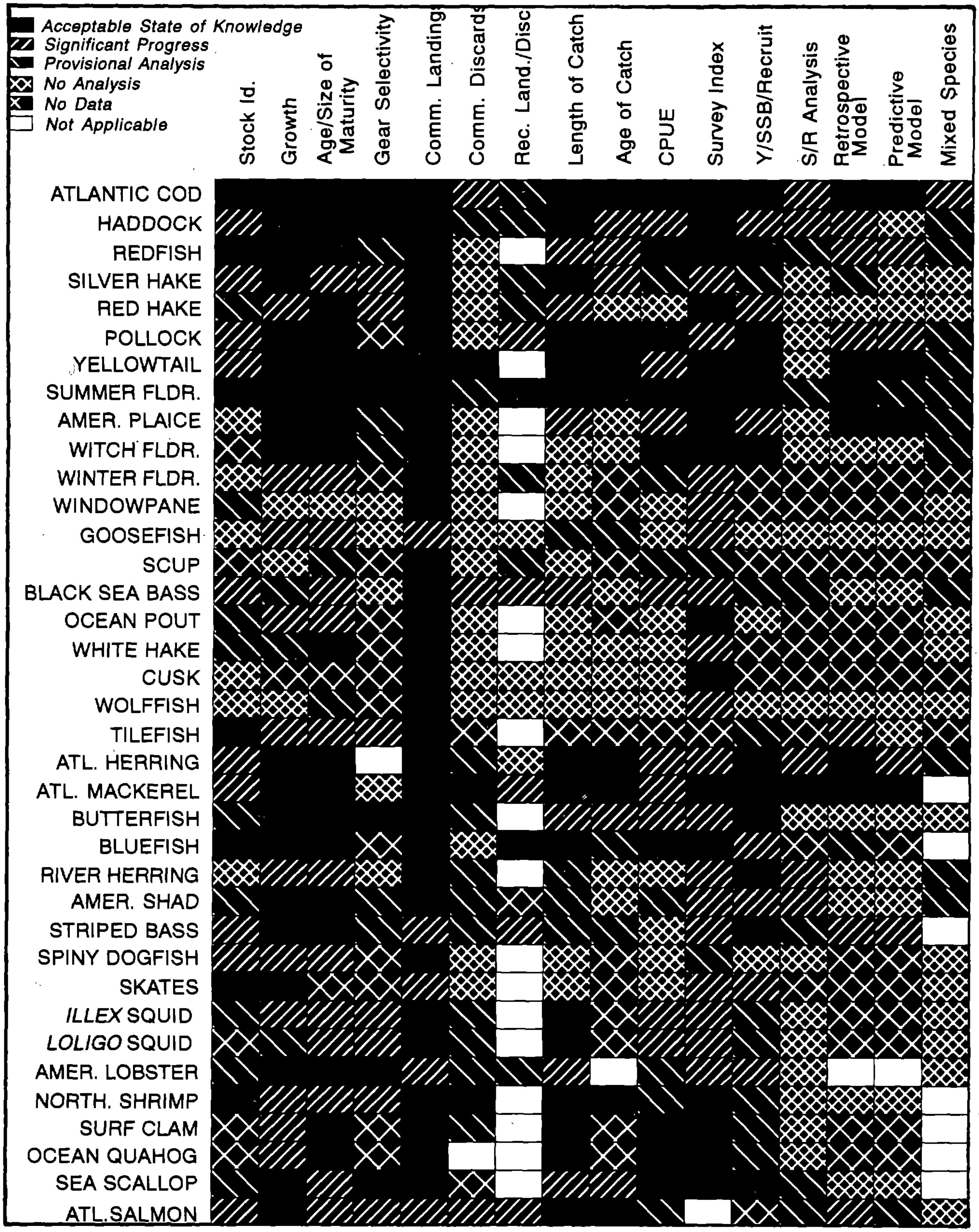
AGE STRUCTURE: assessment also includes analysis of the observed age composition of the catch (*e.g.*, virtual population analysis).

SPAWNING STOCK: assessment also includes analysis of data on spawning stock size and subsequent recruitment.

PREDICTIVE: assessment also includes a model for future stock conditions that accounts for variations in the environment.

For example, in Figure 1 an INDEX level assessment involves information generated by following either the rightmost or leftmost vertical arrows, depending on whether commercial or survey data were available. A YIELD level assessment would also involve information from the box in the lowest rank labeled BIOLOGICAL DATA. Assessments at the AGE STRUCTURE and SPAWNING STOCK levels would require, in addition to the above, information represented in the middle column of boxes in Figure 1. Finally, a PREDICTIVE level assessment would require substantial additional information on the survival of year classes not yet recruited to the fishery.

Figure 2. Status of biological assessment knowledge required for fishery management.



Increasing the level of complexity of an assessment requires additional research; subsequently, substantially more activity each year is required to maintain it at its more complex level. Conversely, the level of an assessment can decrease relatively quickly if sufficient activity is not needed to interpret each years events and data.

The required level of an assessment depends on the complexity of the information needed for management. If managers require estimates of annual quota levels, for example, then a more complex assessment is generally needed.

Both Figures 1 and 2 reflect information about each species separately, as if the individual species had no interactions with one other. There are significant biological (predator/prey) and technological (bycatch) interactions among Northeastern U.S. fishery resources, and a large part of the Center's research program is dedicated to collecting information on and modeling the effects of interactions among these resources. The results of these studies are not presented in this document. The assessments in the Species Synopses section of this report are presented individually, with little indication of the biological interactions among species or of the technical interactions due to the mixed-species nature of many of the fisheries. The significance of the mixed-species nature of the trawl fisheries in the Northeastern United States is illustrated in the section entitled Aggregate Resources Trends. There, aggregate research trawl survey and commercial trawl data are presented illustrating major trends in abundance and catches. The information presented, however, is rather simple, and does not address many of the complexities of the multispecies fisheries.

FISHERY MANAGEMENT

Fisheries occurring primarily in the Exclusive Economic Zone (EEZ) off the Northeastern U.S. are managed under Fishery Management Plans (FMPs) developed by the New England Fishery Management Council, and the Mid-Atlantic Fishery Management Council. Fisheries occurring primarily in state waters are managed by the individual states or under Interstate Agreements under the auspices of the Atlantic States Marine Fisheries Commission. The management plans currently in place are shown in Table 1.

DEFINITION OF TECHNICAL TERMS

Assessment terms used throughout this document may not be familiar to all. A brief explanation of some of these terms follows, organized alphabetically.

Assessment level: Categories of the level of complexity of and data available for each assessment included in this document: index of abundance (INDEX), yield-per-recruit analysis (YIELD), analysis of the age structure of the catch (AGE STRUCTURE), analysis including the relationship between recruitment and spawning stock size (SPAWNING STOCK) and assessment that allows prediction of future (one or two years ahead) stock sizes and catches (PREDICTIVE). These levels are detailed in the subsection titled Kinds of Assessments.

Biological reference points: Fishing mortality rates that may provide acceptable protection against growth overfishing and/or recruitment overfishing for a particular stock. They are usually calculated from equilibrium yield-per-recruit curves, spawning stock biomass-per-recruit curves and stock recruitment data. Examples are $F_{0.1}$, F_{max} and F_{med}.

Exploitation pattern: The distribution of fishing mortality over the age composition of the fish population, determined by the type of fishing gear, areal and seasonal distribution of fishing, and the growth and migration of the fish. The pattern can be changed by modifications to fishing gear, for example, increasing mesh or hook size, or by changing the ratio of harvest by gears exploiting the fish (*e.g.*, gill net, trawl, hook and line, *etc.*).

Exploitation rate: The proportion of a population at the beginning of a given time period that is caught during that time period (usually expressed on a yearly basis). For example, if 720,000 fish were caught during the year from a population of 1 million fish alive at the beginning of the year, the annual exploitation rate would be 0.72.

F_{max}: The rate of fishing mortality for a given exploitation pattern rate of growth and natural mortality, that results in the maximum level of yield-per-recruit. This is the point that defines growth overfishing.

$F_{0.1}$: The fishing mortality rate at which the increase in yield-per-recruit in weight for an increase in a unit-of-effort is only 10 percent of the yield-per-recruit produced by the first unit of effort on the unexploited stock (*i.e.*, the slope of the yield-per-recruit curve for the F_{01} rate is only one-tenth the slope of the curve at its origin).

Growth overfishing: The rate of fishing, as indicated by an equilibrium yield-per-recruit curve, greater than which the losses in weight from total mortality exceed the gain in weight due to growth. This point is defined as F_{max}.

Long-term potential catch: The largest annual harvest in weight that could be removed from a fish stock year after year, under existing environmental conditions. This can be estimated in various ways, from maximum values from production models to average observed catches over a suitable period of years.

Mortality rates: Mortality rates are critical for determining the abundance of fish populations and the effects of harvesting strategies on yield and spawning potential from a stock. Fish abundance is a balance between the factors that act to increase the stock – births – and factors that decrease population numbers – deaths. When births exceed deaths, the stock increases, and vice-versa. The stock is brought

Table 1. Federal and interstate fishery management plans currently in place or under development for fisheries off the northeastern United States

	Plan	Type	Organization Responsible	Since	Last Amendment	Amendment Number
1.	Northeast Multispecies	FMP	NEFMC	1986	1994	6[1]
2.	Atlantic Sea Scallop	FMP	NEFMC	1982	1994	4[1]
3.	American Lobster	FMP	NEFMC	1983	1994	5[1]
4.	Surf Clam-Ocean Quahog	FMP	MAFMC	1977	1990	8
5.	Squid-Mackerel-Butterfish	FMP	MAFMC	1978	1990	4[1]
6.	Summer Flounder	Cooperative	MAFMC/ASMFC	1988	1993	6[1]
7.	Bluefish	Cooperative	MAFMC/AFMFC	1989	-	-
8.	Atlantic Herring	Interstate	ASMFC	1994	-	-
9.	Northern Shrimp	Interstate	ASMFC	1974	1986	-
10.	Striped Bass	Interstate	ASMFC	1981	1989	4[1]
11.	Atlantic Swordfish	FMP	NMFS	1985	-	-
12.	Sharks of the Atlantic Ocean	FMP	NMFS	1993	-	-
13.	Atlantic Billfishes	FMP	NMFS	1988	-	-
14.	Tilefish	FMP	MAFMC		Under development	
15.	Atlantic Salmon	FMP	NEFMC	1987	-	-
16.	Winter Flounder	Interstate	ASMFC	1992	-	-
17.	Scup	Cooperative	MAFMC/ASMFC		Under development	
18.	Dogfish	FMP	MAFMC/NEFMC		Under development	
19.	Black Sea Bass	Cooperative	MAFMC/ASMFC		Under development	
20.	Weakfish	Interstate	ASMFC	1985	1991	1[1]
21.	Atlantic Sturgeon	Interstate	ASMFC	1990	-	-
22.	Shad/River Herring	Interstate	ASMFC	1985	Under development	
23.	Goosefish	FMP	NEFMC/MAFMC		Under development	
24.	Menhaden	Interstate	ASMFC	1992	-	-

[1] Amendment in process

into stability when the number of recruits entering the fishery balances the number of deaths. Fishery managers can control deaths caused by fishing by manipulating the sizes of fish vulnerable to the gear. Fishing mortality can be changed through indirect methods, such as regulating mesh size to make fish of certain ages less vulnerable to the gear. Direct control measures, such as catch quotas or effort limits, determine the rate of fishing mortality on the vulnerable sizes. The total number of births is determined by the abundance of breeders in the population –the spawning stock– which can also be manipulated by managers.

Mortality occurs at all life stages of the population. Depending on the species, mortalities suffered from the egg to larval stages are usually very high, less so from the larval to juvenile stage. In young fish, death can occur from several causes: starvation, predation, or disease. If fish survive their first year, these natural causes of death usually decline dramatically, and in many cases, fishing becomes the dominant source of mortality. Pollution may also add to the death rate of the population. Generally, young fish are more vulnerable to pollution mortalities than are older fish.

Knowing the sources and levels of mortalities affecting fish populations is a critical ingredient of forecasting both landings and spawning stock sizes, and in evaluating the changes in populations that may be induced by regulations such as minimum mesh sizes, minimum fish lengths, quotas, effort limits, and area closures. The rate at which the stock is harvested is usually estimated by calculating the abundance of a cohort or year class over successive years to determine how rapidly it is declining. The total mortality of the population is the sum of deaths due to both natural and fishing-related causes.

Mortalities are usually expressed as rates, which has led to considerable confusion, particularly in the context of fishery management. The following simple example compares the use of fish population mortality rates with a more familiar example of using rates – compound interest applied to a savings account.

If you put $1000 in a savings account with a guaranteed annual interest rate of 5 percent, how much interest is gained over time, and what is the account balance over, say, 10 years? The following table represents a simple way to compute interest and total balance (in dollars) over the ten year period:

Year	Principal Amount	Earned Interest	Bank Balance
1	1000.00	50.00	1050.00
2	1050.00	52.50	1102.50
3	1102.50	55.13	1157.63
4	1157.63	57.88	1215.51
5	1215.51	60.78	1276.29
6	1276.29	63.81	1340.10
7	1340.10	67.01	1407.11
8	1407.11	70.36	1477.47
9	1477.47	73.87	1551.34
10	1551.34	77.57	1628.91

In this example, the balance at the end of one year becomes the principal amount for the next, and so on. The increase in the total balance over time is plotted in the upper panel (A) of Figure 3. The 5 percent interest is applied to the account balance at the end of each year (compounded annually). In order to compute the balance at the end of 10 years, nine prior calculations must be made to trace the interest and balance each year. Although this is a straightforward approach, banks do not compute interest earnings this way, for three reasons: (1) the process is rather lengthy to compute, particularly where the number of time periods may be great; (2) small inaccuracies occur when rounding the account balances to whole cents; these add up to large inaccuracies over a large number of accounts; and (3) most importantly, the method is unrealistic since one cannot apply the annual rate directly to monthly or daily balances. In the real world, savings accounts have constantly varying amounts of principal balance, and interest rates fluctuate.

Fortunately, some rather important mathematical formulas were derived (back in the time of Isaac Newton) that solve these three problems. Computing the account balance at any point in time involves two formulas, and the use of logarithms:

(1) $$r = \ln(1+i)$$

where,

r = **the instantaneous** rate of interest; the rate of interest applied to a very small increment of time;

i = **the periodic** interest rate, expressed as a proportion (5%=0.05);

ln = the logarithm of the quantity 1+i, using the natural logarithm system (sometimes abbreviated ln).

The instantaneous rate corresponding to a 5 percent annual interest is then 0.0488 (*e.g.* ln 1 + 0.05 or ln 1.05). From this calculation, the bank can apply the following formula to compute account balances:

(2) Balance =
Initial Principal Amount X exp(rt)

where,

Balance = the total balance (principal + interest) at time, t;

Initial principal = the amount originally placed into the account;

exp = the base of the natural logarithm system (= 2.71828);

r = the instantaneous interest rate, computed with formula (1);

t = time, expressed in units similar to the interest rate (years, months, days)

Thus, in our example, if the annual interest rate is 5 percent, the account balance after 10 years is: $1000.00 X [exp(0.0488 X 10)] = $1,628.89. Note that the account balance computed with the formulas is two cents lower than in the table. This is because the balances in the table are rounded to whole cents at each step in the calculation. By using the formula rather than the ten-step calculation, the bank saves a tiny bit of interest in this example.

So what does this have to do with mortality rates of fish? The formulas used to illustrate bank interest rates are directly comparable to formulas used by fishery scientists to track the decline of stocks. The one big difference is, of course, that monetary interest rates are set by the bank and well-publicized. In the case of fish populations, scientists must estimate the mortality rates based on measurements of the decline of the population over time.

The decline of a fish stock over time, subjected to a 5 percent annual death rate is portrayed in the lower panel (B) of Figure 3. Note that in this example the population at time 0 (the start) is 1000 fish. The big difference from the interest rate example is that the total bank balance increases, while the number of fish declines. At the end of 10 years, there are 599 fish left in the population. This total is calculated in exactly the same manner as for the savings account:

(3) $$z = -\ln(1-a)$$

where,

z = the instantaneous mortality rate of the population (sometimes called the total instantaneous mortality rate);

a = the periodic mortality rate, expressed as a proportion (5 percent per year = 0.05);

ln = the natural logarithm of the quantity 1+i

The quantity 1-a equals the annual survival rate, which in this case is 1-0.05 = 0.95 (95%); Z = 0.0513. Total numbers in the population are then calculated from a formula similar to (2):

(4) Population Numbers =
IPN X exp(-zt)

where,

Population Numbers = the population remaining at time, t;

IPN = Initial Population Number: the number of fish at the beginning of the time period

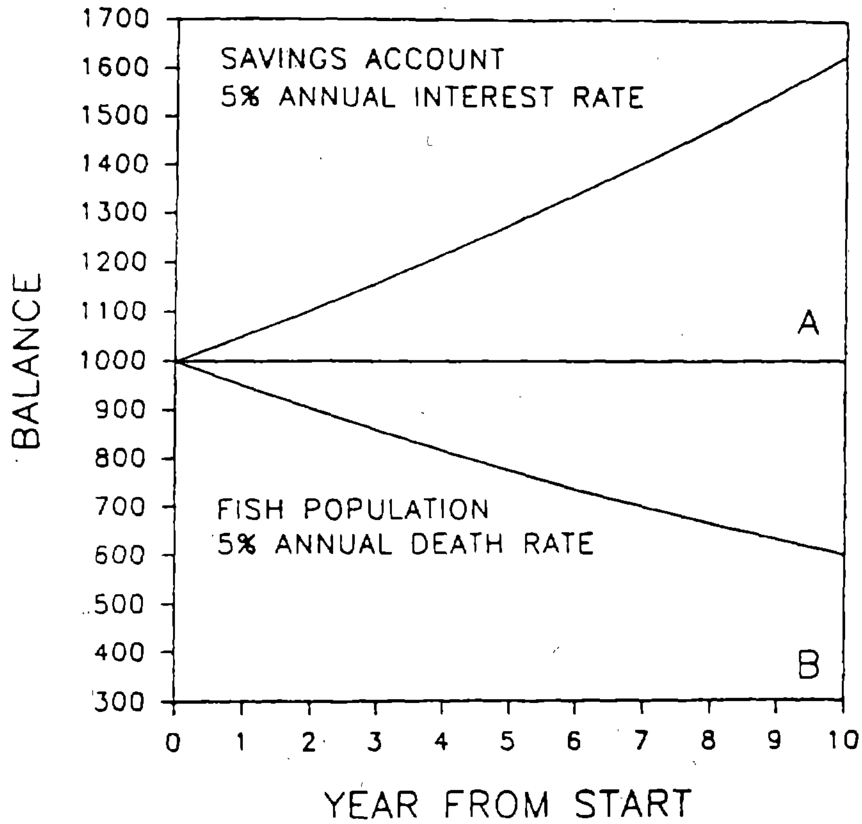


Figure 3. Two examples of the application of annual rates to compute changes in numbers. Panel A gives the expected increase in a theoretical savings account with $1,000 invested at 5% per year with annual compounding and no withdrawals. Panel B gives the expected population size over 10 years with and initial population size of 1,000 fish and an annual mortality rate of 5%.

exp = the base of the natural logarithm system (= 2.71828);

z = the instantaneous mortality rate, computed with formula (3);

t = time, expressed in units similar to the mortality rate (years, months, days).

At the end of 10 years, the number of survivors is 1000 x [exp (-0.0513 x 10)] = 599 fish.

This example uses an annual mortality rate (5 percent) that is unrealistically low for most of the exploited stocks off the Northeastern United States (the exceptions are some long-lived stocks harvested at low rates such as ocean quahog and Acadian redfish). For some heavily fished stocks (scallops, yellowtail flounder) the annual mortality rates of harvested sizes may exceed 80 percent, with the majority of the deaths due to fishing. The instantaneous total mortality rate corresponding to an 80 percent annual mortality rate is: -ln (1-0.80) = 1.609. For an annual mortality rate of 80 percent, the number fish alive after 5 years, from an initial population of 10,000 fish is: 10,000 X [exp (-1.609 x 5)] = 3.2 fish!

Fishery scientists use different notation to account for the various sources of mortalities affecting populations. Using instantaneous rates, natural mortality is usually denoted as M; fishing mortality by F. As instantaneous rates they are additive: M + F = Z (where Z is the total instantaneous mortality rate). One feature of using the instantaneous fishing mortality rate, is that multiplying F by the average population size during the year (N) gives the fishery catch. For example, suppose the instantaneous natural mortality rate (M) is 0.2, and F = 0.6. Total instantaneous mortality is 0.8; the annual mortality rate is 55 percent (i.e., 0.55 = 1-exp [-0.8]). If, at the beginning of the year there are 1000 fish, the average population size during the year is calculated as: (1000 X 0.55) ÷ 0.8 = 688 fish. Multiplying the average population size by F gives the annual catch (688 X 0.6 = 413 fish).

The fishing mortality rate (F) on each age group of a stock is determined by two factors: (1) the proportion of that age group that is big enough to be captured by the gear (usually termed the partial recruitment of each age), and (2) the overall amount of fishing effort on the stock. At intermediate stock abundance levels the relationship between effort and F is direct. A doubling of effort translates into a doubling of the fishing mortality rate. At very low or very high stock sizes (when the stock is either hard to locate or unavoidable), the relation between effort and F may change.

Management of fish populations through direct and/or indirect control measures determines the overall fishing mortality rate. Ultimately the balance generated between births and deaths results in an increasing, decreasing, or stable stock.

Nominal catch: The sum of the catches that are landed (expressed as live weight or equivalents). Nominal catches do not include unreported discards.

Quota: A portion of a total allowable catch (TAC) allocated to an operating unit, such as a vessel size class or a country.

Recruitment: The amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area. For example, the number of fish that grow to become vulnerable to the fishing gear in one year would be the recruitment to the fishable population that year. This term is also used in referring to the number of fish from a year class reaching a certain age. For example, all fish reaching their second year would be age 2 recruits.

Recruitment overfishing: The rate of fishing above which the recruitment to the exploitable stock becomes significantly reduced. This is characterized by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch, and generally very low recruitment year after year.

Spawning stock biomass (SSB): The total weight of all sexually mature fish in the population. This quantity depends on year class abundance, the exploitation pattern, the rate of growth, fishing and natural mortality rates, the onset of sexual maturity and environmental conditions.

Spawning stock biomass-per-recruit (SSB/R): The expected lifetime contribution to the spawning stock biomass for a recruit of a specific age (*e.g.*, per age 2 individual). For a given exploitation pattern, rate of growth, and natural mortality, an expected equilibrium value of SSB/R can be calculated for each level of F.

A useful re-ference point is the level of SSB/R that would be realized if there were no fishing. This is a maximum value for SSB/R, and can be compared to levels of SSB/R generated under different rates of fishing. For example, the maximum SSB/R for Georges Bank haddock is approximately 9 kg for a recruit at age 1.

Status of exploitation: An appraisal of exploitation is given for each stock discussed in the Species Synopsis section using the terms unknown, protected, not exploited, underexploited, moderately exploited, fully exploited, and over-exploited. These terms describe the effect of current fishing effort on each stock, and is based on current data and the knowledge of the stocks over time.

Sustainable yield: The number or weight of fish in a stock that can be taken by fishing without reducing the stock biomass from year to year, assuming that environmental conditions remain the same.

TAC: Total allowable catch is the total regulated catch from a stock in a given time period, usually a year.

Vessel class: Commercial fishing vessels are classified according to their gross registered tons (grt) of displacement. Vessels displacing less than 5 tons are not routinely monitored, and are referred to as undertonnage. Larger vessels are classified as follows:

Vessel Class	GRT
2	5 - 50
3	51 - 150
4	151 - 500

Virtual population analysis (or cohort analysis): An analysis of the catches from a given year class over its life in the fishery. If 10 fish from the 1968 year class were caught each year for 10 successive years from 1970 to 1979 (age 2 to age 11), then 100 fish would have been caught from the 1968 year class during its life in the fishery. Since 10 fish were caught during 1979, then 10 fish must have been alive at the beginning of that year. At the beginning of 1978, there must have been at least 20 fish alive because 10 were caught in 1978 and 10 more were caught in 1979. By working backward year by year, one can be virtually certain that at least 100 fish were alive at the beginning of 1970. A virtual population analysis goes a step further and calculates the number of fish that must have been alive if some fish also died from causes other than fishing. For example, if in addition to the 10 fish caught per year in the fishery, the instantaneous natural mortality rate was also known then a virtual population analysis calculates the number that must have been alive each year to produce a catch of 10 fish each year plus those that died from natural causes. If one knows the fishing mortality rate during the last year for which catch data are available (in this case, 1979), then the exact abundance of the year class can be determined in each and every year. Even when an approximate fishing mortality rate is used in the last year (1979), a precise estimate of the abundance can usually be determined for the stock in years prior to the most recent one or two (e.g., 1970-1977 in the example). Accuracy depends on the rate of population decline and the correctness of the starting value of the fishing mortality rate (in the most recent year). This technique is used extensively in fishery assessments since the conditions for its use are so common; many fisheries are heavily exploited, the annual catches for a year class can generally be easily determined, and the natural mortality rate is known within a fairly small range and is low compared with the fishing mortality rate.

Year class (or cohort): Fish in a stock born in the same year. For example, the 1987 year class of cod includes all cod born in 1987, which would be age 1 in 1988. Occasionally, a stock produces a very small or very large year class which can be pivotal in determining stock abundance in later years.

Yield-per-recruit: The expected lifetime yield-per-fish of a specific age (*e.g.*, per age 2 individual). For a given exploitation pattern, rate of growth, and natural mortality, an expected equilibrium value of Y/R can be calculated for each level of F.

Fishery Landings Trends

Recreational and commercial fishing for marine and estuarine fish stocks off the northeastern United States results in landings that are a significant portion of total U.S. landings. United States commercial landings in 1993 are estimated to be more than 4.7 million mt, of which approximately 16% were from the Northeast region. United States recreational landings are estimated to exceed 88,000 mt (excluding Alaska, Hawaii, and Pacific Coast salmon). Aggregate statistics for U.S. fisheries are detailed in *Fisheries of the United States, 1993.*

Fishery statistics are collected in the northeastern United States through an integrated system of reporting by commercial fishermen and sampling surveys of recreational fishermen. The reports by commercial fishermen are generally termed weighout slips, and these are collected by employees of state agencies as well as the NMFS. Recreational fishermen are surveyed both as they complete fishing trips and through telephone calls to households. While these numbers are not without statistical errors and some biases, they reveal roughly how much is landed and certainly reveal trends in fishing activity and catches.

The landings of domestic commercial and recreational fisheries, and foreign and joint venture fisheries, for 36 of the 39 species described in this document totaled 468,200 mt in 1993, a decrease of 7% from 1992 (Table 2). Of these landings, 21% were from foreign, 72% from domestic commercial, and 6% from domestic recreational fishing. Foreign commercial landings decreased 14%, while domestic commercial landings decreased 6% and recreational landings increased 9%.

The landings trends for six groups of species contributing to northeast fisheries are as follows:

Port agent Paul Swain taking scientific samples of fish landed at New Bedford, circa 1960
Brigham Collection, NMFS/NEFSC Photo Archive

The most important group in terms of weight is traditionally the principal groundfish (Atlantic cod, haddock, redfish, silver hake, red hake, and pollock) accounting for 21% and 18% of the landings in 1992 and 1993, respectively. The invertebrates (short- and long-finned squid, American lobster, Northern shrimp, surfclams, ocean quahogs, sea scallops) accounted for 30% of the landings in 1993, up slightly from 28% in 1992. Principal pelagic species (Atlantic herring, Atlantic mackerel) accounted for about the same percentage (25-26%) in both 1992 and 1993.

The fourth highest landings in 1993 were from other groundfish (goosefish, scup, black sea bass, ocean pout, white hake, cusk, Atlantic wolffish, tilefish, spiny dogfish, skates), which accounted for 14% of the landings, about the same percentage as in 1992 (13%).

Next in importance by weight are flounders and the other pelagics, accounting for 6% and 5%, respectively, of the 1993 total landings.

Total 1993 foreign vessel landings of species and stocks occurring in U.S. waters was 100,100 mt, down 12% from 1992. This includes for example, catches of transboundary migratory pollock and mackerel stocks by Canadian fishermen. It also includes catches of cod, haddock, and scallops from the Canadian sector of Georges Bank.

For more information

NMFS [National Marine Fisheries Service]. 1994. Fisheries of the United States, 1993. *Current Fishery Statistics* No. 9300.

Table 2. Total landings of selected assessment species groups off the northeastern United States, domestic and foreign commercial fishing, and for recreational fishing 1992 and 1993 (1,000 mt)

Species	Commercial				Recreational		Total	
	Foreign		USA					
	1992	1993	1992	1993	1992	1993	1992	1993
Principal Groundfish								
Atlantic cod	11.7	8.5	27.8	22.9	1.5	4.9	41.0	36.3
Haddock	4.1	3.7	2.3	0.9	<0.1	<0.1	6.4	4.6
Redfish	<0.1	<0.1	0.8	0.8	0.0	<0.1	0.8	0.8
Silver hake	0.0	0.0	15.6	17.2	<0.1	<0.1	15.6	17.2
Red hake	0.0	0.0	2.0	1.6	0.2	<0.1	2.2	1.6
Pollock	32.1	20.3	7.2	5.7	<0.1	<0.1	39.3	26.0
Subtotal	**47.9**	**32.5**	**55.7**	**49.1**	**1.7**	**4.9**	**105.3**	**86.5**
Flounders								
Yellowtail flounder	<0.1	0.2	5.4	3.6	0.0	0.0	5.4	3.8
Summer flounder	0.0	0.0	7.3	5.7	3.4	4.0	10.7	9.7
American plaice	<0.1	0.0	6.6	5.8	0.0	0.0	6.6	5.8
Witch flounder	<0.1	<0.1	2.2	2.6	0.0	0.0	2.2	2.6
Winter flounder	<0.1	<0.1	6.0	5.3	0.5	0.7	6.5	6.0
Windowpane	0.0	0.0	2.1	1.6	0.0	0.0	2.1	1.6
Subtotal	**<0.1**	**0.2**	**29.6**	**24.6**	**3.9**	**4.7**	**33.5**	**29.5**
Other Groundfish								
Goosefish	0.5	0.4	16.0	18.6	<0.1	0.0	16.5	19.0
Scup	0.0	0.0	6.0	4.4	2.1	1.3	8.1	5.7
Black sea bass	0.0	0.0	1.3	1.3	1.3	2.1	2.6	3.4
Ocean pout	0.0	0.0	0.5	0.2	0.0	0.0	0.5	0.2
White hake	1.1	1.7	8.5	7.4	<0.1	<0.1	9.6	9.1
Cusk	0.8	0.6	1.6	1.4	<0.1	<0.1	2.4	2.0
Atlantic wolffish	<0.1	0.1	0.5	0.5	<0.1	0.0	0.5	0.6
Tilefish	0.0	0.0	1.6	1.8	<0.1	<0.1	1.6	1.8
Spiny dogfish	0.0	0.0	11.1	15.5	0.0	0.0	11.1	15.5
Skates	0.0	0.0	12.3	8.5	0.0	0.0	12.3	8.5
Subtotal	**2.4**	**2.8**	**59.4**	**59.6**	**3.4**	**3.4**	**65.2**	**65.8**
Principal Pelagics								
Atlantic herring	32.0	31.5	59.7	54.6	0.0	0.0	91.7	86.1
Atlantic mackerel	25.5	26.9	12.4	4.7	0.4	0.5	38.3	32.1
Subtotal	**57.5**	**58.4**	**72.1**	**59.3**	**0.4**	**0.5**	**130.0**	**118.2**
Other pelagics								
Atlantic butterfish	0.0	0.0	2.7	4.6	0.0	0.0	2.7	4.6
Bluefish	0.0	0.0	4.8	4.0	17.0	14.8	21.8	18.8
Subtotal	**0.0**	**0.0**	**7.5**	**8.6**	**17.0**	**14.8**	**24.5**	**23.4**
Anadromous Fish								
River herring	<0.1	<0.1	0.7	0.3	0.0	0.0	0.7	0.3
American shad	0.0	0.0	0.7	0.7	0.0	0.0	0.7	0.7
Striped bass	0.0	0.0	0.8	2.7	2.2	2.5	3.0	5.2
Subtotal	**<0.1**	**<0.1**	**2.2**	**3.7**	**2.2**	**2.5**	**4.4**	**6.2**
Invertebrates								
Short-finned squid	0.0	0.0	17.8	18.0	0.0	0.0	17.8	18.0
Long-finned squid	0.0	0.0	18.2	22.3	0.0	0.0	18.2	22.3
American lobster	0.2	0.0	25.3	25.5	0.0	0.0	25.5	25.5
Northern shrimp	0.0	0.0	3.4	2.3	0.0	0.0	3.4	2.3
Surfclam	0.0	0.0	32.7	33.6	0.0	0.0	32.7	33.6
Ocean quahog	0.0	0.0	22.5	23.4	0.0	0.0	22.5	23.4
Sea scallop	6.1	6.2	14.2	7.3	0.0	0.0	20.3	13.5
Subtotal	**6.3**	**6.2**	**134.1**	**132.4**	**0.0**	**0.0**	**140.4**	**138.6**
Total	**114.1**	**100.1**	**360.6**	**337.3**	**28.6**	**30.8**	**503.3**	**468.2**

Aggregate Resource Trends

by S. Murawski
F. Almeida

The fishery resources off the northeastern United States are harvested by a variety of fishing gears, including trawls, gill nets, traps, longlines, and dredges. While each type of gear takes a different mixture of species, few fishermen target exclusively one species. The degree of mixture in the catches varies among the types of gear used in different areas. In addition, there are predatory and competitive relations among many of the fishery resources.

These relationships result in significant interactions among gear types termed 'technical interactions', and among some species termed 'biological interactions'. Management of fishing activity in the northeast region is a complex problem because of these types of interactions. This complexity is reflected, for example, in the structure of some of the fishery management plans (FMPs). The groundfish resources off New England are managed under the Northeast Multispecies FMP, while several pelagic fisheries in the southern portion of the region are managed under the Squid, Mackerel, and Butterfish FMP.

While much of the stock assessment advice used in managing these fisheries requires knowledge of the dynamics of individual populations of each species, there is an increasing need to consider information on a more aggregated level to fully understand the dynamics of the fisheries. In this section, trends are presented for several aggregate fishery resources to illustrate major changes in the fishery ecosystems off the northeastern United States.

Two sources of data are available for measuring the trends in aggregate resource abundance: (1) research vessel trawl survey data, and (2) commercial

R/V Albatross crew sorts herring during a recent survey cruise. Atlantic herring have rebounded in this region since near-extirpation by foreign fleets in the 1960s.
NMFS/NEFSC photo by Brenda Figuerido

trawl catch and effort data. While neither data source completely reflects the changes in all fishery resources, both provide useful information in interpreting recent changes in fishery resources and fishing activity.

RESEARCH VESSEL TRAWL SURVEY DATA

The Northeast Fisheries Science Center has conducted an intensive bottom trawl survey program off the northeastern United States for more than 30 years. An autumn survey has been conducted annually since 1963; a spring survey was initiated in 1968, and summer and winter surveys have been conducted intermittently. These surveys have employed standard gear and sampling procedures following a stratified random sampling design and thus provide a valuable time series of data for monitoring resource trends. Since bottom-tending gear is used, the data are most appropriate for demersal species, although reliable indices of abundance have been developed for some pelagic species as well. Four groups of species are considered:

1. **Principal groundfish and flounders,** including demersal species such as Atlantic cod, haddock and yellowtail flounder that have historically supported important trawl fisheries.

2. **Other finfish,** including a variety of demersal and pelagicspecies that collectively are of considerable economic importance.

3. **Principal pelagics** (Atlantic herring and Atlantic mackerel).

4. **Skates and spiny dogfish,** which have traditionally been of minor commercial importance but are now a major component of the total finfish biomass.

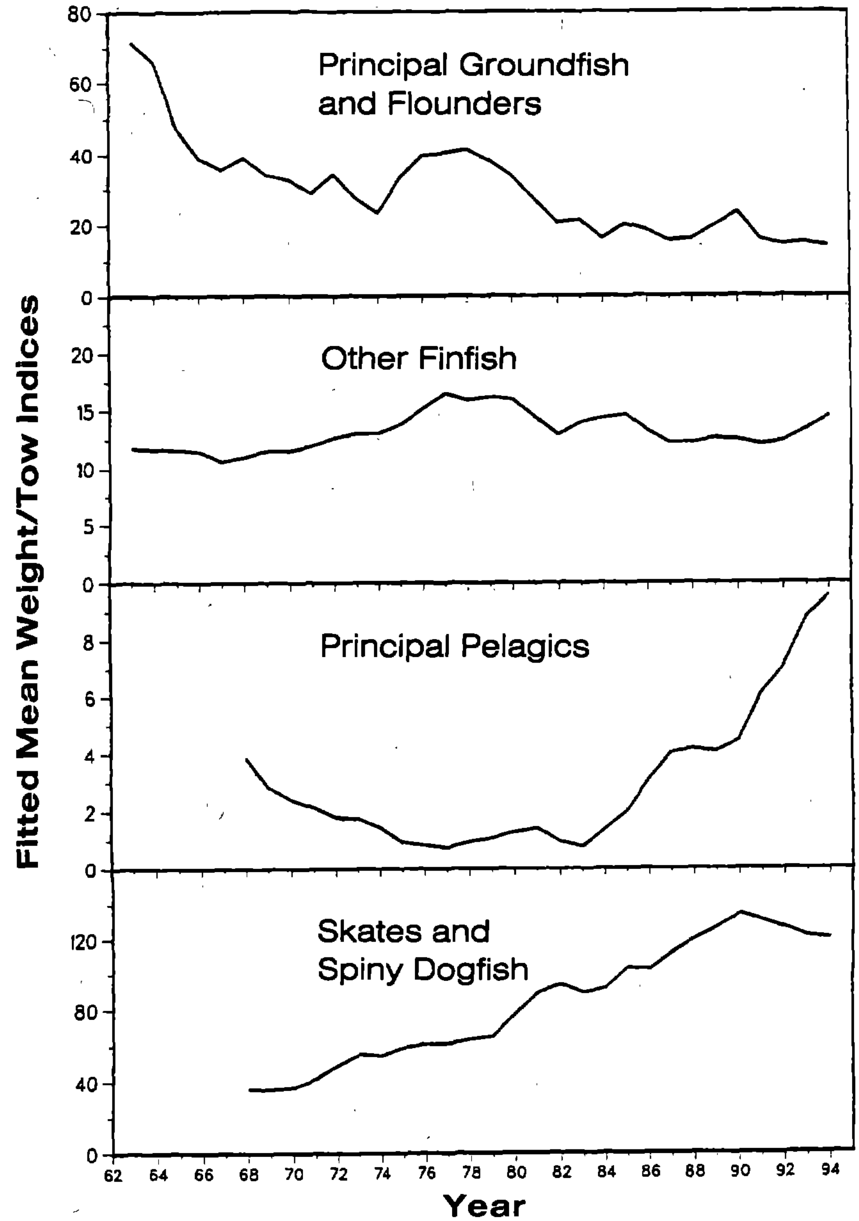


Figure 4. Trends in indices of aggregate abundance (catch in weight per survey trawl haul) for four species groups, reflecting the major changes in fishery resources, 1963-1993.

For each of these groups, an aggregate index of abundance has been developed to monitor resource trends. Autumn survey data (stratified mean catch-per-tow, kilograms) were used for principal groundfish and flounders and for other finfish, while spring survey data were used for principal pelagics and for skates and spiny dogfish. For each group an aggregate index of abundance has been computed as the sum of the individual species stratified mean catch-per-tow values, smoothed to compensate for between-year variability using a first order autoregressive model. No adjustments have been made for differences in the vulnerability of each species to the trawl gear; the overall index in each case thus reflects trends in abundance of those species within each group that are most vulnerable. However, vulnerability to the gear is not thought to change markedly over time. The aggregate indices therefore appear to provide useful general measures of overall resource trends, although they are weighted toward certain species.

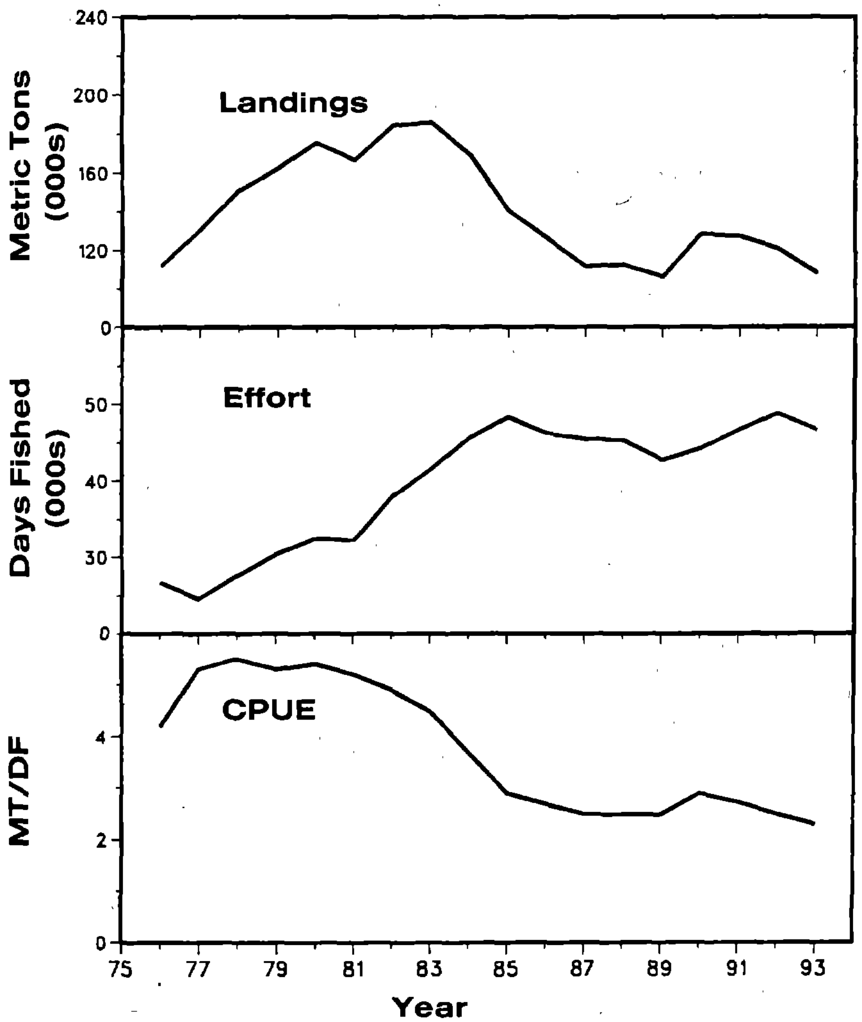


Figure 5. Total multispecies trawl landings (metric tons, all ages) standardized trawl fishing effort (DF, days fished) and landings divided by effort (CPUE, mt/df) since 1976, reflecting major changes in trawl fishing activity and aggregate resource abundance.

SUMMARY OF TRENDS

Principal Groundfish and Flounders

This group includes important gadid species (Atlantic cod, haddock, redfish, silver and red hake, and pollock) and several flatfish (yellowtail flounder, summer and winter flounder, American plaice, witch flounder and windowpane). The combined index for this group declined by almost 70% between 1963 and 1974, reflecting substantial increases in exploitation associated with the advent of distant-water fleets (Figure 4). Pronounced declines in abundance occurred for many stocks in this group, notably Georges Bank haddock, silver and red hake, and most of the flatfish stocks. By 1974, indices of abundance for many of these species had dropped to the lowest levels observed in the history of the survey time series.

Partial resource recovery occurred during the mid- to late- 1970s. This has been attributed to reduced fishing effort associated with increasingly restrictive management under the International Commission for the Northwest Atlantic Fisheries (ICNAF) during the early 1970s, and to implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977. Cod and haddock abundance increased markedly; stock biomass of pollock increased more or less continuously, and recruitment and abundance of several of the flatfish stocks also increased. The aggregate index peaked in 1978. Subsequently, the combined index again declined with the 1987 and 1988 values the lowest in the time series. During 1989-1990, the aggregate index increased due to improved recruitment (primarily for cod, redfish, silver and red hake, and American plaice). The index dropped sharply in 1991 and 1992 and stabilized in 1993, reflecting reduced survey catches of all of these species.

Other Finfish

This group includes a number of demersal and pelagic species that are taken in directed fisheries or are important in mixed-fishery situations. The combined index for this group (Figure 4) includes data for 10 demersal species (white hake, cusk, croaker, black sea bass, scup, weakfish, spot, wolffish, ocean pout, and goosefish) and five pelagic species (alewife, blueback, shad, butterfish, and bluefish). Landings for many of these species are small, although their combined contribution to U.S. commercial and recreational harvests is significant.

The aggregate index for this group was relatively stable from 1963 to 1970 and then increased to peak levels during 1977 to 1980, reflecting unusually high survey catches of Atlantic croaker and spot and strong recruitment of butterfish from the 1979 and 1980 year classes. Survey catches of a number of other finfish species were anomalously low in 1982 for unknown reasons. Strong 1983 and 1984 butterfish year classes contributed to the 1985 peak. The index has since shown a declining trend.

Principal Pelagics

Abundance of Atlantic herring and Atlantic mackerel has been monitored using spring survey data. In general, survey catch-per-tow data for these species have been more variable than those for principal groundfish and flounders, although the aggregate index adequately depicts overall trends. The index dropped to minimal levels in the mid-1970s, reflecting pronounced declines in abundance of both herring and mackerel (including the collapse of the Georges Bank herring stock). Since 1984, the index has markedly increased with the 1993 value the highest in the time series (Figure 4). This trend is corroborated by virtual population analyses (VPA) which indicate high levels of abundance of both the coastwide herring stock and the Northwest Atlantic mackerel stock in recent years. There is also evidence for recovery of the Georges Bank herring stock.

Skates and Spiny Dogfish

The remaining aggregate index includes data for two important resource components, spiny dogfish and skates, which are effectively monitored using spring survey data (Figure 4). Spiny dogfish and seven skate species are included in this index: little, winter, thorny, smooth, rosette, clearnose, and barndoor. The continued increase in this index from the late 1960s through 1990 reflects major changes in relative abundance within the finfish species complex, with increasing abundance of species with low commercial value. The index has declined slightly since 1990, reflecting stabilization of stock sizes, particularly for spiny dogfish. These increases in dogfish and skate abundance during the past three decades, in conjunction with declining abundance of groundfish and flounders, have resulted in the proportion of dogfish and skates in survey catches increasing from roughly 25% by weight in 1963 to nearly 75% in recent years.

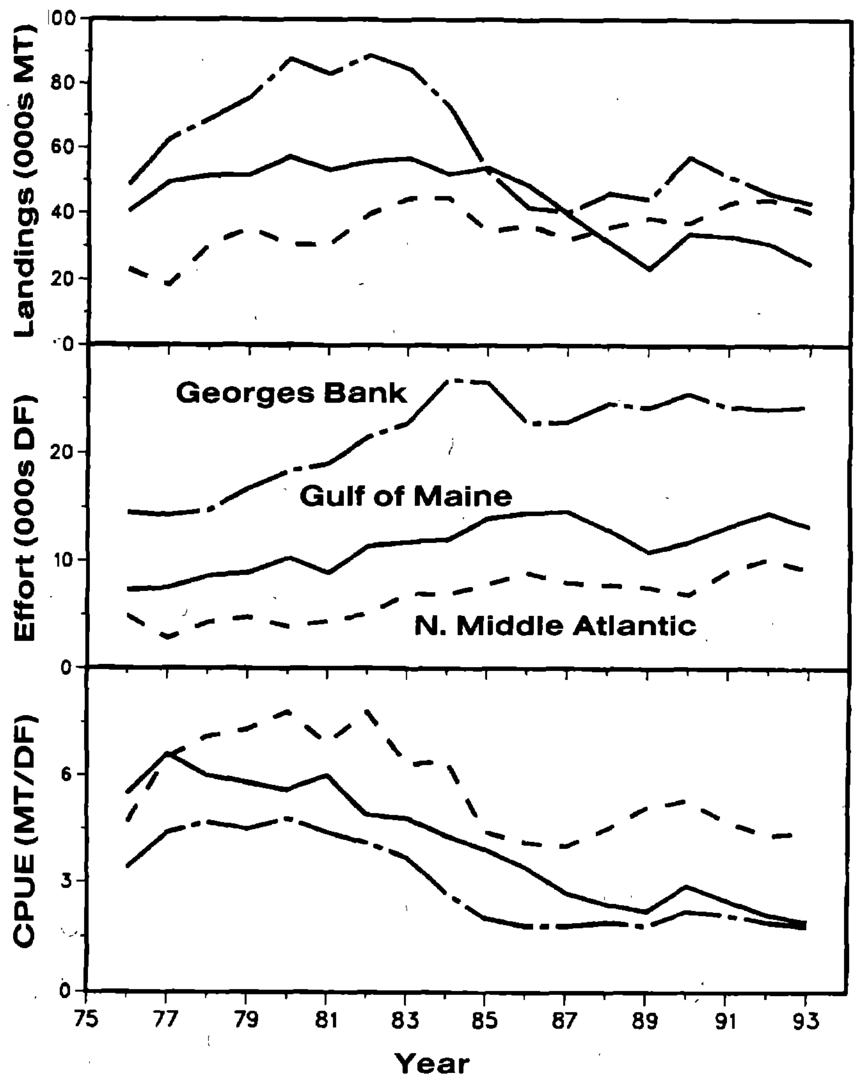


Figure 6. Total trawl landings (metric tons), standardized fishing effort (DF, days fished), and landings divided by effort (catch per unit effort, CPUE, mt/df) since 1976 for three regions, reflecting changes in trawl fishing activity and aggregate resource abundance.

COMMERCIAL TRAWL CATCH AND EFFORT DATA

Commercial trawl landings and effort data have been consistently collected by the NEFSC using dockside interviews and weigh-out reports since implementation of the MFCMA. Because of the mixed-species nature of the trawl fishery throughout most of the region, the relationship between the amount of fishing effort and the landings of individual species or stocks is complex. While simple indices based on total landings and effort will not directly reflect the abundance of any one species, such indices provide useful measures of aggregate abundance that reflect general overall trends. Indices of multispecies CPUE were derived by aggregating trawl landings and effort data for three major fishery assessment areas:

1. Gulf of Maine (GM)
2. Georges Bank (GB)
3. Northern Mid-Atlantic Bight (NMA; comprising the area from Cape Cod through New Jersey)

Nominal fishing effort was standardized to account for variability in the size composition of trawl vessel fleets in the three regions, and the changes in fleet compositions over time. Data collected prior to 1976 were not included because of the problems of standardizing foreign fishing effort, and because complete trawl fishing effort data were not available for the more southern ports. Fishing effort was standardized to the performance of a class 3 (51-150 GRT) trawler fishing on Georges Bank. Appropriate weighting coefficients for smaller- and larger-sized vessels were then applied to derive single estimates of total standardized fishing effort by sub-area.

Total landings of all finfish and invertebrate species caught by trawlers were aggregated over all vessel size classes over all areas (Figure 5). Total landings peaked in 1982 and 1983 at 185,000 mt, and declined steadily to 112,000 mt in 1987 and 1988, a decrease of 39%. Otter trawl landings in 1993 decreased to 108,000 mt (11% lower than 1992) primarily due to decreased landings of cod, yellowtail flounder, and pollock. Fishing effort in terms of number of standardized days fished (Figure 5) nearly doubled from roughly 25,000 days in the 1976-1978 period to roughly 48,000 in 1985. Effort declined slightly between 1986 and 1989, but gradually increased again during 1990-1992 to record high levels. Total trawl effort in 1993 decreased 4% (to 46,700 days fished) from 1992.

The effective increase in fishing effort is greater than indicated by the increases in days fished, however, because the fishing power of individual vessels has increased. Vessels have become larger, with more powerful engines, larger nets, and more sophisticated electronic equipment.

The total landings (metric tons) divided by the total standardized effort (days fished, DF) for all three regions combined generates a catch-per-unit-effort (CPUE) index reflecting the major changes in aggregate species abundance (Figure 5). This index rose from 4.2 in 1976, held roughly steady from 1977 to 1980, but declined steadily and dramatically by about 50% to 2.5 during 1987-1989. A slight increase occurred in 1990 but the CPUE index has since declined to a record-low value of 2.3 in 1993, reflecting the decline in several groundfish stocks. Trends in the CPUE index are similar to those observed in the research trawl index for principal groundfish and flounders, with an initial rise and a subsequent major decline. The CPUE index, however, probably underestimates actual declines in abundance of demersal species because of increasing fleet efficiency. Also, this index includes species not included in the principal groundfish trawl index species such as butterfish and mackerel that have been at relatively high stock levels.

The same general trends in catch, effort, and CPUE are apparent in the data when treated separately for the three assessment regions (Figure 6). During the period 1976-1987, standardized effort increased 100% in the Gulf of Maine, 58% on Georges Bank, and 63% in the northern Mid-Atlantic Bight. Total trawl effort in the Gulf of Maine area decreased from 14,500 days fished in 1992 to 13,200 days fished in 1993 (9%). Landings and CPUE declined 20% and 10%, respectively, and were the lowest in the 1976-1993 time series. Georges Bank trawl effort has remained relatively high but stable since 1988 (increasing 1% from 1992 to 1993). Landings and CPUE on Georges Bank decreased 7% and 5%, respectively in 1993, primarily because of reduced landings of cod and yellowtail flounder. Landings and effort in the northern Mid-Atlantic Bight declined between 1992 and 1993 (9% and 10% respectively), while CPUE remained stable at a low level.

During the past two decades, the species composition of trawl landings has changed dramatically for most vessel size classes and areas. In the Gulf of Maine, landings of pollock, redfish, and flounders have declined. Currently, white hake, silver hake, and American plaice predominate in the landings. On Georges Bank, haddock and yellowtail flounder stocks have declined and are a small fraction of overall catches, which are primarily comprised of cod, winter flounder, and windowpane flounder. In the northern Mid-Atlantic Bight, catches are generally highly mixed. Yellowtail flounder landings declined markedly in the area in 1993 because of the reduced abundance of the 1987 year class. Loligo squid and butterfish landings, however, increased.

CONCLUSIONS ABOUT RESOURCE ABUNDANCE

Both the research trawl data and the aggregate trawl fishery data suggest major changes in the abundance of resources in the Northwest Atlantic, especially since implementation of the MFCMA in 1976. Increases in abundance of groundfish and flounders associated with the reduction of foreign fishery effort during the mid-1970s were followed by increased domestic fishing effort and landings. Abundance of principal groundfish and flounders began declining after 1978, and currently are at historically low levels. Abundance of other finfish has slowly declined since 1986, while that of the principal pelagics has sharply increased in recent years. Trawl fishing effort increased steadily through 1985, and remains at near-record high levels. Total trawl catches increased until 1983, but have subsequently declined to low levels (despite the great increase in fishing effort). Trawl catches in 1993 were among the lowest in the time series. Extensive changes in the species composition of the catches have also occurred over the past two decades, with shifts to previously less desirable species. During this same time, major increases in the abundance of non-target species such as spiny dogfish and skates, have occurred.

Most of the changes in resource abundance can be directly attributed to changes in fishing mortality. For example, increases in abundance of groundfish and flounder occurred during 1975 to 1978 when fishing effort was being reduced by international and domestic management actions. Decreases in abundance began in the early 1980s when fishing effort substantially increased. The record high levels of fishing effort in the late 1980s and 1990s resulted in rapid reduction of new year classes before these were able to achieve full growth and reproduce. Continued high fishing effort has sustained this pattern, with populations of several species now dominated by only one or two age groups.

SUMMARY OF STOCK STATUS

The status of 50 of the finfish and invertebrate stocks reviewed in this document is summarized in Tables 3 and 4, and Figure 7. Status can be measured in several ways: (1) the abundance of the stock, measured against historic levels, (2) landings from the stock, relative to past landings levels, and (3) the exploitation rate (fraction of the stock taken by fishing) relative to quantitative overfishing definitions.

Assessments vetted through the Northeast Regional Stock Assessment Workshop process (*e.g.*, NEFSC 1994a,b; 1995) are evaluated relative to stock status using both abundance (low, medium and high levels), and exploitation

Table 3. Summary of status of 50 finfish and invertebrate stocks off the northeastern United States, 1994

Category [1]	Number of Stocks	Abundance	Number	(%)	Exploitation Rate[2]	Number	(%)
New England Groundfish	25	High	0	(0)	Under	2	(8)
		Medium	5	(20)	Fully	4	(16)
		Low	20	(80)	Over	19	(76)
Mid-Atlantic Groundfish	5	High	0	(0)	Under	0	(0)
		Medium	2	(40)	Fully	0	(0)
		Low	3	(60)	Over	5	(100)
Pelagics	4	High	2	(50)	Under	3	(75)
		Medium	1	(25)	Fully	0	(0)
		Low	1	(25)	Over	1	(25)
Dogfish & Skates	2	High	2	(100)	Under	1	(50)
		Medium	0	(0)	Fully	1	(50)
		Low	0	(0)	Over	0	(0)
Invertebrates	9	High	1	(11)	Under	1	(11)
		Medium	5	(56)	Fully	4	(44)
		Low	3	(33)	Over	4	(44)
Anadromous	5	High	1	(20)	Under	0	(0)
		Medium	0	(0)	Fully	2	(40)
		Low	4	(80)	Over	3	(60)
All	50	High	6	(12)	Under	7	(14)
		Medium	13	(26)	Fully	11	(22)
		Low	31	(62)	Over	32	(64)

[1] Species (number of stocks): **New England Groundfish:** cod (2), haddock (2), redfish, silver hake (2), red hake (2), pollock, yellowtail (3), American plaice, witch flounder, winter flounder (3), windowpane flounder (2), goosefish, ocean pout, white hake, cusk, wolffish; **Atlantic Groundfish**: summer flounder, scup, black sea bass, tilefish, Middle Atlantic yellowtail; **Pelagics**: Atlantic herring, Atlantic mackerel, butterfish, bluefish; **Invertebrates:** *Illex* squid, *Loligo* squid, American lobster northern shrimp, sea scallop (3), surfclam, ocean quahog; **Anadromous**: striped bass, Atlantic salmon, river herring, shad, sturgeons

[2] Exploitation rate categories are underexploited, fully exploited, overexploited.

rate (underexploited, fully exploited, and overexploited). Using this categorization scheme for the species in this report, 62% (31 stocks) are considered to be at a low level of abundance, 26% (13 stocks) at medium, and only 12% (6 stocks) at high abundance (*i.e.*, herring, mackerel, skates, dogfish, striped bass and lobster). Nearly two-thirds of the stocks in the Northeast region (32 stocks) are overexploited; only 14% (7 stocks) are underexploited relative to overfishing definitions (red hake [2], herring, butterfish, mackerel, skates, Illex squid). Since only 18% (9 stocks) of the 50 stocks are currently fully exploited and also at medium-high abundance, the vast majority of the region's resources have been mismanaged.

New England groundfish and anadromous stocks each currently have 80% of their stocks in low abundance. Dogfish and skates, and pelagics show the highest fractions of stocks in high abundance, (100% and 50%, respectively). Mid-Atlantic and New England groundfish stocks have the highest fractions of overexploited stocks (100% and 76%, respectively). As a group, the pelagics possess the highest percentage (75%) of underexploited stocks (Table 3).

Recent (1992-1993) and five-year (1989-1993) trends in landings and abundance are presented in Table 4. During 1992-1993, landings declined in 50% of the stocks, and were unchanged in another 28%. No stock showed major increases in landings during the most recent two years. In the past five years (1989-1993), landings increased in 28% of stocks, declined in 46%, and were unchanged in 26%. Abundance changed equally in 1992-1993: 26% increased, and 26% decreased. However, during the past 5 years, 45% declined, while only 24% increased.

Pelagic and anadromous species exhibited the greatest proportion of stocks showing major increases. New England groundfish and invertebrate species had the highest proportion of stocks exhibiting major declines. For many stocks, changes in landings and abundance appear negligible, but this belies the fact that some of these resources have already collapsed (*e.g.*, redfish, Georges Bank yellowtail, haddock). Conversely, some stocks are at or near record high levels, and annual incremental changes in abundance appear relatively minor (*e.g.*, dogfish and skates).

Recent management actions have been enacted by the New England and Mid-Atlantic Fishery Management Councils and the Atlantic States Marine Fisheries Commission to address the large

Table 4. Summary of changes in landings and abundance for 50 finfish and invertebrate stocks off the northeastern United States

Category[1]	Number of Stocks	Change	Landings				Abundance			
			1992-93		1989-93		1992-93		1989-93	
				(%)		(%)		(%)		(%)
New England Groundfish	25	--	5	(20)	8	(32)	3	(12)	4	(16)
		-	9	(36)	3	(12)	4	(16)	8	(32)
			8	(32)	8	(32)	13	(52)	9	(36)
		+	3	(12)	4	(16)	5	(20)	4	(16)
		++	0	(0)	2	(8)	0	(0)	0	(0)
Mid-Atlantic Groundfish	5	--	0	(0)	0	(0)	0	(0)	0	(0)
		-	2	(40)	2	(40)	1	(20)	1	(20)
			2	(40)	2	(40)	3	(60)	2	(40)
		+	1	(20)	0	(0)	1	(20)	2	(40)
		++	0	(0)	1	(20)	0	(0)	0	(0)
Pelagics	4	--	0	(0)	2	(50)	0	(0)	1	(25)
		-	3	(75)	1	(25)	1	(25)	0	(0)
			0	(0)	0	(0)	0	(0)	1	(25)
		+	1	(25)	1	(25)	2	(50)	0	(0)
		++	0	(0)	0	(0)	1	(25)	2	(50)
Dogfish & Skates	2	--	0	(0)	0	(0)	0	(0)	0	(0)
		-	1	(50)	0	(0)	0	(0)	0	(0)
			0	(0)	0	(0)	2	(100)	1	(50)
		+	1	(50)	1	(50)	0	(0)	1	(50)
		++	0	(0)	1	(50)	0	(0)	0	(0)
Invertebrates	9	--	2	(22)	2	(22)	0	(0)	2	(25)
		-	1	(11)	1	(11)	3	(33)	4	(50)
			3	(33)	3	(33)	2	(22)	1	(12)
		+	3	(33)	1	(11)	2	(22)	1	(12)
		++	0	(0)	2	(22)	1	(11)	0	(0)
Anadromous	5	--	1	(20)	2	(40)	0	(0)	1	(50)
		-	2	(40)	2	(40)	1	(50)	0	(0)
			1	(20)	0	(0)	0	(0)	0	(0)
		+	1	(20)	0	(0)	0	(0)	0	(0)
		++	0	(0)	1	(20)	1	(50)	1	(50)
All	50	--	8	(16)	14	(28)	3	(6)	8	(17)
		-	17	(34)	9	(18)	10	(20)	13	(28)
			14	(28)	13	(26)	20	(40)	14	(30)
		+	11	(22)	7	(14)	10	(20)	8	(17)
		++	0	(0)	7	(14)	3	(6)	3	(7)

Notes: Changes are summarized for 1992-1993 and 1989-1993 (5-years). Symbols are as follows: -- = major decline, - = minor decline, blank = no change, + = minor increase, ++ = major increase.

[1] Stocks in each category are given in Table 3, some stocks cannot currently be classified by changes in abundance levels: Atlantic sturgeon, American shad, river herring, and Gulf of Maine sea scallop.

fraction of stocks considered 'overfished' and at low abundance levels. Amendment #5 of the Northeast Multispecies ('groundfish') FMP was implemented to decrease fishing effort by 50% over 5 to 7 years. Recent stock assessments, however, have indicated that such a timeframe is inadequate to address critical stock declines, especially for cod, haddock and yellowtail flounder. Scientific advice from Stock Assessment Workshop (SAW) 18 (NEFSC 1994b) recommended that fishing mortality be reduced 'to as low a level possible, approaching zero' for groundfish stocks on Georges Bank. Similar advice was given at SAW 17 (NEFSC 1994) for Southern New England yellowtail flounder. In response to the scientific advice and the poor condition of groundfish, the New England FMC has announced its intent to reduce fishing on these stocks immediately. Amendment #7 to the Northeast Multispecies FMP is being developed to markedly reduce fishing mortality rates on critically overfished groundfish, while avoiding increased exploitation on other stocks (*e.g.*, Gulf of Maine and Middle Atlantic) that could result if effort is transferred from one area to another.

Amendment #4 to the Sea Scallop FMP was implemented in 1994 to replace meat count regulations with direct con-

Exploitation Rate

1994 Abundance Level	Underexploited	Fully Exploited	Overexploited	
High	Atlantic Herring Atlantic Mackerel Skates 6%	Spiny Dogfish Striped Bass 4%	American Lobster 2%	12%
Medium	Red Hake-N. Butterfish *Illex* Squid 6%	Pollock Ocean Pout White Hake *Loligo* Squid Northern Shrimp Surfclam Ocean Quahog 14%	Summer Flounder American Plaice Black Sea Bass 6%	26%
Low	Red Hake-S. 2%	Silver Hake-N. Atlantic Salmon 4%	Cod-GM, GB; Haddock–GM,GB Redfish, Wolffish, Tilefish, Shad,Silver Hake–S, Atl. Sturgeon, Yellowtail–CC,GB,SNE,MA Witch Flounder Sea Scallop–GM,GB,MA Winter Flounder–GN,GB,SNE Bluefish, Windowpane–N,S Cusk, Scup, Goosefish, River Herrings 56%	62%
	14%	22%	64%	

Figure 7. Summary of status of 50 finfish and invertebrate stocks reviewed in this report. Stocks are classified by current exploitation rate (underexploited, fully exploited, and overexploited), and current abundance level (low, medium, high). Percentages of stocks in various categories are given.

trols on fishing effort (*e.g.*, days at sea). The elimination of the meat count has resulted in increased exploitation on small scallops, even though a larger ring size (3-1/4") is now required in scallop dredges. To reduce exploitation rates on scallops (now about 80% per year) will require further effort reductions.

Management programs for summer flounder have reduced exploitation levels, although fishing mortality still exceeds the overfishing level. The quota-based system of management has resulted in a series of trip limits, and state-by-state closures as the quota is approached. The time schedule adopted by the Mid-Atlantic FMC calls for additional reductions in mortality to broaden the age distribution within the stock and reduce reliance in the fishery on age 0-2 fish.

Other fishery management programs are currently being developed to address overfishing of inshore stocks (winter flounder, bluefish, weakfish and others) primarily under the jurisdiction of the ASMFC and individual states.

For further information

NEFSC [Northeast Fisheries Science Center]. 1994a. Report of the Seventeenth Northeast Regional Stock Assessment Workshop (17th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-06.

NEFSC [Northeast Fisheries Science Center]. 1994b. Report of the Eighteenth Northeast Regional Stock Assessment Workshop (18th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-22.

NEFSC [Northeast Fisheries Science Center]. 1995. Report of the Nineteenth Northeast Regional Stock Assessment Workshop (19th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 95-02.

Fishery Economic Trends

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J. Walden
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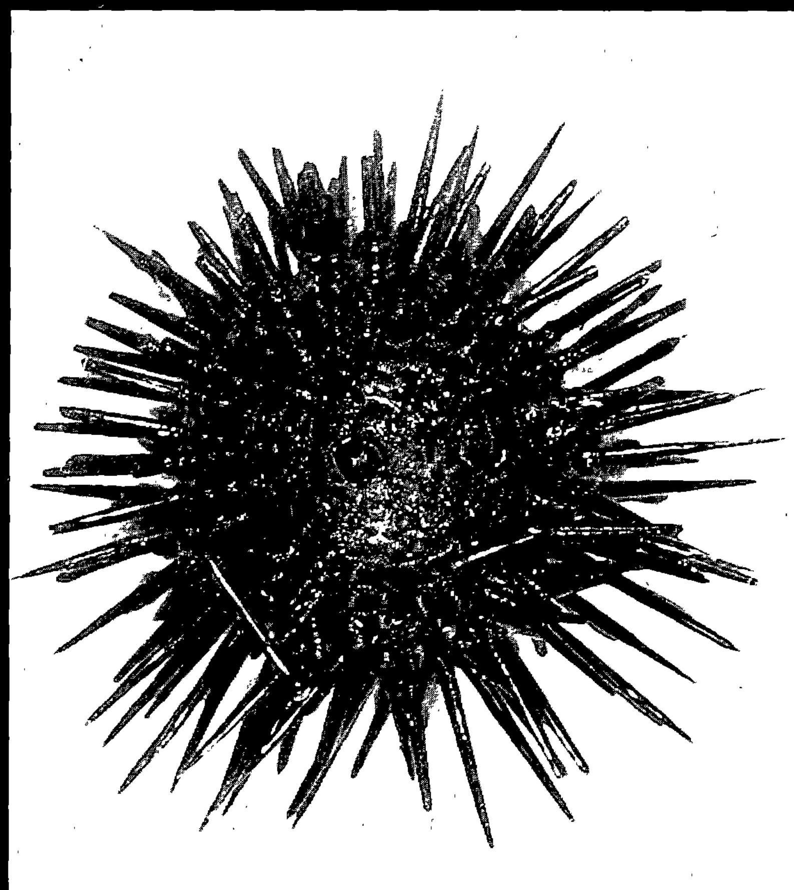
REGIONAL SUMMARY

The Northeast's commercial oceanic and estuarine fisheries produced domestic landings worth $869 (preliminary figure) million dockside in 1993, a decrease of $77 million, or 8% less than final 1992 figures. Annual totals of quantity and value for total finfish and shellfish for 1989-1993 are provided at the end of Table 5. Finfish landings brought in $304 million, representing 35% of the revenue generated in the region. Shellfish landings brought in $565 million, accounting for the remaining 65% of revenue. These figures are preliminary and subject to change as additional information is received from the ports. Preliminary revenue figures estimated at this time last year were 6% below the final figures.

In 1993, total landings increased to 760,000 mt (preliminary), a 7% increase over 1992 (708,000 mt). Finfish landings (531,000 mt) increased 5% over 1992 (508,000 mt), while shellfish landings (229,000 mt) increased by 15% (200,000 mt).

Important species of fish and shellfish landed or raised in the Northeast region are shown in Table 5 along with their quantity, value, and price for the last eight years. Landings of finfish, lobster, shrimp, and crab are given in live weight; landings of all other shellfish are expressed in meat weight. The most important species, ranked in terms of 1993 exvessel value (first sale, dockside), are American lobster, sea scallops, blue crab, cod, hard clams, Atlantic salmon, menha-



Maine divers began taking sea urchins in 1987. In 1993, urchins were the 11th most valuable species in the overall regional landings
NMFS file photo

Table 5. Important species landed or raised in the Northeast, their landings (L, 1000 mt), value (V, millions of dollars) and price (P, dollars per pound), 1989-1993[1]

Year	L	V	P	L	V	P	L	V	P	L	V	P	L	V	P
	Am. Lobster			**Sea Scallops**			**Blue Crab**			**Cod**			**Hard Clam**		
1989	24.0	148.9	2.82	14.4	126.6	3.98	45.6	42.0	0.42	35.6	47.8	0.61	4.2	50.6	5.48
1990	27.6	151.0	2.48	17.2	147.4	3.88	43.9	43.2	0.45	43.6	61.4	0.64	4.6	46.9	4.63
1991	29.1	166.1	2.59	17.2	153.5	4.05	49.5	40.4	0.37	42.2	74.3	0.80	4.4	44.8	4.61
1992	26.0	166.5	2.91	14.2	153.7	4.89	30.1	34.7	0.52	27.9	52.2	0.85	4.3	40.7	4.30
1993	25.6	151.7	2.68	7.4	97.7	6.03	57.1	69.5	0.55	22.9	45.0	0.89	4.3	43.6	4.58
	Atlantic Salmon			**Menhaden**			**Surfclam**			**Oyster**			**Squid *Loligo***		
1989	0.0	0.0	0.00	87.8	31.3	0.05	30.4	30.7	0.46	2.4	22.3	4.16	23.0	21.8	0.43
1990	2.1	16.1	3.50	36.1	37.2	0.05	32.6	32.4	0.45	3.3	40.1	5.54	15.0	14.0	0.43
1991	4.7	30.0	2.89	94.8	33.2	0.05	30.0	29.2	0.44	4.0	40.8	4.67	19.4	22.7	0.53
1992	5.8	45.3	3.52	85.9	31.6	0.05	33.2	34.7	0.47	4.6	55.7	5.44	18.2	23.3	0.58
1993	6.7	42.6	2.86	17.0	41.9	0.06	33.5	38.2	0.52	2.9	36.8	5.81	22.3	29.7	0.60
	Sea Urchins			**Goosefish**			**Ocean Quahog**			**Bluefin tuna**			**Soft Clam**		
1989	4.3	3.6	0.38	11.3	12.6	0.51	23.1	16.4	0.34	1.1	19.7	8.01	2.9	19.4	2.98
1990	6.1	6.1	0.45	10.1	13.1	0.59	21.2	16.3	0.35	1.0	21.2	9.26	2.4	20.8	3.88
1991	9.3	11.2	0.54	12.1	21.8	0.81	22.3	19.0	0.39	0.9	15.3	7.58	1.9	14.8	3.51
1992	12.0	15.2	0.57	15.8	20.7	0.60	23.0	20.1	0.40	0.9	14.5	7.23	1.9	17.8	4.23
1993	19.2	27.2	0.64	17.6	20.8	0.54	23.4	20.6	0.40	1.0	19.3	8.92	2.0	19.0	4.27
	Summer flounder			**Winter flounder**			**Amer. Plaice**			**Silver Hake**			**Yellowtail Flounder**		
1989	6.2	22.2	1.63	6.6	19.6	1.34	3.5	8.8	1.14	17.8	9.4	0.24	5.6	13.9	1.13
1990	3.0	12.0	1.84	7.0	17.1	1.11	2.5	5.6	1.03	20.0	11.1	0.25	14.4	28.1	0.89
1991	4.6	14.8	1.45	7.6	19.1	1.14	4.3	8.9	0.94	16.1	11.1	0.31	7.6	17.4	1.03
1992	6.4	19.6	1.39	6.5	16.2	1.14	6.6	13.9	0.95	16.2	10.9	0.30	5.7	14.0	1.12
1993	4.5	15.4	1.56	5.3	15.3	1.31	5.8	15.0	1.17	17.2	14.0	0.37	3.6	10.4	1.30
	Swordfish			**Witch Flounder**			**Squid *Illex***			**Pollock**			**White Hake**		
1989	2.7	17.2	2.92	2.4	9.0	1.73	6.8	3.2	0.22	10.5	9.9	0.43	5.1	4.4	0.39
1990	2.3	15.1	2.92	1.5	5.8	1.78	11.3	6.5	0.26	9.6	10.6	0.50	4.9	4.3	0.39
1991	1.8	12.0	3.00	1.8	6.1	1.57	11.9	6.9	0.26	7.9	9.9	0.57	5.6	5.4	0.44
1992	1.7	10.8	2.90	2.2	7.0	1.41	17.8	9.7	0.25	7.2	10.5	0.66	8.4	8.0	0.43
1993	1.5	9.9	2.93	2.6	9.0	1.57	18.1	8.6	0.22	5.7	8.4	0.67	7.5	7.3	0.44
	Butterfish			**Atlantic Herring**			**Bigeye Tuna**			**Scup**			**Northern Shrimp**		
1989	3.0	3.9	0.60	40.7	5.0	0.06	0.4	2.7	3.18	3.5	6.1	0.78	3.6	7.8	0.98
1990	2.3	2.8	0.56	51.3	5.7	0.05	0.4	3.9	4.03	4.2	6.4	0.68	4.4	6.9	0.72
1991	2.1	2.7	0.59	48.5	6.3	0.06	0.7	6.2	3.93	6.8	7.8	0.52	3.4	6.8	0.91
1992	2.8	3.4	0.56	55.8	6.8	0.06	0.5	4.8	4.66	5.9	7.6	0.59	3.4	7.3	0.99
1993	4.5	6.8	0.69	49.7	6.5	0.06	0.8	5.8	3.48	4.3	5.5	0.58	2.3	5.2	1.03
	Tilefish			**Spiny Dogfish**			**Black Sea Bass**			**Haddock**			**Yellowfin Tuna**		
1989	0.5	2.0	1.81	4.4	0.8	0.09	1.0	2.7	1.20	1.7	4.5	1.19	0.5	1.6	1.33
1990	0.9	3.8	1.97	14.6	3.3	0.10	1.3	3.0	1.06	2.5	6.0	1.10	0.6	2.4	1.71
1991	1.2	4.2	1.61	11.5	2.4	0.09	1.2	3.1	1.20	1.8	4.6	1.13	2.0	3.5	0.80
1992	1.7	5.5	1.51	11.4	2.9	0.11	1.3	2.8	1.00	2.3	5.6	1.09	1.4	3.9	1.23
1993	1.8	5.0	1.23	15.5	4.5	0.13	1.3	2.9	0.98	0.9	2.7	1.38	0.6	2.7	2.15
	Striped Bass			**Skates**			**Windowpane Flounder**			**Mussels**			**Weakfish**		
1989	0.1	0.4	2.12	6.7	0.9	0.06	2.6	3.1	0.55	4.3	3.4	0.35	1.7	2.7	0.73
1990	0.3	1.0	1.48	11.4	2.0	0.08	2.0	1.7	0.38	3.9	2.9	0.34	1.4	2.2	0.69
1991	0.3	1.4	1.75	11.3	1.8	0.07	3.7	4.4	0.54	2.9	2.2	0.33	1.5	2.5	0.77
1992	0.6	2.4	1.73	12.5	2.5	0.09	2.1	3.0	0.64	4.1	3.0	0.34	1.1	1.9	0.79
1993	0.7	2.7	1.87	8.1	2.5	0.14	1.6	2.3	0.66	2.7	2.0	0.34	1.1	1.9	0.78
	Bluefish			**Atlantic Mackerel**			**Red Hake**			**Redfish**			**Ocean Pout**		
1989	2.7	1.3	0.22	8.1	3.2	0.18	1.6	0.6	0.17	0.6	0.9	0.66	1.3	0.3	0.10
1990	3.6	2.1	0.26	9.9	3.6	0.16	1.6	0.6	0.17	0.6	0.7	0.53	1.3	0.3	0.10
1991	3.5	1.7	0.22	16.5	5.4	0.15	1.6	0.8	0.22	0.5	0.5	0.46	1.4	0.3	0.10
1992	3.4	1.7	0.23	11.8	3.6	0.14	2.2	1.1	0.22	0.8	0.8	0.42	0.5	0.1	0.10
1993	3.0	1.8	0.27	4.6	1.3	0.13	1.7	0.9	0.24	0.8	0.8	0.46	0.2	0.1	0.10

	Total Shellfish[2]		**Total Finfish[2]**		**Total[2]**	
	L	V	L	V	L	V
1989	197.2	526.9	468.0	260.7	665.2	787.6
1990	201.0	547.2	558.0	321.3	759.0	868.5
1991	216.5	574.5	522.3	352.9	738.8	927.4
1992	199.6	594.7	508.4	351.7	708.0	946.4
1993	229.1	564.9	530.8	303.9	759.9	868.8

[1] 1993 data is preliminary

[2] P not meaningful for total figures

Table 6. Number of vessel permits issued in the Northeast by gear and permit category, 1993

For vessels larger than 5 GRT

Proposed Gear Use	Bluefin Tuna	Summer Flounder	American Lobster	NE Multi-species	Ocean Quahog	Surf-clam	Sea Scallop	Squid, Mackerel, Butterfish	Total
Purse seines	16	5	2	12	2	2	2	48	89
Beach seines	0	0	1	0	0	1	0	5	7
Boat seines	0	4	2	6	2	2	2	17	35
Bottom trawls	0	1407	893	1763	186	277	791	1303	6620
Midwater trawls	0	21	8	30	2	4	4	228	297
Otter trawls	0	92	33	76	13	15	40	71	340
Boat dredges	0	150	192	119	753	974	1453	101	3742
Gill/entanglement nets	59	147	70	473	11	13	27	390	1190
Pots/traps	4	18	2053	81	1	2	9	17	2185
Hand line	2161	94	2	224	1	1	2	133	2618
Rod and reel	4360	812	35	1065	1	4	3	967	7247
Longlines/setlines	549	51	7	571	6	8	8	62	1262
Harpoon	298	0	0	1	0	0	0	0	299
Other gear	0	17	12	17	14	32	31	38	161
Diving gear	0	5	322	4	10	16	47	1	405
Total	**7447**	**2823**	**3632**	**4442**	**1002**	**1351**	**2419**	**3381**	**26497**

For vessels smaller than or equal to 5 GRT

Proposed Gear Use	Bluefin Tuna	Summer Flounder	American Lobster	NE Multi-species	Ocean Quahog	Surf-clam	Sea Scallop	Squid, Mackerel, Butterfish	Total
Purse seines	3	0	0	5	0	0	0	15	23
Beach seines	0	1	0	0	0	0	0	1	2
Boat seines	0	1	0	3	0	0	0	6	10
Bottom trawls	0	110	35	178	7	14	49	93	486
Midwater trawls	0	3	0	4	1	2	2	12	24
Otter trawls	0	10	3	15	2	4	9	9	52
Boat dredges	0	0	3	1	106	151	250	0	511
Gill/entanglement nets	11	55	20	196	2	3	5	208	500
Pots/traps	0	5	818	23	2	3	8	6	865
Hand line	2236	85	8	321	0	3	4	120	2777
Rod and reel	3869	484	13	872	5	9	6	571	5829
Longlines/setlines	12	27	1	322	1	2	2	42	409
Harpoon	143	0	0	1	0	0	0	1	145
Other gear	0	2	3	12	17	32	19	5	90
Diving gear	0	6	163	1	11	17	45	1	244
Total	**6274**	**789**	**1067**	**1954**	**154**	**240**	**399**	**1090**	**11967**

den, surfclams, oysters and *Loligo* squid. Seven of the ten most valuable species are invertebrates and five of the ten species are harvested predominantly inshore (0 to 3 miles).

Several observations can be made from the price and landings data presented in Table 5. First, landings and value of sea scallops declined drastically in 1993. While sea scallops remained the second most valued species in the Northeast, exvessel revenues dropped by 36% and landings declined by 48%.

Secondly, landings of the region's "traditional" groundfish species (cod, haddock, and yellowtail flounder) declined from 35,900 to 27,400 mt, a 31% decrease from 1992 and a 47% decline from 1991. Value of these traditional groundfish in 1993 was $58.1 million, 19% less than in 1992 ($71.8 million) and 40% less than in 1991 ($96.3 million). The three "traditional" groundfish species accounted for 7% of total 1993 catch by value and just 4% by weight.

Sea urchins, for which no fishery existed prior to 1987, rose to become the eleventh most valuable species in 1993. Farmed Atlantic salmon, which were not produced in the Northeast until 1990, was the sixth most valuable species. This reflects the growing importance of marine aquaculture to the Northeast economy; Atlantic salmon (and steelhead trout) are now being raised at more than 20 sites in Maine.

Relatively few species accounted for most of the value of landings in the Northeast. The top ten generated 69% ($597 million) of the landings value. Despite declines in lobster and sea scallop landings in 1993, these two species remained the most valuable, accounting for 29% of the total value of all species landed. Blue crab accounted for the largest revenue gain (in absolute terms) in 1993, doubling in value from 1992. Menhaden, which made the greatest absolute gain in landings in 1993, became the seventh most valuable species, accounting for 42% of total landings (by weight) and 5% by value.

Table 7. Identified vessels' landings (1000 mt, landed weight) and ex-vessel revenue (millions of dollars) in the Northeast, by gear type, 1993

Gear Types	Landings	Revenue
Otter trawl, bottom--fish	121.0	173.2
Dredge--sea scallop	10.7	93.8
Dredge--surfclam & ocean quahog	55.8	52.5
Longline, bottom and pelagic	6.5	26.7
Pots & traps--lobster	3.7	19.9
Sink gill net	14.9	16.8
Purse seine--tuna	0.3	5.8
Otter trawl, bottom-scallops	0.5	4.3
Otter trawl, bottom-shrimp	1.7	3.8
Otter trawl, bottom-paired	1.4	3.1
Pots and traps--crab	1.4	1.5
Purse seine--menhaden	9.4	1.2
Otter trawl, midwater, paired	0.3	1.1
Purse seine--herring	5.9	0.6
All other gears	8.4	5.4
Total	**241.9**	**409.7**

Table 8. All weigh-out vessels' landings (1000 mt, landed weight) and ex-vessel revenue (millions of dollars) in the Northeast, by gear type, 1993

Gear Types	Landings	Revenue
Otter trawl, bottom--fish	129.7	187.0
Pots & traps--lobster[1]	21.5	115.2
Dredge-sea scallop	11.4	102.6
Dredge--surfclam & ocean quahog	56.0	53.7
Purse seine--menhaden	310.9	40.9
Pots & traps--blue crab	25.9	32.4
Long line, bottom and pelagic	7.7	29.7
Sink gill net	22.7	24.8
Diving gear	16.7	24.3
Rakes	1.8	17.8
Hoes	1.5	12.8
Hand line, other	0.9	12.7
Tongs and grabs	0.6	7.2
Dredge--clam	0.6	6.0
Purse seine--herring	38.4	5.1
Otter trawl, bottom--shrimp	2.2	5.0
Otter trawl, bottom--scallops	0.5	4.4
Dredge--oyster	0.2	1.9
Unknown [2]	15.1	95.0
All other gears	40.2	50.7
Total	**704.5**	**829.1**

1 Lobster not yet complete in weighout data
2 Includes oyster dredge

DATA COLLECTION CONSIDERATIONS

At present, NMFS is attempting to enhance its data collection, archival, and analysis systems to support increasingly complex needs of fisheries management. In the Northeast Region, 1993 marks the end of a traditional voluntary method of data collection from many vessel owners, operators, and dealers. Regulations implemented in 1994 in several FMPs require mandatory reporting programs.

In 1993, as in past years, NMFS obtained information on landings through the collection of weighout sales receipts (at the point of first sale) using a network of federal and state port agents located at 14 field offices in the Northeast (Maine to Virginia). Interviews with vessel operators were also conducted by the port agents when vessels landed. The "interview records" contain information on variables such as gear type, fishing location, and effort. The percentage of trips interviewed varies, depending on, among other things, port, size of vessel, and length of trip or trip type. Additional data are collected by conducting a monthly or annual canvas to fill in gaps.

All of the landings recorded are associated with the type of gear that produced them. However, the further the collection of information is in time from the date and place of first sale, the more difficult it is to associate landings with a particular vessel and trip-specific fishing effort.

All vessels fishing in the EEZ (craft larger than 5 gross registered tons, GRT) are required by law to be registered with the U.S. Coast Guard. All craft smaller than 5 GRT must have either a state or Coast Guard registration number. Any vessel used commercially to exploit species managed under federal fishery management plans (FMPs) in the region is required to apply annually for an appropriate fishery-specific permit.

Table 6 shows the number of vessel permits issued by fishery category and gear type for 1993. Frequently, vessel

Table 9. Number of identifiable vessels using otter trawl, scallop dredge, and other gear in the Northeast region by ton class and subregion, 1983-1993

Year		Scallop Dredges				Otter Trawls				All Vessels			
		TC2	TC3	TC4+	Total	TC2	TC3	TC4+	Total	TC2	TC3	TC4+	Total
1983	Northeast	61	121	109	291	496	556	140	1192	776	800	254	1830
	New Eng	52	84	84	220	448	435	113	996	581	583	193	1357
	M-A&Ches	9	72	39	120	54	175	44	273	215	334	103	652
1984	Northeast	43	125	117	285	492	609	140	1241	795	850	273	1918
	New Eng	37	83	93	213	443	459	119	1021	611	595	217	1423
	M-A&Ches	6	72	44	122	54	205	31	290	197	360	104	661
1985	Northeast	20	91	117	228	474	553	154	1181	772	795	290	1857
	New Eng	20	64	86	170	421	422	129	972	590	554	217	1361
	M-A&Ches	0	48	44	92	59	171	35	265	193	316	110	619
1986	Northeast	10	87	105	202	437	536	150	1123	732	782	284	1798
	New Eng	10	46	80	136	379	389	126	894	540	505	209	1254
	M-A&Ches	0	53	39	92	63	186	39	288	203	341	108	652
1987	Northeast	17	101	116	234	508	536	141	1185	810	797	292	1899
	New Eng	17	47	89	153	445	369	112	926	631	493	209	1333
	M-A&Ches	0	64	34	98	65	195	34	294	187	358	98	643
1988	Northeast	27	111	136	274	486	564	161	1211	828	817	329	1974
	New Eng	26	56	109	191	422	370	126	918	651	499	242	1392
	M-A&Ches	1	63	42	106	64	225	39	328	177	368	113	658
1989	Northeast	41	116	159	316	402	551	151	1104	735	812	341	1888
	New Eng	38	57	125	220	360	374	112	846	599	509	247	1355
	M-A&Ches	4	68	54	126	44	217	46	307	143	365	130	638
1990	Northeast	35	129	161	325	413	516	143	1072	767	786	338	1891
	New Eng	32	77	133	242	373	358	108	839	598	512	252	1362
	M-A&Ches	3	82	55	140	42	189	43	274	180	353	129	662
1991	Northeast	32	114	153	299	403	483	139	1025	808	735	309	1852
	New Eng	29	65	126	220	368	339	115	822	628	469	241	1338
	M-A&Ches	4	72	52	128	36	170	34	240	192	335	108	635
1992	Northeast	50	112	148	310	422	473	117	1012	871	722	298	1891
	New Eng	48	62	119	229	374	328	93	795	681	454	227	1362
	M-A&Ches	3	71	50	124	51	174	36	261	203	333	106	642
1993	Northeast	69	100	136	305	435	484	121	1040	923	731	285	1939
	New Eng	67	50	110	227	341	327	98	766	677	452	218	1347
	M-A&Ches	2	60	40	102	96	189	41	326	256	338	104	698

NOTES:

TC2 = 5-50 gross registered tons (grt), TC3 = 51-150 grt, TC4 = 151+ grt.

Northeast vessels include those that landed at least once in Maine, Massachusetts, New Hampshire, Rhode Island, Connecticut, New York, New Jersey, Maryland, Virginia, or Delaware.

New England vessels include those that landed at least once in Maine, Massachusetts, New Hampshire, Rhode Island, or Connecticut.

Mid-Atlantic and Chesapeake (M-A&Ches) vessels include those that landed at least once in New York, New Jersey, Maryland, Virginia, or Delaware. Maryland and Virginia joined this reporting system in 1981, and New York in 1986.

The "All Vessels" columns provide a unique count of vessels regardless of gear used.

The "Northeast" row eliminates duplication of vessels that landed in both subregions.

Table 10. Percentage of landings (by weight) by gear type for selected species in the Northeast, 1993

Gear Type	Cod	Yellowtail Flounder	Haddock	Other Multispecies[1]	Menhaden	Summer Flounder	Lobster	Sea Scallops	Swordfish	Atlantic Herring
Bottom trawl	71.3	84.3	93.5	84.5	0.0	93.1	2.2	5.6	0.4	5.1
Midwater trawl	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.7	12.5
Hook gear	7.3	0.0	2.4	2.2	0.0	0.3	0.0	0.0	93.7	0.0
Gill net	19.9	3.5	3.6	8.6	0.2	0.1	0.0	0.0	4.8	0.0
Pots/traps	0.0	0.0	0.0	0.0	0.1	0.4	0.1	0.0	0.0	0.0
Lobster pot	0.1	0.0	0.0	0.1	0.0	0.0	94.1	0.0	0.0	0.0
Scallop dredge	0.3	10.9	0.6	1.1	0.0	2.7	0.0	93.0	0.0	0.0
Other gear	1.1	1.4	0.0	3.5	99.7	3.2	3.6	1.4	0.4	82.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Gear Type	Atlantic Mackerel	Butterfish	Loligo	Black Sea Bass	Scup	Goosefish	Northern Shrimp	Bluefin Tuna
Bottom trawl	80.9	97.7	98.3	54.5	84.9	39.7	95.7	0.6
Midwater trawl	10.3	0.0	0.1	0.0	1.1	0.0	0.0	0.0
Hook gear	0.8	0.0	0.3	0.1	1.5	0.1	0.0	3.1
Gill net	2.2	0.2	0.0	0.1	0.1	11.7	0.0	0.0
Pots/traps	3.6	0.4	0.4	39.8	7.8	0.0	4.5	0.0
Lobster pot	0.0	0.0	0.0	1.9	0.0	0.1	0.0	0.0
Scallop dredge	0.0	0.0	0.0	0.5	0.0	39.1	0.0	0.0
Other gear	2.2	1.7	0.9	3.1	4.6	9.3	0.0	96.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] Other multispecies include pollock, winter flounder, witch flounder, windowpane flounder, American plaice, redfish, white hake, red hake, whiting, and ocean pout.

owners apply for a permit in several different fisheries and under several gear types. Hence, the number of permits issued is far greater than the number of unique vessels or boats.

The greatest number of permits were issued for rod-and-reel use in several fisheries. These permits are used principally for catching bluefin tuna. Bottom trawl gear was the major permitted gear for the summer flounder, Northeast multispecies, and squid, mackerel, and butterfish fisheries. Pots and traps were the major permitted gear for American lobster, while in the ocean quahog, surfclam, and sea scallop fisheries, dredges were the major gear.

The collection of weighout receipts coupled with the ability to identify particular vessels allows landings to be associated with vessel and gear characteristics. Table 7 summarizes landings and revenues in 1993 by gear type for identified vessels. Only a portion of the total landings, however, can be associated with specific vessels. In 1993, these landings constituted about 33% of all landings, and accounted for about 50% of the total revenue. Vessels using otter trawl gear had the highest revenue among uniquely identified vessels.

Table 8 summarizes the value and landings from both identified and nonidentified vessels in the weigh-out data, *i.e.*, it includes the portion of the total landings that cannot be associated with any given vessel. Clearly, landings and revenues from some gear types cannot be well-matched to specific, individual vessels (*i.e.*, compare Table 7 and Table 8).

Although the majority of the region's vessels use a single gear, a significant number employ more than one gear type. The most important gear types used, as measured by exvessel revenue, are bottom otter trawls, lobster pots and traps, scallop dredges, and surfclam and ocean quahog dredges. These four gear types accounted for nearly 55% of the total revenues in 1993, a percentage that has been shrinking as nontraditional species and gears become more important.

Table 9 shows the total number of identifiable vessels using scallop dredge, otter trawl, and other gear represented in the weigh-out data base from 1983 through 1993. The total number of vessels in both the scallop dredge fishery and in the otter trawl fishery increased during the late 1980s, and has since remained at a relatively high level.

Table 10 shows the percentage of each species landed by identifiable gear type in the EEZ for 1993. This table shows the variability in harvesting strategies for individual species. For example, black sea bass is landed predominantly with two distinct gear types, bottom trawl and pots and traps. Goosefish are landed by bottom trawls, gill nets, and scallop dredges.

FLEETS AND FISH

Tables 11-19 present condensed pictures of the activity of known vessels, as captured by the port data collection system. All information about an individual vessel's activity has been aggregated into an annual picture. This information was then aggregated across groups or fleets of vessels on the basis of gear use, area

Table 11. New England otter trawl vessels, all gears used

	Ton Class 2					Ton Class 3					Ton Class 4				
	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
Vessel count	360	373	368	374	341	374	358	339	328	327	112	108	115	93	98
Average age	24	24	24	22	24	16	17	18	19	20	8	10	11	12	13
Average GRT	28	27	27	26	27	101	102	103	102	102	193	178	177	175	175
Average days absent	62	62	61	64	53	123	133	140	149	142	174	173	187	194	188
Average crew size	2.8	2.8	2.8	2.7	2.7	5.3	5.3	5.3	5.3	5.2	7.1	7.0	7.1	6.8	6.9
Revenue per day absent ($)	920	944	1072	955	886	1844	1960	2136	1911	1913	3305	3321	3655	3399	3237
Lb per day absent	1585	2020	1965	1659	1492	2685	3454	3583	3158	3197	5955	6302	6459	6454	5548
Average number of trips per vessel	54	51	50	53	53	35	37	36	38	38	25	28	28	31	30

Table 12. Mid-Atlantic otter trawl vessels, all gears used

	Ton Class 2					Ton Class 3					Ton Class 4				
	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
Vessel count	44	42	36	51	96	217	189	170	174	189	46	43	34	36	41
Average age	21	26	24	25	25	15	16	17	18	18	8	11	13	14	12
Average GRT	30	30	28	29	29	103	105	104	104	109	175	175	179	178	176
Average days absent	55	63	81	64	37	70	84	99	102	83	99	135	153	125	140
Average Crew Size	2.7	2.7	2.6	2.5	2.4	4.8	4.8	5.1	4.9	4.9	7.4	7.3	7.5	7.3	7.0
Revenue per day absent ($)	861	731	763	741	1126	1682	1750	1896	1751	2206	3226	3020	3322	4009	3775
Lb per day absent	2241	2057	1730	1659	2207	4536	4561	5335	4676	5600	8017	7727	8674	12740	8185
Average number of trips per vessel	54	61	74	60	35	22	25	31	30	29	19	28	32	27	32

Table 13. Northeast bottom pair trawl vessels, all gears used and pair trawl gear only

	Ton Class 3				Ton Class 4			
	1990	1991	1992	1993	1990	1991	1992	1993
Vessel count	4	4	13	6	6	10	20	20
Average age	12	7	14	15	6	6	11	13
Average GRT	93	122	125	126	175	179	176	177
Average days absent	168	160	165	213	161	187	205	186
Average crew size	4.0	5.8	5.9	6.2	5.0	5.8	6.3	6.6
Revenue per day absent ($)	2261	3020	2624	2461	3961	4790	3341	3237
Lb per day absent	4342	4178	3474	3296	6841	8855	5468	4362
Average number of trips per vessel	54	46	32	34	32	43	34	31
Pair Trawl Gear Only:								
Average days absent	12	18	19	23	36	31	21	24
Average crew size	4.0	5.8	5.9	6.2	5.0	5.8	6.3	6.6
Revenue per day absent ($)	4117	5016	2855	4059	5428	4908	5592	5280
Lb per day absent	5918	6743	3777	4956	8250	6498	6612	6120
Average number of trips per vessel	3	4	3	5	7	6	4	5

fished, and tonnage class to provide a set of indicators on how vessels are performing. Most information concerns effort, landings, and revenue. No cost information is reported. Tonnage class 2 vessels range from 5 to 50 gross registered tons (GRT); class 3 vessels are 51 to 150 GRT; and class 4 vessels are larger than 150 GRT.

Several caveats are in order concerning how vessels were categorized by fleet. In general, if a vessel landed at least once in a port in a region, its total activity (*i.e.*, all trips regardless of gear used) was ascribed to that particular region, defined as either New England, Mid-Atlantic and Chesapeake, or the entire Northeast. Hence, a vessel's activity may be represented in more than one table. The same multiple representation exists for gear use. For example, if a vessel gillnetted and longlined in the same year, its total activity will be represented in the total activity sections of both tables. Its "primary gear" activity, however, reflects only activity that occurred while using one gear type (*i.e.*, either gillnetting or longlining). For some gears no distinction is made between primary gear activity and total activity because a gear's use constituted the overwhelming majority of the activity of that fleet.

New England Otter Trawl

In 1993, the total revenue for New England otter trawlers was derived primarily from cod (20%), Loligo squid (12%), winter flounder (8%), American plaice (8%), yellowtail flounder (7%), and monkfish (7%). The total number of vessels using this gear in New England has declined annually since 1988 (Table 9). In 1993, the fleet comprised 766 vessels, most of which were class 2 (45%) and class 3 vessels (43%) (Table 11). Average landings and revenue per day absent decreased in tonnage classes 2 and 4 and remained constant in tonnage class 3. The average number of trips within each vessel class was unchanged between 1992 and 1993, but the average trip length (days absent) decreased.

Mid-Atlantic Otter Trawl

In 1993, the total revenue for Mid-Atlantic otter trawlers was derived primarily from *Loligo* and *Illex* squid (33%), summer flounder (27%), silver hake (9%) and scup (8%). The number of vessels using this gear in the Mid-Atlantic increased to 326 in 1993, the highest number since 1988 (Table 9). Increases in the number of vessels occurred in all three tonnage classes (Table 12). Tonnage class 2 and 3 vessels exhibited large increases in average landings and revenue per day absent in 1993 despite marked declines in the average number of days absent from port. Tonnage class 4 vessels showed opposite trends; average revenues and catch per day absent declined in 1993, while average days absent increased.

Northeast Pair Trawl

In 1993, 26 vessels participated in bottom pair trawling activities in the Northeast region (Table 13). Of these 26 vessels, 6 were tonnage class 3 and 20 were tonnage class 4. Pair trawling for multispecies finfish was prohibited in March 1994, when Amendment 5 to the Multispecies Groundfish management plan was implemented.

Since 1990, vessels harvesting finfish by means of pair trawling have been more efficient with significantly higher revenue per day absent and landings per

Table 14. Northeast scallop dredge vessels, all gears used

	Ton Class 2			Ton Class 3					Ton Class 4				
	1991	1992	1993	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
Vessel count	32	50	69	116	129	114	112	100	159	161	153	148	136
Average age	23	23	25	15	16	16	17	18	13	13	14	14	15
Average GRT	27	26	26	119	118	119	121	118	182	181	181	182	182
Average days absent	53	50	53	149	152	178	178	162	182	191	213	211	215
Average crew size	3.0	2.9	3.0	7.7	7.3	7.5	7.7	7.7	9.3	9.2	9.6	9.5	9.5
Revenue per day absent ($)	1241	1018	1118	2421	2542	2524	2475	1854	3301	3399	3283	3423	2323
Lb per day absent	2598	2104	2250	5412	5887	5483	4522	2664	7249	7129	6448	5813	3389
Average number of trips per vessel	32	20	36	20	19	22	22	19	18	19	20	19	19

Table 15. Northeast vessels that used shrimp trawls, all gears used and shrimp gear only

	Ton Class 2					Ton Class 3				
	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
All gears										
Vessel count	169	178	165	186	172	49	46	33	38	30
Average age	20	18	20	18	19	20	20	22	22	21
Average GRT	26	26	25	24	25	81	78	76	73	77
Average days absent	63	67	69	66	67	100	115	117	123	116
Average crew size	2.4	2.4	2.6	2.4	2.3	4.8	4.8	4.4	4.4	4.6
Revenue per day absent ($)	845	873	1054	984	905	1461	1619	1925	1631	1441
Lb per day absent	1324	1673	1919	1512	1460	2385	3022	3719	3216	2057
Average number of trips per vessel	59	60	61	57	56	64	67	66	58	61
Shrimp Trawl Gear Trips Only:										
Average days absent	28	27	24	21	21	35	36	34	27	20
Average crew size	2.4	2.4	2.6	2.4	2.3	4.8	4.8	4.4	4.4	4.6
Revenue per day absent ($)	902	808	972	957	808	1418	1448	1740	1696	1363
Lb per day absent	1006	1164	1115	984	794	1712	2271	2120	1738	1247
Average number of trips per vessel	27	26	23	21	21	32	30	32	26	20

Table 16. Northeast vessels that used gill nets, all gears used and gill-net trips only

	Ton Class 2					Ton Class 3				
	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
All gears										
Vessel count	224	209	240	240	233	23	16	12	18	7
Average age	14	15	14	15	16	18	14	15	16	14
Average GRT	21	22	22	22	21	81	80	80	83	71
Average days absent	67	72	73	75	72	92	110	74	100	103
Average crew size	2.6	2.7	2.6	2.7	2.6	4.3	4.3	5.8	4.0	4.0
Revenue per day absent ($)	1117	1031	1173	1163	1169	2247	1959	1743	1821	1997
Lb per day absent	3429	2407	2263	2244	2479	8963	3875	3339	3601	3872
Average number of trips per vessel	61	64	64	62	61	51	58	46	49	57
Gill Net trips Only										
Average days absent	51	58	57	59	60	45	54	53	34	66
Average crew size	2.6	2.7	2.6	2.7	2.6	4.3	4.3	5.8	4.0	4.0
Revenue per day absent ($)	1126	1042	1138	1152	1181	2658	1949	1737	1746	2066
Lb per day absent	3006	2555	2447	2435	2663	6185	5323	3848	4068	3910
Average number of trips per vessel	47	52	49	48	51	21	35	40	19	41

Table 17. Northeast vessels that used long lines or line trawls, all trips regardless of gear used and longline/line trawl trips.

	Ton Class 2					Ton Class 3					Ton Class 4				
	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
All gears															
Vessel count	71	90	119	135	148	62	60	76	65	70	16	11	8	8	11
Average age	15	14	13	14	13	11	12	13	13	14	6	6	7	7	7
Average GRT	23	27	26	24	23	94	91	89	90	95	173	174	177	173	174
Average days absent	52	55	59	62	51	85	88	97	104	107	119	111	138	119	141
Average crew size	2.4	2.7	3.1	2.8	2.9	4.8	4.4	4.6	4.4	4.5	6.9	6.0	6.1	6.7	6.8
Revenue per day absent ($)	1217	1334	1719	1577	1681	2382	2516	2567	2563	2789	3395	3709	3440	2890	2597
Lb per day absent	1878	1732	1821	1846	1948	1125	1307	1538	1826	3419	1832	1911	2209	3879	2236
Average number of trips per vessel	40	36	41	41	37	10	12	15	16	18	6	6	8	12	12
Long line/line trawl trips only:															
Average days absent	36	32	32	33	31	65	71	71	84	78	105	103	107	114	105
Average crew size	2.4	2.7	3.1	2.8	2.9	4.8	4.4	4.6	4.4	4.5	6.9	6.0	6.1	6.7	6.8
Revenue per day absent ($)	1239	1428	1966	1691	1804	2456	2626	2710	2506	2796	3375	3641	3686	2922	2642
Lb per day absent	1414	1259	1529	1447	1492	949	1068	1347	1367	1510	1287	1519	1433	1533	1954
Average number of trips per vessel	25	15	18	16	17	5	7	8	10	8	4	5	5	7	6

Table 18. Northeast surfclam and ocean quahog vessels and Mid-Atlantic vessels: all trips

	Ton Class 2					Ton Class 3					Ton Class 4				
	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
All Regional Surfclam/Ocean Quahog Vessels															
Vessel count	10	9	31	36	28	87	81	60	59	66	46	43	28	24	25
Average age	42	41	13	15	18	22	23	21	22	22	25	27	21	19	18
Average GRT	42	42	22	21	23	103	104	109	108	107	189	189	181	175	173
Average days absent	43	46	27	36	25	61	45	61	81	75	67	58	92	137	169
Average crew size	3.0	3.0	2.7	2.6	2.9	3.8	4.0	4.1	4.0	4.0	8.3	8.6	9.6	9.6	10.0
Revenue per day absent ($)	2217	2254	2024	1308	1938	4633	6621	6577	5849	6368	5625	7198	7626	6281	4887
Lb per day absent (live wt.)	22995	19854	16575	12386	16009	71479	98106	102875	92354	84914	110653	121480	127243	103491	86752
Average number of trips per vessel	36	50	43	36	24	60	55	67	70	60	61	58	91	107	111
Mid-Atlantic Surf Clam/Ocean Quahog Vessels Only															
Vessel count	8	6	11	10	9	81	78	57	53	54	46	42	27	24	25
Average days absent	37	36	15	19	25	60	45	59	83	71	67	57	93	137	169
Average crew size	3.0	3.0	3.1	3.3	3.4	3.9	4.0	4.1	4.1	4.0	8.3	8.7	9.4	9.6	10.0
Revenue per day absent ($)	2279	2183	3203	3685	2959	4879	6699	6893	6045	7318	5625	7354	7608	6281	4887
Lb per day absent (live wt.)	24626	21169	55225	64437	35376	76227	99907	110209	95306	97927	110653	122893	128787	103491	86752
Average number of trips per vessel	36	44	15	17	24	61	56	69	72	59	61	59	93	107	111

Table 19. Northeast vessels using offshore lobster gear, all trips and offshore lobster trips.

	Ton Class 2					Ton Class 3				
	1989	1990	1991	1992	1993	1989	1990	1991	1992	1993
All Gears										
Vessel count	41	61	61	57	55	42	44	39	31	23
Average age	15	15	15	17	18	10	10	11	12	12
Average GRT	24	23	23	23	22	86	87	90	91	87
Average days absent	88	104	125	106	107	139	120	145	129	128
Average crew size	2.7	2.6	3.2	3.2	3.2	4.2	4.3	4.2	4.0	3.9
Revenue per day absent ($)	1255	1246	1083	948	874	2215	2753	2591	2996	2327
Lb per day absent	549	683	674	495	482	948	1352	1330	1228	1106
Average number of trips per vessel	69	86	106	92	95	35	34	39	35	32
Offshore Lobster Trips Only										
Average days absent	40	57	100	30	82	132	112	104	51	78
Average crew size	2.7	2.6	3.2	3.2	3.2	4.2	4.3	4.2	4.0	3.9
Revenue per day absent ($)	1371	1509	1065	1420	790	2268	2848	2686	2981	2243
Lb per day absent	575	653	411	520	293	944	1199	1133	1102	916
Average number of trips per vessel	22	40	85	20	21	31	28	29	13	22

day absent than otter trawlers that worked alone. Although pair trawling trips occurred during all months of 1993, pair trawling by vessels was an occasional activity, *i.e.*, not their primary means of fishing.

Northeast Scallop Dredge

Table 14 shows the activity of the Northeast sea scallop fleet. Tonnage class 2 vessels (which are not included in the table prior to 1991 due to negligible levels of effort and landings) have recently accounted for a greater level of activity. For the overall fleet, landings and revenues decreased sharply in 1993 (by about 35%). For all but the smallest vessels, revenues and landings per day absent fell sharply.

Crew sizes in Table 14 are based upon vessel berths and do not represent actual observations.

Northeast Shrimp Trawl

The northern shrimp fishery is a seasonal (winter/spring) fishery. Ninety-five percent of shrimp landings are made by vessels using shrimp trawls, and 85% of the fleet consists of tonnage class 2 vessels. The principal gears used by shrimp vessels during the six month off-season are otter trawls, gill nets and lobster traps.

Table 15 shows the activity of the shrimp fleet, as well as its other fishing activity. Shrimp trawl gear was used during 29% of the days spent at sea, and contributed 25% to the total revenues of the fleet.

For those trips using shrimp trawls, substantial decreases in average landings and average revenue per day absent occurred in 1993.

Northeast Gillnet

This is a broad category of gear, but it excludes the large mesh drift net used for large pelagics. In 1993, the total revenue for small-mesh drift and sink gillnets was derived primarily from cod (33%), pollock (14%), monkfish (10%), and several other species of lesser value. Ninety-five percent of gill-net vessels are tonnage class 2 vessels, which employ other gear (usually otter trawls and shrimp trawls) for approximately 20% of the year.

The total number of vessels in this fishery declined from 258 in 1992 to 244 (four were tonnage class 4) in 1993 (Table 16). Both average revenue per day absent and average landings per day absent increased in 1993.

Long Line and Line Trawl

In 1993, 83% of the total revenue from these related gears was attributed to swordfish (31%), tilefish (16%), bigeye tuna (16%), cod (13%) and yellowfin tuna (7%).

Participation in this fleet increased from 208 vessels in 1992 to 229 in 1993 (Table 17). Average revenue for all vessels increased by 3% in 1993. Average landings per day absent were significantly greater in 1993 for class 2 and 3 vessels.

Surfclam and Ocean Quahog Dredge

This fishery has stabilized in many respects due to the individual transferable quota (ITQ) management system implemented in 1991. The number of vessels in the fishery has remained at 119 during the past three years.

The activity summarized in Table 18 is divided between the activity of all vessels in the Northeast region using surfclam/ocean quahog dredges and those vessels landing in Mid-Atlantic ports. Only 31 of the 119 vessels in the Northeast region landed outside the Mid-Atlantic area.

During the last two years, some vessels agreed to harvest surfclams owned by another vessel's ITQ. These vessels obtained about half the value of the catch, with the remaining revenue accruing to the ITQ owner. The lower price received by these vessels reflected the rental price for capital and labor services to harvest the resource, which was lower than the full market value of the clams. The revenue for the surfclam fishery, as stated in Table 5, was adjusted so that the prices paid to ITQ owners were taken into account. In the case of vessel performance, however, (Table 18), adjusted revenues are reported, reflecting what vessels actually earned.

Offshore Lobster Traps/Pots

The delineation between offshore and inshore lobster fisheries is not precise, as many vessels fish both sides of the three-mile line that divides inshore from offshore. Roughly 20% of the lobster revenue in 1993 was from offshore trips, while 80% was from inshore. A small portion of lobsters taken offshore is caught as bycatch by the otter trawl fleet.

The lobster fleet is dominated by tonnage class 2 and 3 vessels, so tonnage class 4 activity was omitted from Table 19. Annual landings of offshore lobster and fleet total revenues fell in 1993, as did both average landings and revenue per day absent. Vessels became more dependent on lobster gear for their income in 1993; the average days absent for those trips in which offshore lobster gear was exclusively used markedly increased over 1992. Seventy-seven percent and 60% of total offshore lobster effort involved the exclusive use of offshore lob-

Man with salmon, Boston Fish Pier, circa 1938. Presently, wild Atlantic salmon are comparatively rare in New England rivers. In recent years, these fish have been successfully farmed for the commercial market, and are now the sixth most valuable species in the region.
O.E. Sette Collection, NMFS/NEFSC Photo Archive

Table 20. Northeast region: Value (millions of dollars) of imported edible fishery products in 1992 and 1993

Product Category	1992	1993
Fresh or frozen sea herring	3.5	2.7
Fresh, whole groundfish, halibut, and other flatfish	45.5	42.4
Frozen,whole groundfish, halibut, and other flatfish	7.1	10.4
Salmon, fresh or frozen	64.3	60.9
Frozen groundfish blocks	243.2	160.4
Other fish, fresh or frozen	54.3	66.2
Ocean perch fillets	66.7	65.4
Fresh groundfish and flatfish fillets	39.2	42.8
Frozen groundfish and flatfish fillets	283.9	297.8
Other fresh, frozen fillets	126.6	142.7
Salted or dried groundfish	38.4	33.6
Salted herring	3.7	3.4
Canned tuna	146.9	112.0
Canned sardines	26.6	29.0
Minced fish	16.7	16.8
Clam products	11.0	10.2
Crab products	45.7	71.1
Lobster, fresh	114.1	109.8
Lobster, frozen	124.0	128.7
Other lobster products	51.0	37.2
Scallops	107.8	160.3
Shrimp products	424.1	447.6
Squid	11.4	14.3
Other fishery products	155.1	179.4
Total	**2210.8**	**2245.1**

ster gear, respectively, for tonnage class 2 and 3 vessels.

AQUACULTURE

Although aquaculture is growing and has potential for supplementing wild-catch fishery products in many seafood markets, aquacultural activities in the Northeast are still mostly experimental. The success of Atlantic salmon farms, however, has sparked interest in the potential of raising alternative species such as cod, haddock, summer flounder, and shellfish (clams, oysters, mussels, scallops).

TRADE

Historically, the Northeast region has run a trade deficit in edible fishery products because of the large port-of-entry in New York and the region's proximity to Canadian fishing ports. In 1993, this deficit increased by $15.0 million over 1992. Imports rose by $34.3 million (1.5%) while exports increased by $19.3 million (4.7%).

Increases in the value of specific import products (Table 20) occurred for scallops ($52.5 million), crab products ($25.4 million), frozen groundfish and flatfish fillets ($13.9 million), frozen lobster ($4.7 million), fresh groundfish and flatfish fillets ($3.6 million), and frozen whole groundfish, halibut and other flatfish ($3.3 million). These were partially offset by decreases in value of imported frozen groundfish blocks ($82.8 million), canned tuna ($34.9 million) and fresh lobster ($4.3 million).

Increases in the value of export products in 1993 (Table 21), were led by sea urchin roe ($22.9 million), other fresh and frozen fish ($9.6 million) fresh or frozen salmon ($8.3 million), butterfish ($3.3 million), and live sea urchins ($1.5 million). These increases were partially offset by decreases in the export value of fresh or frozen cod ($11.3 million), fresh lobster ($7.8 million), fish sticks and portions ($6.8 million), fresh or frozen fish fillets ($5.0 million), and fresh or frozen tuna ($1.9 million).

Table 21. Northeast Region: value (millions of dollars) of exported fishery products in 1992 and 1993

Product Category	1992	1993
Herring, fresh or frozen	0.8	1.8
Processed herring products	10.1	10.4
Salmon, fresh or frozen	23.7	32.0
Cod, fresh or frozen	18.4	7.1
Mackerel, fresh or frozen	1.0	0.7
Dogfish, fresh or frozen	15.0	15.1
Butterfish	3.1	6.4
Tuna, fresh or frozen	19.3	17.4
Other fish, fresh or frozen	49.3	58.9
Fish fillets, fresh or frozen	30.5	25.6
Fish sticks and portions	12.9	6.1
Sea urchin, live	6.6	8.1
Sea urchin, roe	21.0	43.9
Other roe products	6.6	7.3
Shrimp, fresh	2.7	2.2
Shrimp, frozen	25.0	24.7
Shrimp, canned	9.2	9.1
Lobster, fresh	76.0	68.2
Lobster, frozen	3.9	2.5
Other lobster products	1.3	0.5
Crab products	6.5	7.6
Squid, fresh or frozen	15.7	16.5
Shellfish, fresh	5.4	5.2
Clam products	4.4	4.8
Scallop, fresh and frozen	8.4	7.5
Other shellfish	1.9	4.3
Other edible fishery products	29.5	33.6
Total	**408.2**	**427.5**

Table 22. New England imports (thousand of metric tons) of selected fishery products from Canada and all other sources, 1992-1993

	1992		1993	
	Canada	**Other**	**Canada**	**Other**
Cod	124.4	115.7	63.6	125.4
Groundfish	96.4	136.9	79.4	149.5
Flatfish	33.5	14.8	28.2	18.6
Other finfish	26.6	52.1	28.9	78.5
Scallops	7.6	1.3	8.9	4.5
Total	**288.5**	**320.8**	**209.0**	**276.5**

NOTES:
With the exception of scallops, product forms include whole fresh and frozen, frozen blocks, fresh and frozen fillets. Groundfish are cusk, hake, haddock, pollock, and ocean perch. Flatfish include halibut. Finfish weights are expressed in live weight equivalents and scallops in meat weights

Table 23. Top ten countries receiving exports of fishery products from the Northeast region, ranked by value of exports (millions of dollars), 1992-1993

Country	Value	
	1992	1993
Canada	119.1	137.1
Japan	72.5	100.5
France*	64.1	64.5
Italy*	37.0	26.4
United Kingdom*	12.9	21.5
Spain	12.5	14.0
Netherlands*	5.6	11.3
Belgium	10.9	9.0
Germany*	8.8	8.7
South Korea	0.5	7.1
Total	343.9	400.1

* = European Union member

Table 24. Marine products processing and wholesaling establishments and their employment levels for 1988-1993

	Processing		Wholesaling		Total	
	Plants	Employees	Plants	Employees	Plants	Employees
1988						
New England	261	6582	626	2470	887	9052
Mid-Atl. *	210	7805	363	2789	573	10594
Northeast	471	14387	989	5259	1460	19646
1989						
New England	252	6182	681	2744	933	8926
Mid-Atl. *	191	7472	371	2860	562	10332
Northeast	443	13654	1052	5604	1495	19258
1990						
New England	247	5832	689	2928	936	8760
Mid-Atl. *	178	6890	357	2278	535	9168
Northeast	425	12722	1046	5206	1471	17928
1991						
New England	245	5530	685	2976	930	8506
Mid-Atl. *	166	6776	333	2158	499	8934
Northeast	411	12306	1018	5134	1429	17440
1992						
New England	232	5367	698	2912	932	8279
Mid-Atl. *	171	6516	364	2354	529	8870
Northeast	403	11883	1062	5266	1465	17149
1993**						
New England	221	4727	670	3041	891	7768
Mid-Atl. *	161	6027	348	2490	509	8517
Northeast	382	10754	1018	5531	1400	16285

* Mid-Atlantic region includes Virginia, Maryland, Delaware, New Jersey, New York, and Pennsylvania
** 1993 data are preliminary

Canada has traditionally been the largest trading partner for the New England states. In 1993, imports from Canada of cod, groundfish, and flatfish declined (Table 22). Canada has closed some of its major fishing grounds during the past year, an important factor in the decline of imports from Canada. Reductions in Canadian imports in 1993 were offset by increases ($55.7 million) in imports of fishery products from other countries (Table 22).

Table 23 lists the top ten countries by value receiving fishery product exports from the Northeast region in 1992 and 1993. Canada generated the highest value followed by exports to Japan. However, the next seven nations all belong to the European Union and, as a block, are more important than either Canada or Japan. Exports to the top ten nations in 1993 increased 16% in value and accounted for 94% of the value of all fishery products exported from the Northeast region.

PROCESSING

Fish processing in the Northeast Region utilizes both domestic landings and, increasingly, imported products. Processing is defined as any activity that adds value to raw products such as filleting, cooking, breading, canning, or smoking. The most important processed products, by value, are fresh or frozen fish fillets, and breaded, cooked fish. New England plants produce the majority (92%) of fresh and frozen fish fillets, steaks, or portions, while Mid-Atlantic plants produce 73% of canned products and 91% of the cured products. Edible fish product processing of regionally caught species was again led by surf clam processors, producing canned products of whole and minced clams, chowder, and juice.

The number of plants and their average annual employment levels, as identified in the annual processed product surveys during 1988-1993, are shown in Table 24. Employment in both New England and Mid-Atlantic plants has declined annually since 1988, as has the average number of employees per plant.

The number of processing firms has also declined reflecting the shrinking supply of fresh domestic fish.

FOREIGN FISHING AND JOINT VENTURES

Directed foreign fishing operations in the Northeast Region began with the passage of the Magnuson Act in 1976, and joint venture arrangements started in 1982. Since that time, directed foreign

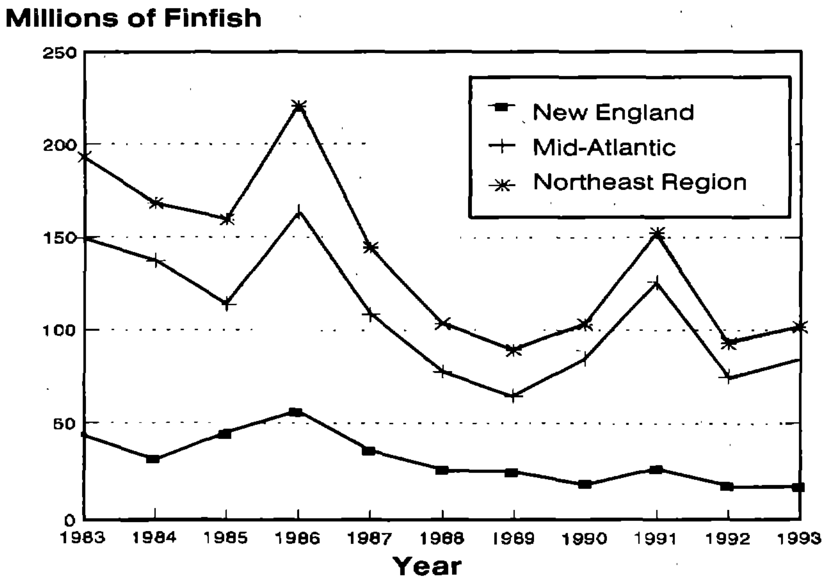


Figure 8. Estimated number of fish caught by recreational fishermen, by subregion

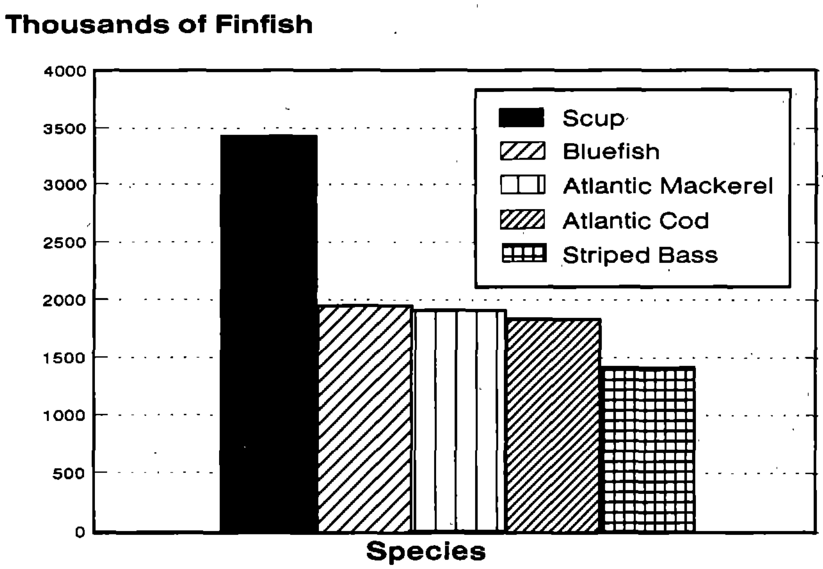


Figure 9. Top five species caught in New England in 1993

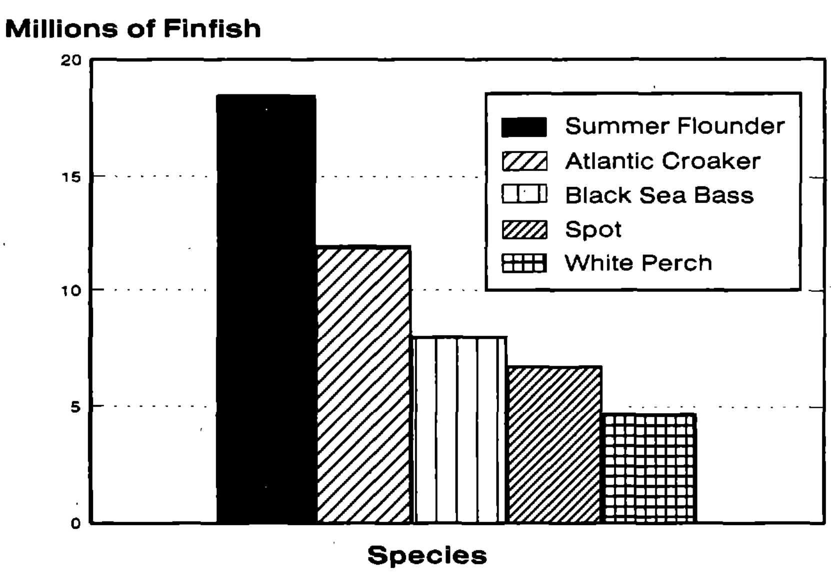


Figure 10. Top five species caught in the Mid-Atlantic in 1993

fishing has been phased out; in 1992, no foreign fishing allocations were given.

In 1993, no joint ventures occurred within the U.S. Atlantic coast EEZ.

RECREATIONAL FISHING

Data collected in the 1993 Marine Recreational Fisheries Statistics Survey (MRFSS) indicate that the total number of finfish caught by recreational anglers in the Northeast Region increased slightly from 1992 (Figure 8).[1] The 1993 catch (101.5 million fish) was 9% greater than 1992 (92.8 million fish) and 12% greater than the 1989 level of 89.2 million fish. Catches in the Mid-Atlantic increased 11% (from 75 million in 1992) to 84 million, while catches in New England fell slightly (from 17.7 million in 1992) to 17.4 million in 1993.

Scup, bluefish, Atlantic mackerel, Atlantic cod and striped bass were the most common recreationally-caught species in 1993 in New England (Figure 9). Together, these five species constituted roughly 61% (by number of fish) of the total recreational catches in New England. Summer flounder, Atlantic croaker, black sea bass, spot and white perch were the most commonly caught species in the Mid-Atlantic in 1993 (Figure 10), and accounted for about 59% of the total recreational catches in number in this region.

Recreational fishing effort in the Northeast Region increased slightly in 1993. Approximately 18.7 million trips were taken, a 4% increase over 1992 (17.9 million; Figure 11). Anglers in the Mid-Atlantic accounted for about twice as many trips as their counterparts in New England. This can be partially attributed to the longer fishing season in the Mid-Atlantic.

Private and rental boats accounted for the highest%age of recreational fishing effort in the Northeast Region (52% of total fishing trips). Shore fishing was second (36% of trips), and party and charter boat fishing was third (Figure

[1] The time series of recreational catch is currently under revision by the MRFSS. At press time, revised estimates were available for 1989-1993.

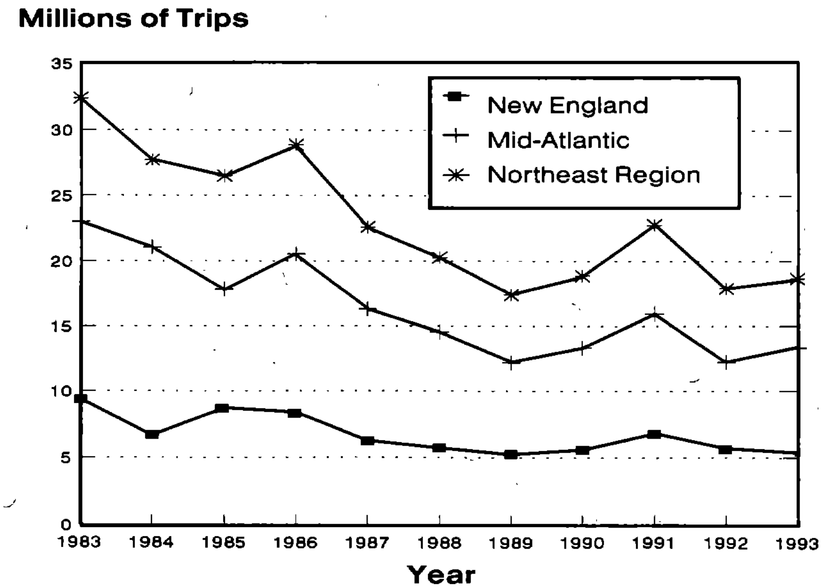


Figure 11. Estimated number of recreational fishing trips by subregion.

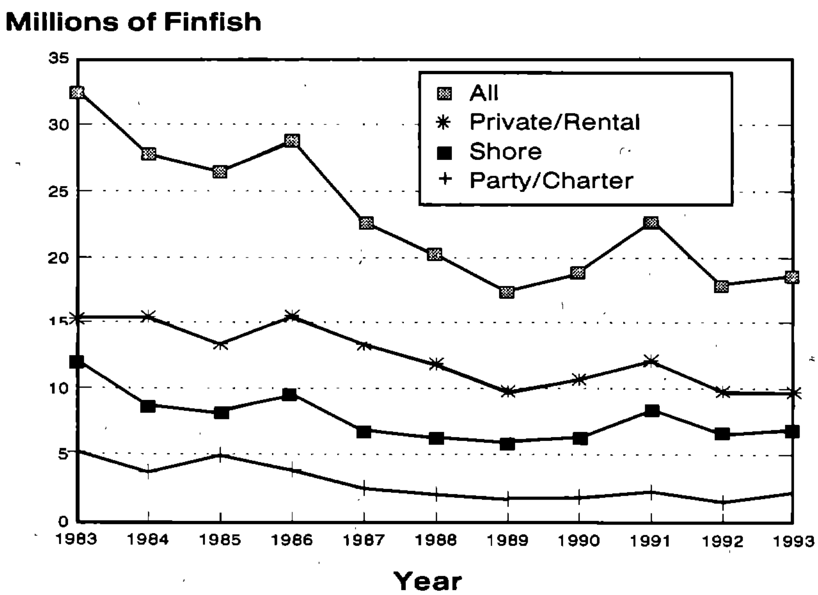


Figure 12. Estimated number of recreational fishing trips by mode in the Northeast Region.

12). Effort declined slightly in the private/rental mode (from 9.8 million trips in 1992) to 9.7 million. Shore fishing and party/charter boat fishing increased moderately (from 6.6 million and 1.5 million trips) to 6.8 million and 2.2 million, respectively.

Recently, NMFS has expanded efforts in the Northeast Region to collect marine recreational economic data needed to assess the economic demand for and value of recreational fishing. A comprehensive economic survey of recreational anglers in the Northeast Region has recently been designed to reduce economic and research gaps in our knowledge of marine recreational fishing. The economic value of marine recreational fishing will be an essential component in future fishery management decisions, and foundations must be developed within which future recreational policies can be evaluated.

NET NATIONAL BENEFITS

Previous issues of this report have discussed how economics relate to the Magnuson Fishery Conservation and Management Act of 1976, and presented various economic concepts, including resource rents and the economic value of fish resources based on their ability to grow and reproduce. Little has changed in the Northeast Region that would develop resource rents, beyond moratoria on entry in the groundfish and sea scallop fisheries.

Fishery Observer Program

by S. Murawski
K. Mays
D. Christensen

The Northeast Fisheries Science Center has conducted a large-scale program in which trained scientific observers are sent to sea aboard commercial fishing vessels. This program is not new in its concept - - 'sea sampling' of Northeast groundfish trips dates back to 1913 (Alexander *et al.* 1915). What is different is the scope, objectives and intensity of the modern program. This year observers will sample on about 1600 fishing trips and collectively spend the equivalent of 10 years at sea (Table 25).

WHY SAMPLE CATCHES AT SEA?

Landings from commercial fishing trips have been sampled in northeast ports for well more than 100 years. Logistically, landings tend to be relatively easy to monitor and sample. Why then go to the great expense of sending observers to sea aboard a very small fraction of the total trips taken in a fishery? Quite simply, the NEFSC Fishery Observer Program provides data that are unobtainable by just sampling landings. The objectives of this program are many and varied:

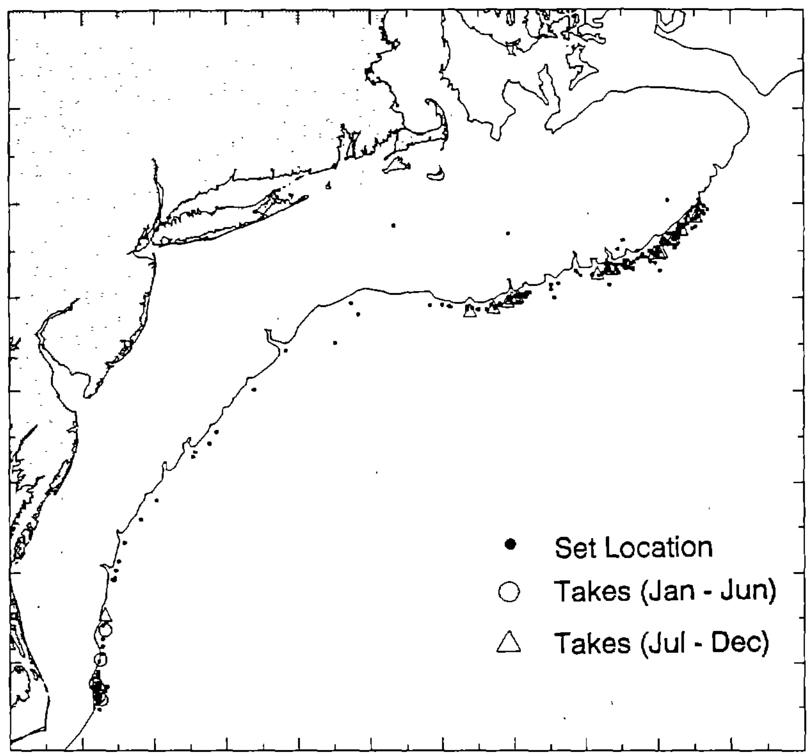


Figure 13. Locations of 'takes' of bottlenose dolphins in drift nets set for large pelagic fish species (*e.g.* swordfish and tunas) off the Northeast United States, 1989-1992. Data are from sea sampled trips only. Takes refer to both mortalities and animals caught by the gear but released alive.

1. Estimates of Takes of Protected Species

Marine mammals, sea turtles, and sea birds are protected by a variety of statutes aimed at minimizing potential negative interaction with fisheries and other activities. Chief among these statutes are the Marine Mammal Protection Act and the Endangered Species Act. Sea sampling to document catches of protected species has been concentrated in several specific fisheries: groundfish gill net in the Gulf of Maine, swordfish longline, pelagic drift-net, and pelagic pair trawl. Observers document each take of a marine mammal, bird, turtle, *etc.* Takes are defined as a mortality, a live release, or an observed escape during gear retrieval (Figure 13). A significant fraction (>10%) of vessel trips in these fisheries are sampled annually. Total takes are estimated by expanding takes on sea sampled trips to all trips made by the corresponding fleet. The selection of trips sampled is done carefully so as to be representative of the fleet's performance by season and area, and other factors.

Table 25. Observer trips and days at sea completed in different domestic fisheries

Fishery	1989		1990		1991		1992		1993	
	Trips	Days	Trips	Days	Trips	Days	Trips	Days	Trips	Days
Otter trawl										
Mid-Atlantic	39	138	46	141	85	257	61	241	30	121
Gulf of Maine	68	202	34	87	84	200	61	237	30	155
Georges Bank	51	337	38	230	40	229	41	281	33	239
S. New England	52	158	32	145	71	254	42	175	38	133
Total otter trawl	**210**	**835**	**150**	**603**	**280**	**940**	**205**	**934**	**131**	**648**
Shrimp trawl	40	47	31	34	54	59	85	92	75	76
Gillnet										
New England sink	102	132	141	188	965	1217	1190	1400	754	887
Swordfish drift	13	100	9	67	10	80	18	171	9	134
Mid-Atlantic	0	0	0	0	0	0	0	0	20	22
Total gillnet	**115**	**232**	**150**	**255**	**975**	**1297**	**1208**	**1571**	**783**	**1043**
Swordfish longline	0	0	2	32	5	85	14	289	35	398
Groundfish longline	0	0	0	0	17	28	17	28	3	4
Tuna pair trawl	0	0	0	0	0	0	9	67	18	151
Bottom pair trawl	0	0	0	0	0	0	0	0	5	39
Sea scallop dredge	0	0	0	0	2	21	15	186	21	265
Sea bass pot	8	8	10	10	5	5	0	0	0	0
Lobster pot	3	18	7	29	3	30	3	16	5	33
Total- all fisheries	**376**	**1140**	**350**	**963**	**1341**	**2465**	**1556**	**3183**	**1076**	**2657**

2. Estimates of Discards of Fishery Resources

Catches brought aboard fishing vessels are mainly sorted for marketable species and sizes, with the unwanted or non-marketable portion of the catch discarded at sea (Figures 14-16). The 'discards' occur because prohibited or low-valued animals are caught along with the marketable species sought. In some fisheries, large catches of undersized commercial species also occur and result in substantial quantities of the species catch being discarded. In the Northeast, low-valued species such as dogfish, skates, and sculpins are often together taken along with high-valued species such as flounders, cods, and hakes, and these low-valued species are commonly discarded. Accurate stock assessments require that all deaths due to the fishery - - either as landings or discards -- be measured. Measuring the effects of fishing activities on the ecosystem also requires information on catches of all species, even if they are totally discarded.

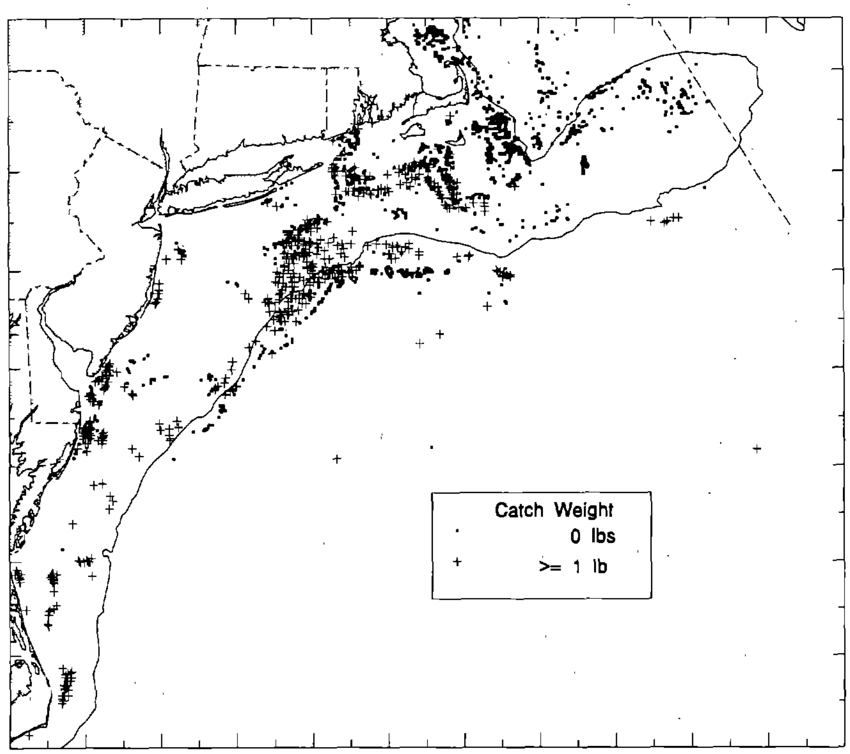


Figure 14. Locations of otter trawl tows observed by sea samplers, along with locations where summer flounder were caught in 1991. Data are given for the region from Georges Bank to Cape Hatteras.

At-sea sampling of fishermen's catches provides the most reliable (albeit a very costly) method of acquiring data on the quantity and species composition of discards, as well as information on the specific reasons why animals are discarded (*i.e.*, too small, no market for the species, fish damaged, *etc.*). With these data, it is possible to more completely understand the effects of fishing and to estimate the potential biological and economic benefits of changes in conservation and management measures (*i.e.*, minimum legal sizes, trip quotas for individual species, *etc.*).

3. Biological Sampling of the Catch

Scientific observers aboard fishing vessels also collect biological samples of the catch (Figures 17-19). Size and age samples and other observations taken at sea (*e.g.*, sexual maturity) are often not obtainable by sampling dockside landings or if so, samples may be biased towards legal sizes or valuable species. Size and age samples of discards permit the estimation of discard size age composition, which often differs considerably from that in the landings. In most cases, discard of marketable species are of small fish, although damaged legal-sized fish may also be discarded.

Because sea sampling occurs throughout the year, the program affords an excellent opportunity to collect samples of fish gonads and other parts to study seasonal cycles of sexual maturity and growth. The latter is especially important since validation of the timing of annual marks on fish scales or ear bones (otoliths) is an important first step in developing a reliable method to routinely 'age' fish, scallops, clams, mammals, *etc.*

The Sea Sampling Program also allows for biological sampling of species that come to port, but not as whole fish. For example, goosefish (monkfish) are generally landed as 'tails', livers, and more recently, 'cheeks' and 'skin'. Reliable samples for catch size composition of the catch can only be taken when the fish are whole, or if an appropriate 'conversion factor' can be estimated. Sea sampling allows for estimation of size composition of goosefish, white hake, sea scallops, and other species that are not usually landed whole.

Biological samples are also obtained for species that are totally discarded. These samples provide the major source of biological data on age, food habits, maturities, *etc.*, for protected species (*e.g.*, harbor porpoise, birds, sea turtles). Like-

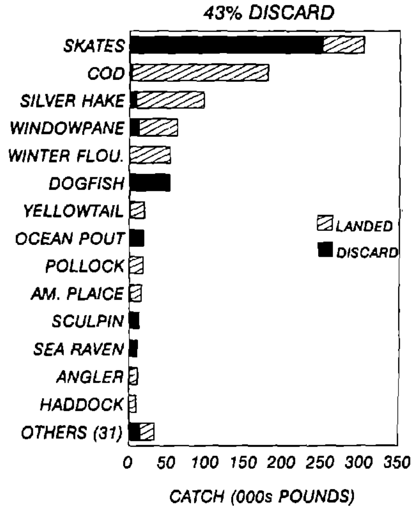


Figure 15. Species composition of otter trawl catches in sea sampling trips on Georges Bank in 1991. Catch by species is divided into the proportion discarded and landed. Overall, 43% of the catch weight was discarded, primarily skate, dogfish, ocean pout, and other low-valued species.

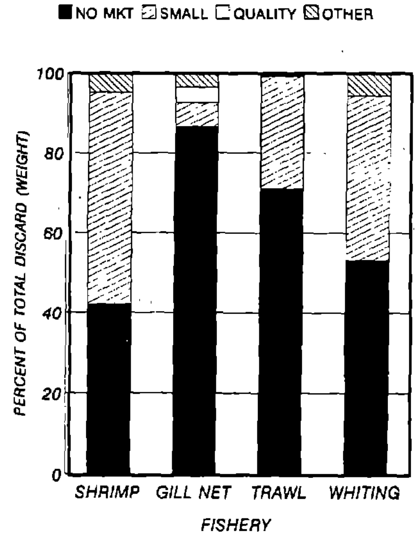


Figure 16. Reasons given for the discard of catch in sea sampling trips in the Gulf of Maine during 1991. Note that the reasons for catch discard vary considerably by fishery.

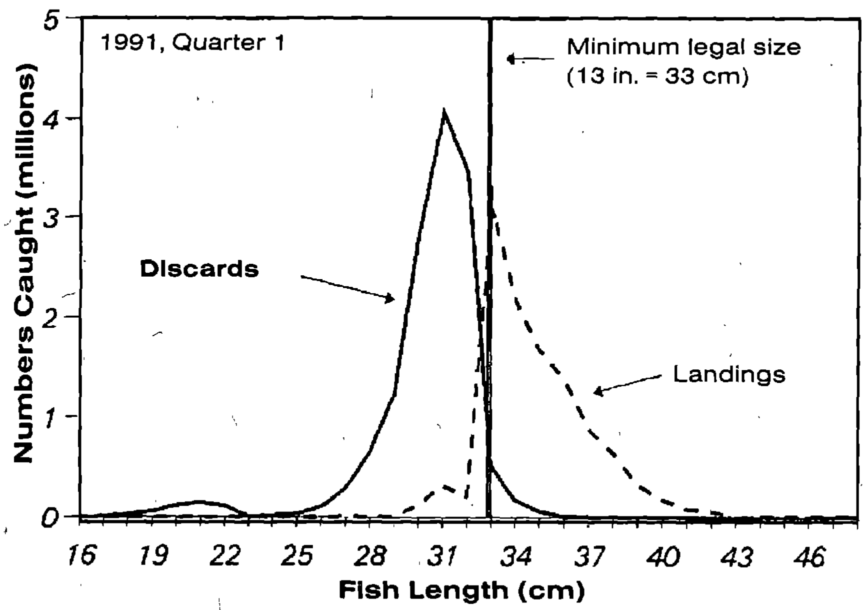


Figure 17. Size composition of yellowtail flounder catches during the first quarter of 1991. Discard size compositions are based on samples collected on sea sampling trips, landings size compositions are derived from port samples. Taken in aggregate, the catch is composed primarily of a single size mode, centered at 31 cm (12 in.). The minimum legal size is 13 in., resulting in a substantial quantity of discards.

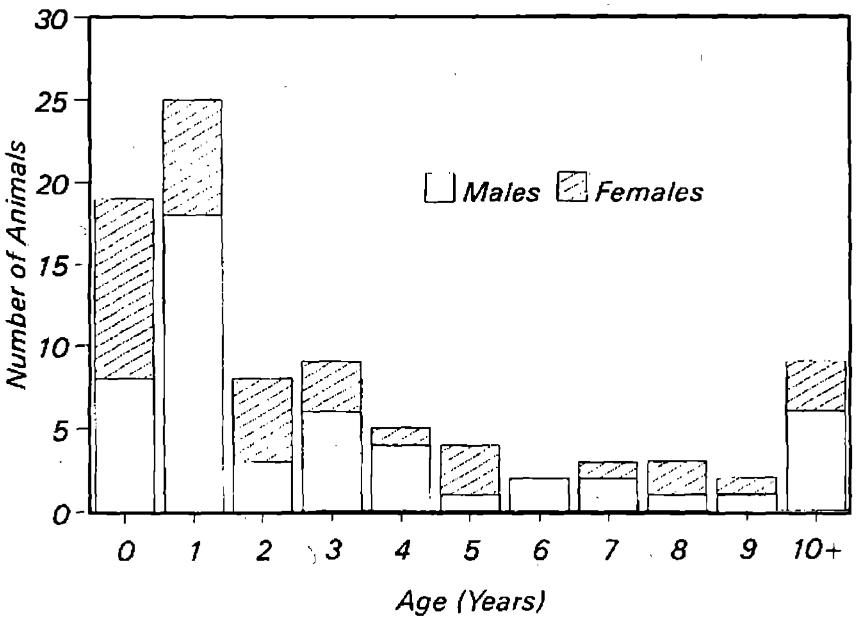


Figure 18. Age composition of harbor porpoises obtained during sea sampling trips aboard sink gillnet vessels in the Gulf of Maine. No animals were sacrificed for the purposes of biological sampling. The data were obtained from animals that were dead when brought aboard.

Observers document how protected species like sea turtles are encountered during commercial fishing. *NMFS/NEFSC photo*

wise, observations on non-commercial fish species allow a more complete picture of the effects of harvesting on the entire fishery system.

4. Design and Monitoring of Conservation Gear

Reduction in discards of finfish and protected species has been attempted using a variety of methods, including the development of more selective fishing gear. The development and deployment of such gear requires testing (*i.e.*, to ensure the gear can be safely and efficiently used) and validation (*i.e.*, to ensure this gear is having the intended effect).

In the Gulf of Maine northern shrimp fishery, for example, the Nordmore grate was tested and subsequently implemented as a method to reduce the take of juvenile groundfish (Figures 20 and 21). Sea sampling was used in the initial gear trials, and the at-sea observer program continues to monitor the fishery following full implementation of the grate requirement. The fishery observer data indicate significant reductions in finfish bycatch after introduction of the Nordmore grate in the shrimp fishery. Although reduced catches of important groundfishes are in part due to their decreased abundance in recent years, the grate has been effective in reducing the fraction of finfish caught in this fishery, thereby reducing fishing mortality on young groundfish.

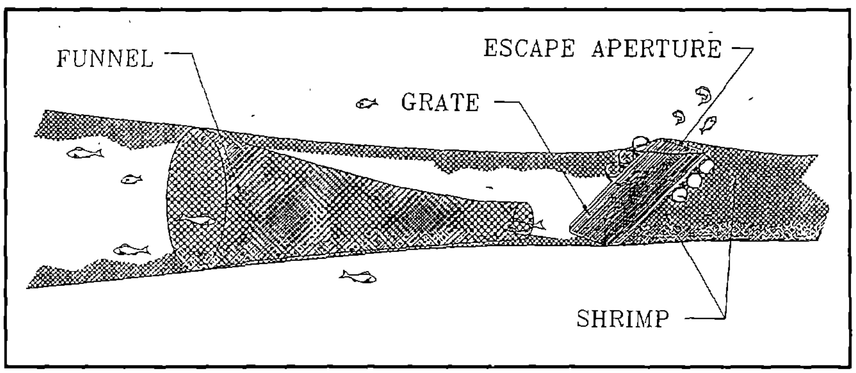


Figure 20. Schematic of the Nordmore grate system required in shrimp trawls in the Gulf of Maine. A rigid plastic grate is fixed in the net, with a hole in the net near the top of the grate. Fish and shrimp are funneled across the grate, where shrimp and small items pass through the grate into the cod-end of the net. Most fish are larger than the bar spacing of the grate, and thus pass up its inclined surface, and out the hole in the top of the net.

Similar studies evaluating the effectiveness of acoustic alarms to deter harbor porpoise from entering groundfish sink gillnets have also been conducted using scientific observers. The study involved alarm-equipped and control nets, fished in the vicinity of harbor porpoise aggregations. Results from this work are currently being evaluated to determine the efficacy of this method in reducing harbor porpoise mortalities.

Other gear-related studies in which at-sea observers were used include evaluating the effectiveness of changes in trawl mesh size (*e.g.*, for New England groundfish), and assessing the effects of changes in scallop meat count requirements, and minimum dredge ring sizes on the size composition of scallop catches.

5. Monitoring of Experimental Fisheries

The use of 'experimental fisheries' in the Northeast has occurred when industry has sought to develop fisheries that conflict with current regulations, or when new fishery opportunities arise. Experimental fisheries currently exist for silver hake (whiting) on the Cultivator Shoals area of Georges Bank, for ocean quahogs in the Gulf of Maine, and a spiny dogfish fishery in the southern New England area. In the Cultivator Shoals fishery, small mesh fishing for whiting is allowed within the boundaries of the regulated 'large mesh' area. This fishery is closely monitored for the catch of regulated species such as cod, flounders, and haddock. To date, sea sampling observations have documented very low bycatches of regulated species and the whiting fishery has thus been allowed to continue. Without the sea sampling evidence, it is doubtful that this fishery would have been allowed to proceed.

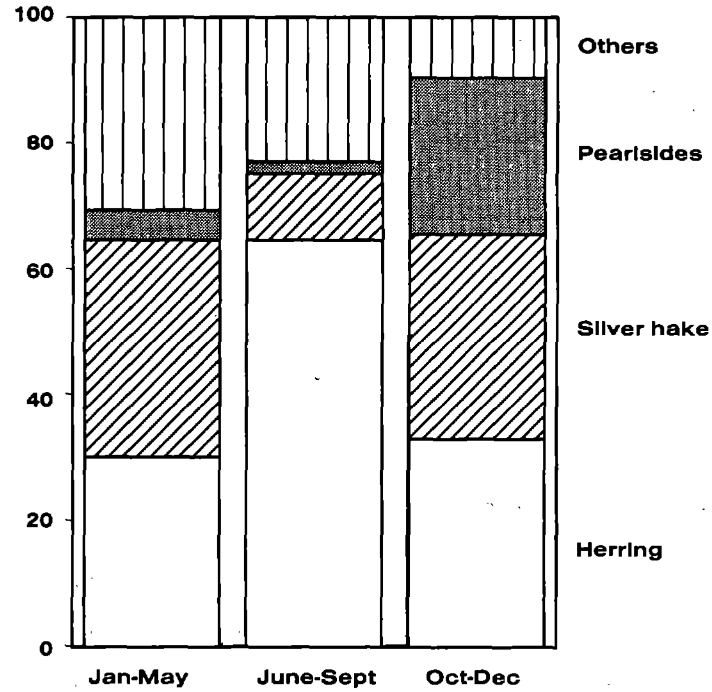


Figure 19. Diet composition of incidentally-caught harbor porpoises taken during sea sampling trips in the Gulf of Maine sink gill-net fishery.

6. Economic Information on Revenue and Costs

What is the economic 'health' of a fishery? Revenue data (*e.g.*, landed value) collected from fishermen and dealers in the ports provide the income side of the economic equation. However, data on the costs of fishing are scarce and difficult to obtain. Fishery observers attempt to fill this gap by soliciting information from participating vessel owners and captains regarding the costs of expendables (ice, fuel, gear, bait), labor (captain, crew share), and other fixed costs (repairs, electronics, and hull expenses). Other economic data are requested through follow-up questions after completion of the sea sampling trip. The intent of these studies is not to pry into the workings of individual businesses, but to better understand the economic 'health' and proficiency of fishing. This information is extremely important in the fishery management process, be-

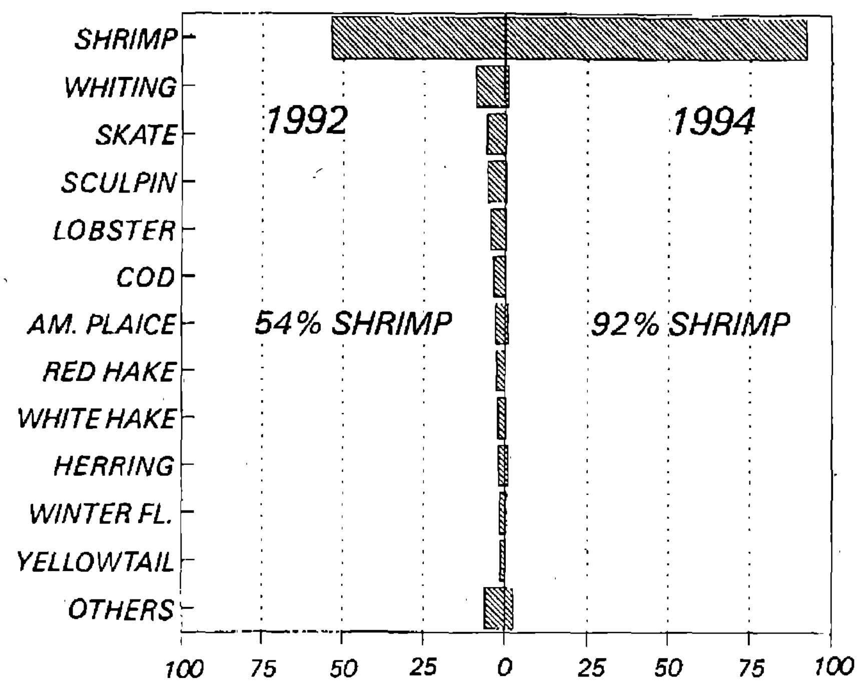


Figure 21. Species composition of catches in sea sampling trips in the Gulf of Maine northern shrimp fishery, 1992 and 1994. In 1992, no observed trips were equipped with the Nordmore grate, whereas in 1994, the grate was required. Note that the proportion of shrimp in the total catch increased from 54 to 92%. Although groundfish abundance decreased during the period, the dramatic effect of the grate is nevertheless apparent.

Observers collect information while accompanying commercial fishermen during active fishing. These individual records are confidential, and data is reported only after it has been aggregated with that from many other vessels and trips to form an overall picture of fleet activity. *NMFS/NEFSC file photo*

cause it allows quantitative analysis of the potential economic impacts of various management options. Federal rules require that the long-term economic benefits of regulation exceed the short-term costs of such measures. Net economic benefits are the sum of two components: benefits (and costs) to the producers (*e.g.*, fishermen), and benefits and costs to consumers. Detailed information on wages and levels of employment in the fisheries is essential in determining the effects of regulations on jobs in the harvesting sector. The sea sampling program provides an important source of contact with knowledgeable individuals in the industry best able to provide such data.

7. Gear Performance and Characteristics

When scientific observers are deployed aboard commercial vessels, they make detailed measurements of various attributes of the fishing gear, including how it is rigged and deployed. These measurements are important for two reasons. First, by noting variables of mesh size, number of hooks, time of trawl tow, hanging dimension (*e.g.*, square *vs.* diamond mesh) *etc.*, in relation to the catch attributes (quantity, species composition, size distribution of catch) it is possible to conduct statistical analyses of the factors that result in high (or low) rates of discard, species mix, changes in catch rate, *etc.* Second, gear performance observations, when collected over time, can be used to better calibrate catch-per-unit-effort abundance measures. For example, if the average size of nets, duration of tow, ground-cable length, *etc.*, increases over time, these may have a direct effect on catch per day fished by the fleet (even for same sized vessels). Given sufficient information, these factors can be included in research assessment analyses to provide a more complete and accurate picture of fishing intensity and effectiveness.

8. Foreign Fishery Monitoring

The Magnuson Act allows foreign fisheries to occur within the U.S. EEZ when a surplus of fish, not likely to be taken by U.S. citizens, is determined to be available. This situation has not occurred in several years, but did occur throughout the 1970s and 1980s. Under these provisions, foreign fishing companies are required to pay a set fee per ton of fish landed, and to assume the costs of providing 100% observer coverage on their vessels. The observers collect the same information as that obtained from domestic sea sampling trips. The fate of foreign fishing in the Northeast EEZ is uncertain. If it does occur in the future, the sea sampling program will again be used to monitor these fishing activities.

9. Contact with Fishermen

Sea sampling programs have always provided an excellent channel for two-way communication between fishermen and fishery scientists. In the 1970s and 1980s, sea sampling was conducted primarily by stock assessment scientists who were interested in obtaining first-hand knowledge of the fisheries and in talking one-on-one with fishermen. Although valuable to the scientists, at that time the sea sampling program could only sample about two dozen trips per year, far too few for a meaningful representation of the fleet. The current domestic fishery observer program is a significant expansion over the early efforts, as are today's mandated data collection requirements. The program remains, however, an important link between scientists and fishermen. Ideas, complaints and information communicated between sea samplers, captain, and crew are a valuable source of information for all parties, and we hope to strengthen this aspect of the program in the future.

SEA SAMPLING OPERATIONS

The NEFSC fishery observer program is unique in that the majority of funds for the program are provided to an independent contractor (currently the Manomet Observatory for Conservation

Sciences, Manomet, Massachusetts). The contractor hires observers, administers the logistics of observer deployment and debriefing, and enters all observer data into computer files. The small staff of the NEFSC sea sampling investigation provides logistical and contract support, and translates the priorities of the Center's programs into a detailed schedule of fisheries to be sampled and at what frequency. Data from the fishery observer program are made available to Center staff of the Population Dynamics Branch (for use in fish stock assessments), the Marine Mammal Investigation (for use in protected species assessment), and the Economics Investigation (for use in assessments of fishery performance). Individual vessel records are not available to anyone else, and are held in strict confidence. Summaries of sea sampling data, appropriately aggregated so individual vessels cannot be identified, are provided to NMFS Regional Office and regional Fishery Management Councils to support quantitative evaluations of various management actions.

Fishery observers themselves have varied backgrounds. A large number of the observers are recent college graduates with a concentration in biology. Some have extensive practical experience in commercial fishing or other maritime occupations. Training of observers is comprehensive. An initial three-week training course is given by NEFSC staff, with the assistance of experts in a variety of fields. Observers are instructed in fish, mammal, bird, turtle, and invertebrate species identification; gear identification and measurement; marine safety and survival skills; and fishery regulation and enforcement (although observers are not affiliated with the enforcement side of NMFS or the Coast Guard). The extensive recordkeeping requirements of the job are reviewed, as is proper ship-board etiquette.

Priorities for sea sampling of various fisheries are determined by: (1) national priorities (*i.e.*, endangered or protected species such as marine mammals); (2) priorities of Fishery Management Councils; and (3) scientific priorities related to stock assessment activities. For the past several years, most 'sea days' have been spent monitoring fixed-gear fisheries for takes of protected species (*e.g.*, harbor porpoise takes in the Gulf of Maine sink gill-net fishery).

Priorities for sea sampling not related to protected species currently are: (1) monitoring of closure areas and experimental fisheries on Georges Bank; (2) collection of discard data in the summer flounder fishery, (3) monitoring of discards in the Gulf of Maine northern shrimp fishery; (4) sampling of the sea scallop fisheries in the Middle-Atlantic and Georges Bank; and (5) large-mesh otter trawl fishery sampling throughout the entire Northeast region.

The NEFSC Sea Sampling program has proved to be a valuable source of information on the region's fisheries, unobtainable by other means. Data acquired in this program have been important in helping to sharpen the species and size selectivity of several fisheries in the Northeast and in reducing unwanted bycatch. Furthermore, these data have resulted in improved biological and economic assessments of the status of the region's fisheries. The cooperation of various owners, captains, and crew in assisting with the immense logistics of this program is greatly appreciated.

For more information

Alexander, A. B., H. F. Moore and W. C. Kendall. 1915. Report on the otter trawl fishery. *Report of the U.S. Commissioner of Fisheries for the fiscal year 1914*: Appendix VI. *Bur. Fisheries Doc.* 816.

Anderson, J. 1992, unpublished. Sea sample database system (SSDBS) users manual. Woods Hole, MA: NOAA/NMFS/NEFSC.

NEFSC Marine Mammal Investigation, eds.. 1992. Harbor porpoise in eastern North America: status and research needs. Results of a scientific workshop held May 5-8 1992. Woods Hole, MA: NOAA/NMFS/NEFSC. *Ref. Doc.* 92-06.

Murawski, S. A. 1994. Opportunities in bycatch mitigation. *In* R. H. Stroud, ed., p. 299-312, Conserving America's Fisheries: A National Symposium on the Magnuson Act. Savannah, GA: National Coalition for Marine Conservation.

Read, A. J., J. E. Craddock, D. Gannon. 1994. Life history of harbor porpoises and pilot whales taken in commercial fishing operations off the Northeastern United States. Final Report Contract 50-EANE-2-00082. Woods Hole, MA: NOAA/NMFS/NEFSC.

Species Synopses

The synopses of information on the status of the stocks of the 39 species or groups of species presented in this section are based on commercial and recreational fishery data and on research survey data, as described in the Introduction to this report. The synopses are arranged by major groups: principal groundfish, flounders, principal pelagics, other pelagics, invertebrates, anadromous fish, and marine mammals. Each synopsis briefly reviews the biology of the animals and the general nature of the fishery, summarizes recent catch statistics and research survey results, indicates the general status of the stock, and where possible, predicts future stock status.

For each stock or species a summary table[1] of catch statistics is presented, along with one or more graphs showing how landings and stock abundance have varied over time. The measures of stock abundance include research vessel survey catch per tow, estimated stock biomass from virtual population analyses, and catch per unit of fishing effort.

Indices of abundance from the NEFSC research vessel bottom trawl surveys were fit to a time series model (autoregressive integrated moving average (ARIMA) (Box and Jenkins 1976, Forgarty *et al.* 1988, NEFC 1988, Pennington 1985, 1986). The approach is based on the concept that the biomass of multi-age class stocks should not be expected to change radically from year to year without the identification of a reasonable causative agent. The ARIMA model filters the effects of measurement error (random within survey variation) in the survey abundance indices from true variation in population levels and therefore provides better estimates of population trends. Abundance indices from special surveys such as the NEFSC scallop and clam surveys, and the Massachusetts Division of Marine Fisheries bottom trawl survey were not modeled using ARIMA due primarily to the shorter durations of these time series.

References in the text to catches or indices of abundance usually refer to values given in the tables and figures. In some cases, however, summary statistics provided in the text for different areas, fishing gears, or data sources are not presented in the tables and figures.

Catch statistics in the tables are given in thousands of metric tons (mt), rounded to the nearest 100 mt; values less than 100 mt are indicated as <0.1. Values less than 10 are indicated by a dash, and values not yet available are indicated by N/A.

Many of the assessments summarized in this section are presented in greater detail in NEFSC Reference Documents, which may be obtained from the Northeast Fisheries Science Center upon request. Additionally, in recent years, the NEFSC has reviewed assessments of selected species-stocks at semi-annual Stock Assessment Workshops. The reports of these workshops, cited in many of the species synopses sections, are also available on request from the NEFSC.

For further information

Box, G.E.P. and G. Jenkins. 1976. Time series analysis:forecasting and control. Revised edition. San Francisco: Holden-Day.

Fogarty, M.J., J.S. Idoine, F.P. Almeida and M. Pennington. 1986. Modeling trends in abundance based on research vessel surveys. *ICES* [International Council for Exploration of the Sea] *C.M.* 1986/G:92.

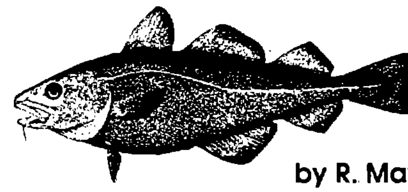
Northeast Fisheries Center. 1988. An evaluation of the bottom trawl survey program of the Northeast Fisheries Center. *NOAA Tech. Memo. NMFS-F/NEC* 52.

Pennington, M. 1985. Estimating the relative abundance of fish from a series of trawl surveys. *Biometrics* 41:197-202.

Pennington, M. 1986. Some statistical techniques for estimating abundance indices from trawl surveys. *Fish Bull.* (U.S.) 84:519-526.

[1] The tables and figures in this section are labeled using decimal notation by species and by table or figure within that species. For example, Figure 7.3 indicates the third figure for the seventh species synopsis, yellowtail flounder.

Atlantic Cod



by R. Mayo

The Atlantic cod, *Gadus morhua*, is a demersal gadoid species distributed in the Northwest Atlantic from Greenland to North Carolina. Cod are omnivorous feeders and commonly attain lengths up to 130 cm (51 in.) and weights up to 25 to 35 kg (55 to 77 lb). Maximum age is in excess of 20 years, although young fish (ages 2 to 5) generally constitute the bulk of the catch. Sexual maturity is attained between ages 2 to 4; spawning occurs during winter and early spring.

In U.S. waters, cod are assessed as two stocks: Gulf of Maine, and Georges Bank and Southward. Important commercial and recreational fisheries are supported by both stocks. The commercial fisheries are conducted year round with otter trawls and gillnets as primary gear. Recreational fishing also occurs year round; peak activity occurs during the late summer in the lower Gulf of Maine, and during late autumn to early spring from Massachusetts southward.

Growth rates differ between the two stocks, although each is exploited by the same gear types with similar selection characteristics. Growth of cod has traditionally been slower in the Gulf of Maine than on Georges Bank but appears to have increased in the most recent years. Sexual dimorphic growth differences have also become less pronounced in both stocks.

United States commercial and recreational fisheries for cod are managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Total commercial cod landings from the Georges Bank and Gulf of Maine stocks in 1993 were 31,400 mt, down 21% from 39,500 mt in 1992 and 43% less than in 1991. United States commercial landings in 1993 totaled 22,900 mt, 18% less than in 1992 (27,800 mt), and the lowest since 1973.

Fisherman with cod, F/V *Kingfisher*, circa 1930
O.E. Sette Collection, NMFS/NEFSC Photo Archive

Basket of cod, R/V *Albatross* resource survey, 1990
NMFS/NEFSC Photo by Brenda Figuerido

"At the current level of fishing mortality, commercial landings are expected to decline to about 7,000 mt in 1994 and are likely to remain at or below that level in 1995."

Gulf of Maine

Total nominal commercial catch (exclusively United States) in 1993 was 8,300 mt, 24% less than in 1992 and a 53% decline from the record-high 1991 total of 17,800 mt. Commercial fishing effort (standardized days fished) was 20% lower in 1993 than in 1992 but still reflects a relatively high level of exploitation. Standardized commercial LPUE (landings per day fished) for otter trawls continued to decline in 1993 and was about 50% below the 1990 level. Directed trips, which accounted for between 15 and 49% of the annual U.S. otter trawl catch during 1984-1989, accounted for about 70% of the 1990 and 1991 total landings, but the fraction declined to 45% of the total in 1993.

Fishery age composition data indicate that commercial landings in 1993 were dominated by the below average 1990 year class, as well as survivors from the 1987 year class; the older cohort accounted for only 16% of the 1993 landings by number, but still represented 34% by weight.

The NMFS research vessel abundance and biomass indices declined to record low levels in both the autumn 1993 and spring 1994 surveys. Survey catch-at-age data indicate that the strong 1987 year class is no longer predominant, and has been replaced by a series of average to below-average year classes from 1988 through 1991.

Fishing mortality in 1993 remained at a relatively high level (F = 0.93) and was far above F_{max} (F = 0.27) and well in excess of the F needed to attain 20% maximum spawning potential ($F_{20\%}$ = 0.35), the management target established for this stock.

Atlantic Cod
Gulf of Maine

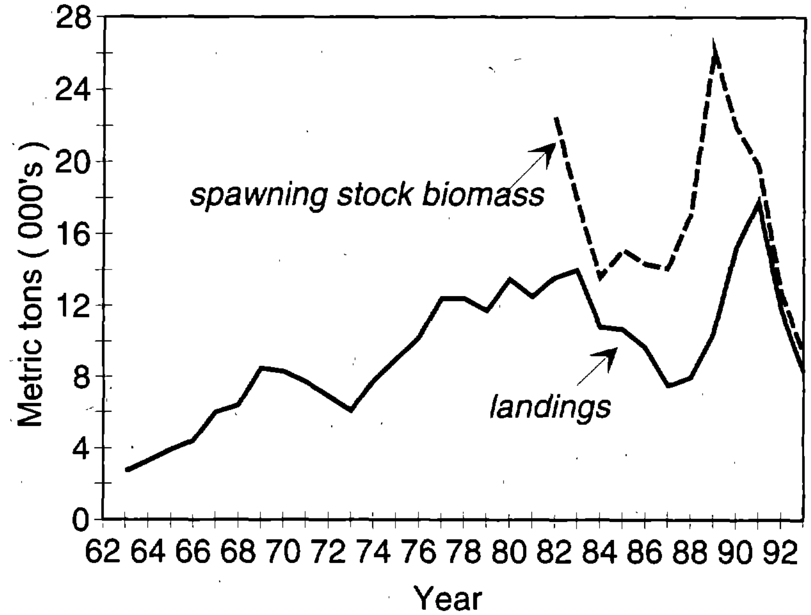


Table 1.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year: 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	1.9[1]	2.7	3.0	2.4	2.6	3.0	4.2	3.5	2.5	1.0	2.7
Commercial											
United States	11.7	10.8	10.7	9.7	7.5	8.0	10.4	15.2	17.8	10.9	8.3
Canada	<0.1	-	-	-	-	-	-	-	-	-	-
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	13.6	13.5	13.7	12.1	10.1	11.0	14.6	18.7	20.3	11.9	11.0

[1]1979-1983

Gulf of Maine Atlantic Cod

Long-term potential catch	=	10,000 mt
SSB for long-term potential catch	=	30,000 mt
Importance of recreational fishery	=	Major
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2.3 years, males 2.1 years, females
Size at 50% maturity	=	36 cm (14.2 in.), males 32 cm (12.6 in.), females
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%}$ = 0.35

M = 0.20 **$F_{0.1}$ = 0.16** **F_{max} = 0.27** **$F_{20\%}$ = 0.35**

F_{1993} = 0.93

The 1987 year class (17.8 million fish at age 2) is the largest in the 1982-1993 series and about twice the size of the above-average 1980 and 1986 year classes. Recent recruitment, however, has been poor as the 1988-1991 year classes (all ≤ 4.5 million fish) are among the poorest on record.

Spawning stock biomass (SSB) peaked in 1989 at 26,100 mt, following recruitment of the strong 1987 year class to the spawning stock. However, SSB subsequently declined to 9,400 mt in 1993 and is projected to decline further in 1994 and 1995 to about 8,000 mt as the 1987 cohort is fished out. If fishing mortality remains at the current level in 1995, SSB will continue to decline to unprecedented record low levels (between 6,000 mt and 7,000 mt) as the much weaker 1988-1991 year classes dominate the spawning stock.

At the current level of fishing mortality, commercial landings are expected to decline to about 7,000 mt in 1994 and are likely to remain at or below that level in 1995. By the end of 1994, the 1987 year class will be only a minor component of the stock.

The Gulf of Maine cod stock is at a low biomass level and is overexploited. Fishing mortality must be reduced substantially to halt the declining trend in SSB and eliminate overfishing.

Georges Bank and Areas to the South

Total commercial landings (United States and Canada) in 1993 were 23,100 mt, 19% less than in 1992. The 1993 U.S. catch (14,600 mt) was the lowest since 1972, and well below the 1977-1991 annual average of 28,700 mt. Canadian 1993 landings totaled 8,500 mt, 27% lower than in 1992. United States commercial fishing effort (standard days fished) declined by 3% between 1992 and 1993 but was only 6% below the record high 1991 level. United States commercial LPUE reached a record low in 1993 and has declined by more than 50% since 1990. Commercial landings in 1993 were dominated by the 1990 year class. This cohort alone accounted

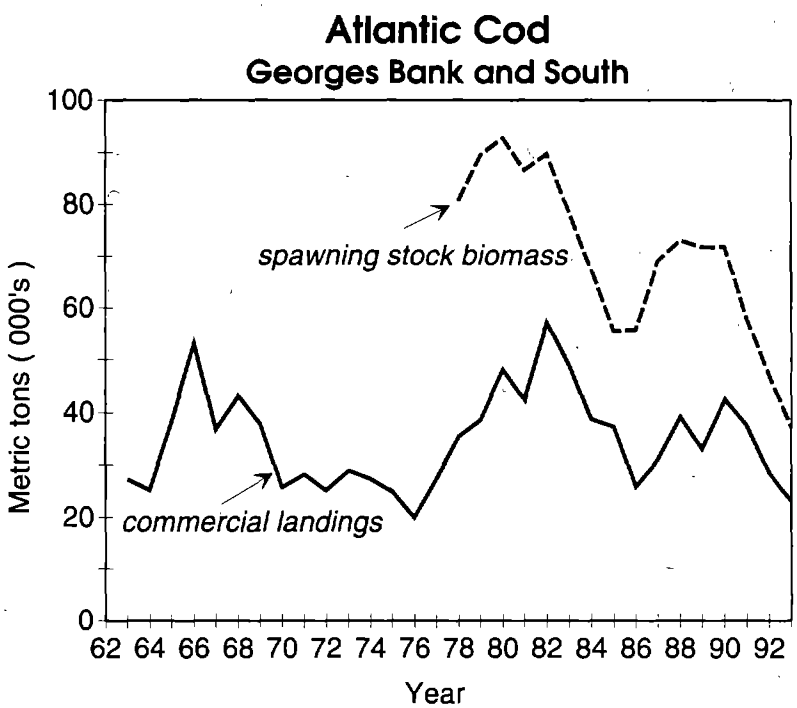


Table 1.2 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	4.9[1]	2.4	4.6	1.1	1.2	4.3	1.9	1.7	1.3	0.5	2.2
Commercial											
United States	27.9	32.9	26.8	17.5	19.0	26.3	25.1	28.2	24.2	16.9	14.6
Canada	7.3	5.8	10.5	8.4	11.9	12.9	8.0	14.3	13.4	11.7	8.5
Other	1.8	-	-	-	-	-	-	-	-	-	-
Total nominal catch	41.9	41.1	41.9	27.0	32.1	43.5	35.0	44.2	38.9	29.1	25.3

[1]1979-1983

Georges Bank Atlantic Cod

Long-term potential catch	=	35,000 mt
SSB for long-term potential catch	=	105,000 mt
Importance of recreational fishery	=	Major
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	1.9 years, males 1.7 years, females
Size at 50% maturity	=	41 cm (16.1 in.), males 39 cm (15.4 in.), females
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishering mortality rate corresponding to overfishing definition	=	$F_{20\%} = 0.36$

$M = 0.20$ $F_{0.1} = 0.16$ $F_{max} = 0.30$ $F_{20\%} = 0.36$ $F_{1993} = 0.91$

"The 1990 year class (22.2 million fish at age 1) was estimated to be slightly above average. Recent recruitment, however, has been extremely poor as four out of the last five year classes were well below average. The 1991, 1992, and 1993 year classes are the lowest on record."

Fishermen with cod, R/V *Atlantis*, 1927

O.E. Sette Collection, NMFS/NEFSC Photo Archive

for 55% of the catch by number and 41% by weight.

The NMFS research vessel survey indices in autumn 1993 and in spring 1994 were the second lowest and lowest, respectively, in the survey time series, and continue to indicate that the stock is at an extremely low level. The 1990 year class dominates the stock, with older fish almost nonexistent and incoming year classes relatively weak.

Fishing mortality in 1993 (F=0.91) was the highest on record, and far in excess of the F needed to attain 20% maximum spawning potential ($F_{20\%}$ = 0.36), the management target established for this stock.

The 1990 year class (22.2 million fish at age 1) was estimated to be slightly above average. Recent recruitment, however, has been extremely poor as four out of the last five year classes were well below average. The 1991, 1992, and 1993 year classes are the lowest on record.

Spawning stock biomass increased from 55,000 to 72,000 mt between 1985 and 1990 due to the strong 1983, 1985, and 1987 year classes entering the spawning stock. However, SSB has since declined and in 1993 fell to a record low 37,000 mt. Spawning stock biomass is expected to decline to unprecedented low levels in 1994 and 1995 as the 1990 year class is fished down and the much weaker 1991, 1992, and 1993 cohorts recruit to the spawning stock.

The Georges Bank cod stock is at a very low biomass level and is overexploited. Without substantial reductions in mortality, there is a possibility of stock collapse.

For further information

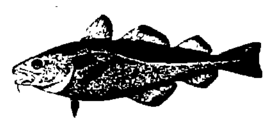
Mayo, R.K. 1995. Assessment of the Gulf of Maine cod stock for 1994. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Reference Document* 95-02.

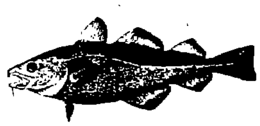
O'Brien, L. 1990. Effects of fluctuations in stock abundance upon life history parameters of Atlantic cod, *Gadus morhua* L. for the 1970-1987 year classes from Georges Bank and the Gulf of Maine. Seattle: University of Washington. Master's thesis.

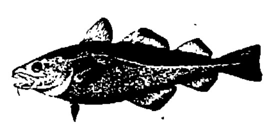
Serchuk, F.M. and S.E. Wigley. 1992. Assessment and management of the Georges Bank cod fishery: an historical review and evaluation. *J. Northw. Atl. Fish. Sci.* 13: 25-52.

Serchuk, F.M., R.K. Mayo and L. O'Brien. 1994. Assessment of the Georges Bank cod stock for 1994. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Reference Document* 94-25.

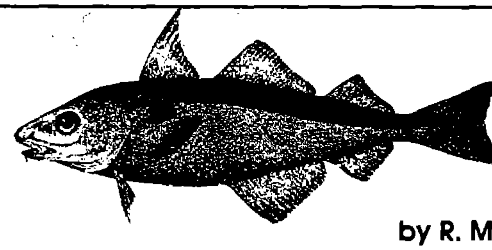
Serchuk, F.M., M.D. Grosslein, R.G. Lough, D.G. Mountain, and L. O'Brien. 1994. Fishery and environmental factors affecting trends and fluctuations in the Georges Bank and Gulf of Maine Atlantic cod stocks: an overview. *ICES Mar. Sci. Symp. 198:77-109.*







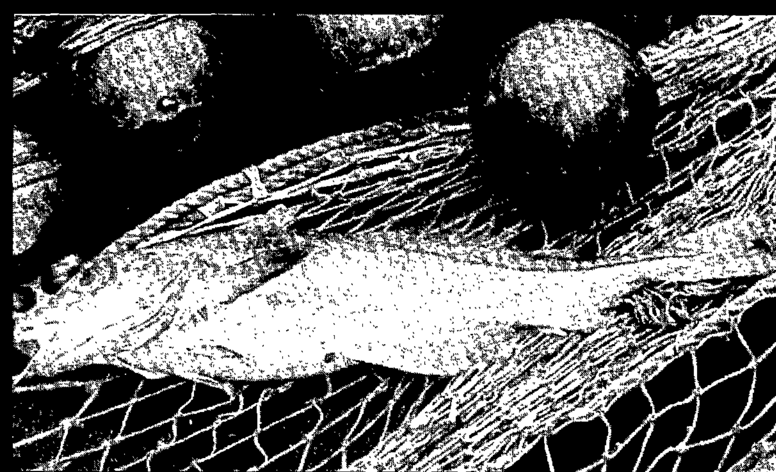
Haddock



by R. Mayo

The haddock, *Melanogrammus aeglefinus*, a demersal gadoid species, is distributed on both sides of the North Atlantic. In the western Atlantic, haddock range from Greenland to Cape Hatteras. Highest concentrations off the U.S. coast occur on the northern and eastern section of Georges Bank and in the southwestern Gulf of Maine. Two stocks occur in U.S. waters; the Gulf of Maine stock, and the Georges Bank stock. Haddock are most common at depths of 45 to 135 m (25 to 75 fathoms) and temperatures of 2° to 10°C (36° to 50°F). Adult haddock on Georges Bank appear to be relatively sedentary, but seasonal coastal movements occur in the western Gulf of Maine. Haddock prey primarily on small invertebrates, but fish are also consumed by adult haddock.

The growth rate of haddock has changed substantially over the past 30 to 40 years, possibly in response to changes in abundance. Prior to 1960, when haddock were considerably more abundant than at present, the average length of an age 4 fish was approximately 48 to 50 cm (19 to 20 in.). Presently, growth is more rapid, with haddock reaching this size at age 3. Changes in sexual maturation have also been observed during the past three decades. During the early 1960s, all females age 4 and older were fully mature, and approximately three-quarters of age 3 females were mature. In recent years, the maturation schedule has shifted by about one year; currently nearly all age 3 and three-quarters of age 2 female haddock are mature. Although the presence of early maturing fish increases spawning stock biomass, it is uncertain if these younger fish are spawning successfully or producing eggs of sufficient quality to contribute strongly to the reproductive success of the population.



Haddock
NMFS/NEFSC Photo by Brenda Figuerido

Spawning occurs between January and June, with peak activity during late March and early April. Individual females may produce up to 3 million eggs, but a 55 cm (22 in.) individual produces approximately 850,000 eggs. Major spawning concentrations occur on eastern Georges Bank, although some spawning also occurs to the east of Nantucket Shoals and along the Maine coast. Juvenile haddock remain pelagic for several months before settling to the bottom.

The principal commercial fishing gear used for haddock is the otter trawl. Recreational catches are insignificant. Fishing is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan (FMP). In the FMP, haddock overfishing is defined as occurring when fishing mortality results in a spawning potential that is 30% or less of the spawning potential in the absence of fishing. For the present growth rate and maturation schedule, this fishing mortality rate is 0.35.

Total landings (United States and Canada) in 1993 from the Georges Bank and Gulf of Maine haddock stocks were 4,600 mt, 28% lower than in 1992 (6,400 mt). United States landings decreased by 61%, from 2,300 mt in 1992 to 900 mt in 1993.

"The sharp decline in landings observed since 1983 (7,600 to 200 mt) and the corresponding decline in the autumn research index are indicative of the status of this stock."

Gulf of Maine

Commercial landings of Gulf of Maine haddock declined from about 5,000 mt annually in the mid-1960s to less than 1,000 mt in 1973. Total annual landings increased sharply between 1974 and 1980, and averaged 7,000 mt from 1980 to 1983. Since 1983, catches have declined to record-low levels (500 mt or less since 1988). Recreational catches have also declined and have been at insignificant levels since 1981. Virtually all landings from this stock are now taken by the U.S. fishery.

The NEFSC autumn survey biomass index (adjusted for changes in survey gear) has declined steadily since 1978 and between 1989 and 1992 fell to a new record low every year, reaching 0.09 in 1992. This value is less than 1% of the peak 1963 survey index. Although the index increased in 1993, it was still the fourth lowest in the 30-year series. Survey catch at age data continue to indicate that recruitment has been poor since 1982.

The sharp decline in landings observed since 1983 (7,600 to 200 mt) and the corresponding decline in the autumn research index are indicative of the status of this stock. Abundance remains at an historic low and recruitment has been insufficient to support landings, resulting in recruitment overfishing and continued stock depletion. Preliminary estimates of fishing mortality on this stock are greater than $F_{30\%}$. Spawning stock biomass is below maintenance level and is likely to remain so in the near future. Fishing mortality must be reduced significantly in order to enhance prospects for resource recovery.

Haddock
Gulf of Maine

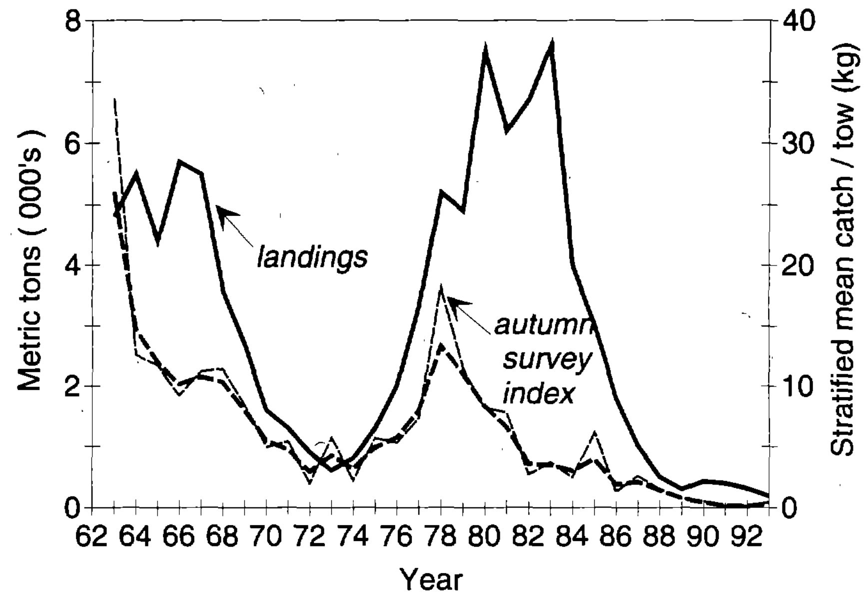


Table 2.1 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	4.4	2.8	2.2	1.6	0.8	0.4	0.3	0.4	0.4	0.3	0.2
Canada	0.5	1.2	0.8	0.2	0.2	0.1	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	4.9	4.0	3.0	1.8	1.0	0.5	0.3	0.4	0.4	0.3	0.2

Gulf of Maine Haddock

Long-term potential catch	=	5,000 mt
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	1.8 years, females
		2.1 years, males
Size at 50% maturity	=	35 cm (14 in.)
Assessment level	=	Yield per recruit
Overfishing definition	=	30% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.35

$M = 0.20$ $F_{0.1} = 0.24$ $F_{30\%} = 0.35$ $F_{1993} > F_{30\%}$

"Recovery of this stock will require that fishing mortality be reduced to the lowest level possible."

Georges Bank

Total commercial landings of Georges Bank haddock increased from about 50,000 mt annually prior to 1965 to nearly triple that amount in 1965 and 1966 due to intense fishing by the distant-water fleets. Following the high levels of landings during the mid-1960s, landings declined through 1976. Catches increased between 1977 and 1980, reaching about 28,000 mt, but catches declined after 1980, dropping to 4,500 mt in 1989. Since 1989, landings have ranged between 4,400 and 6,900 mt. In 1993, landings were 4,400 mt, the second lowest ever and 28% less than the 6,100 mt landed in 1992. Of the 1993 total, U.S. landings accounted for only 16% (700 mt), while Canadian landings accounted for the remainder (3,700 mt).

The NEFSC spring and autumn bottom trawl surveys indicate that the biomass of haddock has declined markedly since the late 1970s. The 1992 and 1993 autumn survey indices (3.2 and 4.3 kg per tow, respectively) are higher than the time series minimum of 0.94 kg per tow in 1991, but are extremely low relative to historic levels.

Population estimates derived from virtual population analysis indicate that this stock remains in a collapsed state. Total stock size declined from 133 million fish in 1979 to 14 million in 1991, while spawning stock biomass declined from about 70,000 mt in 1978 to 10,000 mt by 1993. Due to slightly improved recruitment in recent years, total stock size increased to about 25 million fish in 1993, and spawning stock biomass increased to about 20,000 mt in 1995.

Recruitment was poor during most of the 1980s. The 1989 and 1990 year classes continued this trend, each producing only about 2-3 million fish at age 1. The strongest year classes were those of 1983, 1985, 1987, and most recently,

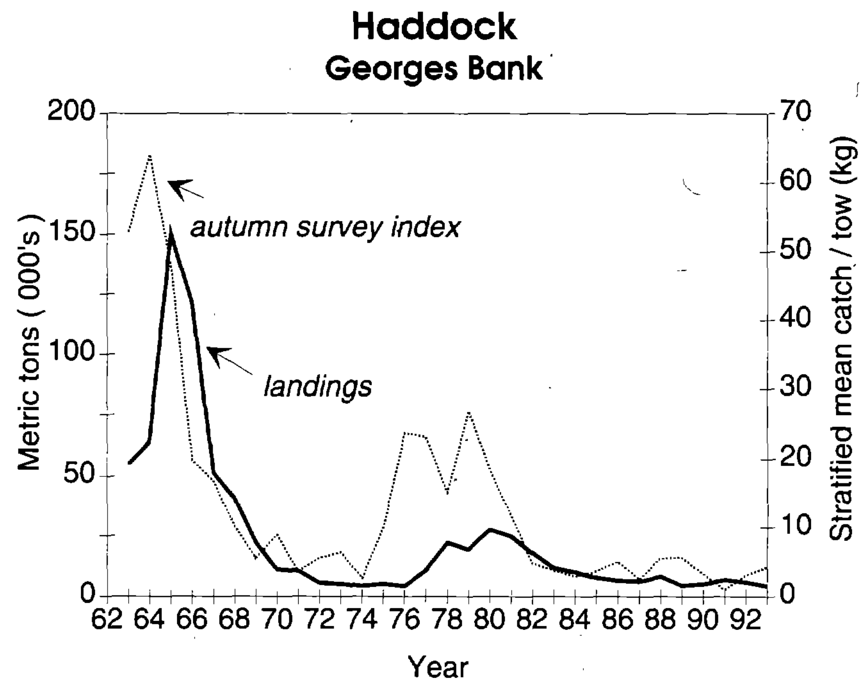


Table 2.2 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	<0.1	<0.1	<0.1	-	-	-	-	-	-	-	-
Commercial											
United States	10.2	8.8	4.3	3.3	2.2	2.5	1.4	2.0	1.4	2.0	0.7
Canada	4.6	1.4	3.5	3.4	4.1	5.9[1]	3.1	3.3	5.5	4.1	3.7
Other	0.2	-	-	-	-	-	-	-	-	-	-
Total nominal catch	15.0	10.2	7.8	6.7	6.3	8.4[1]	4.5	5.3	6.9	6.1	4.4

[1]Suspected of being roughly 2,000 mt too high due to misreporting.

Georges Bank Haddock

Long-term potential catch	=	47,000 mt
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	1.5 years, females 1.3 years, males
Size at 50% maturity	=	30 cm (12 in.), females 27 cm (11 in.), males
Assessment level	=	Age structured
Overfishing definition	=	30% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.35

$M = 0.20$ $F_{0.1} = 0.24$ $F_{30\%} = 0.35$ $F_{1993} \gg F_{30\%}$

1992, each contributing between 14 to 17 million fish; although these year classes appear relatively strong compared to the intervening year classes, they are weak compared to the dominant year classes of the 1970s. The 1991 and 1993 year classes (7 to 8 million fish) appear to be about average when compared to the 1964-1993 mean. Fishing mortality on age 4 and older haddock was estimated to be about 0.54 in 1992 and 1993, but declined to about 0.3 in 1994.

Population projections suggest that, if recruitment and fishing mortality remain at current levels, abundance and biomass of this stock will not increase substantially. Because of the low level of spawning stock biomass, recruitment is not expected to improve in the near future, perpetuating the severely depleted condition of the stock. Recovery of this stock will require that fishing mortality be reduced to the lowest level possible.

Fishermen sorting haddock, circa 1955
Brigham Collection, NOAA/NEFSC Photo Archive

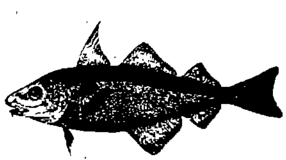
For further information

Clark, S.H., W.J. Overholtz, and R.C. Hennemuth. 1982. Review and assessment of the Georges Bank and Gulf of Maine haddock fishery. *J. Northw. Atl. Fish. Sci.* 3:1-27.

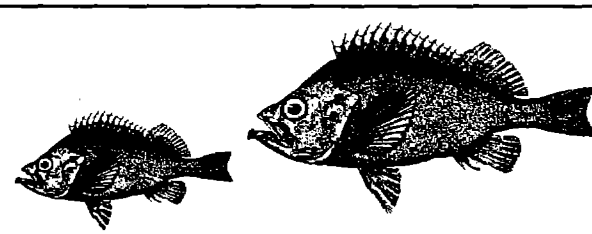
Gavaris, S. and L. VanEeckhaute. 1995. Assessment of haddock on Eastern Georges Bank. *DFO Atlantic Fisheries Research Document* 95/6.

NEFSC [Northeast Fisheries Science Center]. 1995. Report of the 20th Regional Stock Assessment Workshop (20th SAW). Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc./SAW 20.*

O'Brien, L. and R. Brown 1995. Assessment of the Georges Bank haddock stock for 1994. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc./SAW 20.*



Redfish

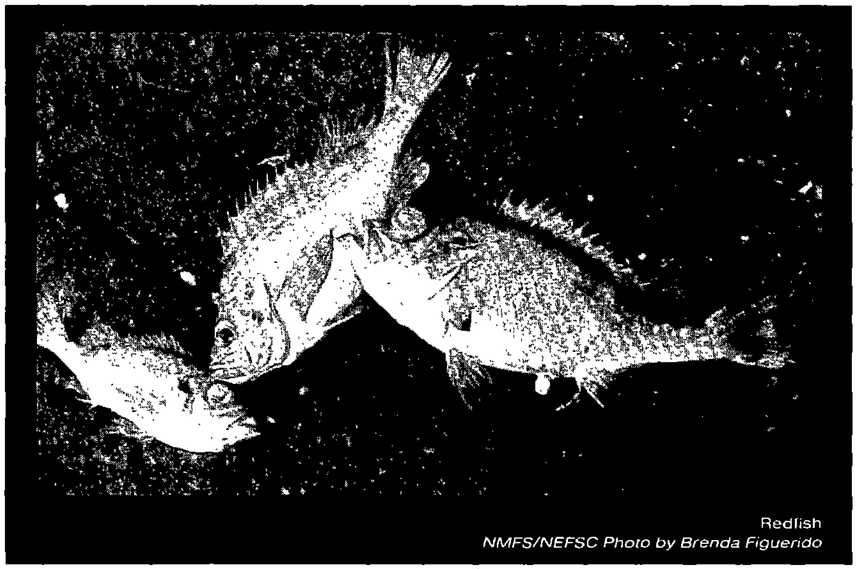


by R. Mayo

Redfish or ocean perch, *Sebastes*, spp., are distributed throughout the North Atlantic from the coast of Norway to Georges Bank. Off New England, *Sebastes fasciatus* are most common in deep waters of the Gulf of Maine to depths of 300 m (975 ft). Redfish are slow growing, long-lived animals with an extremely low natural mortality rate. Ages in excess of 50 years and maximum sizes of 45 to 50 cm (18 to 20 in.) have been noted. In the Gulf of Maine, redfish reach maturity in about 5 to 6 years at an average length of 20 to 23 cm (8 to 9 in.). Females are viviparous, retaining eggs in the ovary after fertilization until yolk-sac absorption. Mating takes place in autumn, with subsequent larval extrusion occurring the following spring and summer.

The principal commercial fishing gear used for redfish is the otter trawl. Recreational catches are insignificant. Fishing is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. The total nominal catch increased between 1991 and 1992 from 500 to 850 mt and remained stable at 800 mt in 1993.

During the development phase of the Gulf of Maine fishery, U.S. nominal catches rapidly rose to a peak level of about 60,000 mt in 1942 followed by a gradual decline. Nominal catches increased from approximately 10,000 to 11,000 mt during 1974-76 to approximately 14,000 to 15,000 mt in 1978-79. Catches subsequently declined, dropping to 530 mt in 1991, the lowest annual catch since the directed fishery commenced in the early 1930s. In the past 20 years, only two strong year classes, those produced in 1971 and 1978, have recruited to the fishery. However, length composition data from bottom trawl surveys suggest that one or more moderately strong year classes produced in the mid-1980s recruited to the fishery during the early 1990s. These fish were first detected in the 1991 commercial length composition and appeared in greater numbers as a distinct mode at 25 cm in 1992.



Redfish
NMFS/NEFSC Photo by Brenda Figuerido

The standardized catch per unit effort index declined from 6.1 mt per day in 1968 to approximately 2.4 mt per day between 1975 and 1978, and to less than 1.0 mt per day since 1987. The NEFSC autumn survey biomass index declined from 40.4 kg per tow in 1968 to an average of 3.8 kg per tow during 1982-84. The autumn biomass index subsequently increased to an average of 6.5 kg per tow during 1985-89 and has averaged 10.0 kg per tow during 1990-93. Average biomass levels evident since 1990 represent a 2.5-fold increase over the early 1980s but are still well below average levels of the 1960s and early 1970s.

The increase in biomass in 1990-93 is consistent with incremental increases in survey abundance indices (mean number per tow) during the past two to three years, and reflects accumulated recruitment and growth of one or more recent year classes.

Estimates of exploitable biomass (ages 5 and older) from virtual population analysis declined by 75%, from 136,000 mt in 1969 to 32,000 mt in 1985. Projections are not available for 1993 because the virtual population analysis was discontinued in 1986. Average fishing mortality during the 1970s was slightly greater than F_{max} (0.13) and twice the $F_{0.1}$ (0.06) level. During the late 1970s, the combination of declining stock size and increased fishing effort on the 1971 year class produced fishing mortality rates that were 50% greater than F_{max} and three times higher than $F_{0.1}$. Fishing mortality has declined in recent years to a level less than or equal to $F_{0.1}$, and well below F_{max}. Equilibrium surplus production models have indicated that the long-term potential catch from the stock is about 14,000 mt. Given the low population abundance and poor recruitment during most of the 1980s, surplus production in the near future will remain considerably less than that, as indicated by the continued low level of nominal catches.

Landings since 1989 have been extremely low (<900 mt/yr), reflecting low

"Catches need to remain low to allow the slow recovery of this stock to continue."

levels of stock abundance and fishing mortality. Given the present pattern of exploitation, the fishery remains extremely dependent on recruiting year classes. Recruitment has been poor since 1971, except for the moderate 1978 year class and some modest recruitment from the mid-1980s. Stock biomass has slowly been increasing in the 1990s but remains low relative to the 1960s and 1970s. Unless recruitment markedly improves, biomass and yield are not expected to increase substantially; the population remains in an overexploited condition due to the truncated age structure and relatively low biomass level. Catches need to remain low to allow the slow recovery of this stock to continue.

For further information

Mayo, R. K. 1980. Exploitation of redfish, *Sebastes marinus* (L.), in the Gulf of Maine-Georges Bank region, with particular reference to the 1971 year class. *J. Northw. Atl. Fish. Sci.* 1:21-38.

Mayo, R.K. 1987. Recent exploitation patterns and future stock rebuilding strategies for Acadian redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine-Georges Bank region of the Northwest Atlantic. *In* Proceedings of the International Rockfish Symposium, p. 335-353. Anchorage, Alaska, October 20-22, 1986. Fairbanks, AK: University of Alaska Sea Grant College Program. *Alaska Sea Grant Report 87-2.*

Mayo, R.K. 1993. Historic and recent trends in the population dynamics of redfish, *Sebastes fasciatus* Storer, in the Gulf of Maine-Georges Bank Region. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-03.

Northeast Fisheries Center. 1986. Report of the Second NEFC Stock Assessment Workshop. Woods Hole, MA: NOAA/NMFS/NEFC. *Lab. Ref. Doc.* 86-09.

Redfish
Georges Bank

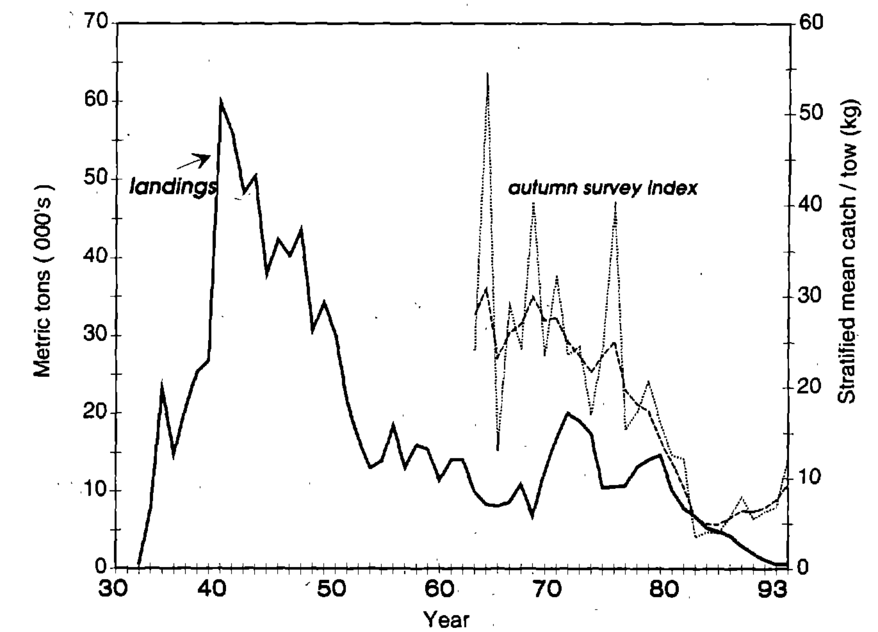


Table 3.1 Recreational catches and commercial landings (thousand metric tons)

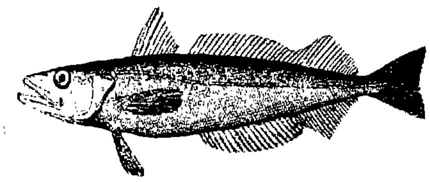
Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	9.9	4.7	4.2	2.9	1.9	1.1	0.6	0.6	0.5	0.8	0.8
Canada	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Other	0.4	-	-	-	-	-	-	-	-	-	-
Total nominal catch	10.4	4.8	4.3	3.0	2.0	1.2	0.6	0.6	0.5	0.8	0.8

Gulf of Maine and Georges Bank Redfish

Long-term potential catch	=	14,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	5 to 6 years
Size at 50% maturity	=	20 to 23 cm (7.9 to 9.0 in.)
Assessment level	=	Yield per recruit
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.12

M = 0.05 **$F_{0.1}$ = 0.06** **F_{max} = 0.13** **$F_{1993} \le F_{0.1}$**

Silver Hake



by T. Helser

The silver hake or whiting, *Merluccius bilinearis*, is a widely distributed, slender, swiftly swimming fish with a range extending from Newfoundland to South Carolina. Silver hake are important predators and concentrate in response to seasonal variations in hydrographic conditions, food availability, and spawning requirements. In U.S. waters, two stocks have been identified based on morphological differences; one extends from the Gulf of Maine to northern Georges Bank, and the second occurs from southern Georges Bank to the mid-Atlantic area. Silver hake undertake extensive migrations, and winter in the deeper waters of the Gulf of Maine for the northern stock and along the outer continental shelf and slope for the southern stock. Silver hake move toward shallow water in the spring, spawn during the late spring and early summer, and return to the wintering areas in autumn. Peak spawning occurs earlier in the southern stock (May and June) than in the northern stock (July and August).

Major spawning areas include the coastal region of the Gulf of Maine from Cape Cod to Grand Manan Island, southern and southeastern Georges Bank, and the Southern New England area south of Martha's Vineyard. More than 50% of age 2 fish (20 to 30 cm, 8 to 12 in.), and nearly all age 3 fish (25 to 35 cm, 10 to 14 in.) are sexually mature. Silver hake grow to a maximum length of around 65 cm. Ages up to 15 years have been reported, but few fish older than age 6 have been observed in recent years. Instantaneous natural mortality is assumed to be 0.4 (*i.e.*, 33% annual mortality rate due to natural causes).

The otter trawl is the principal gear used in the commercial fishery. Recreational catches are currently insignificant. Fishing is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan.

Silver hake (bottom of photo)
NMFS/NEFSC photo by Brenda Figuerido

Total nominal catches decreased by 22% between 1990 and 1992 (20,000 to 15,600 mt) but increased in 1993 to 17,200 mt.

Gulf of Maine-Northern Georges Bank

Following the introduction of distant-water fleets in 1962, total landings increased rapidly to a peak of 94,500 mt in 1964, dropped sharply in 1965, and declined for 13 years, reaching the lowest level in the series (3,400 mt) in 1979. Prior to the inception of the Magnuson Fishery Conservation and Management Act (MFCMA), distant-water fleet landings averaged about 49% of the total catches. Activity by distant-water fleets diminished after 1977 and U.S. landings increased slightly during the early 1980s, reaching 8,500 mt in 1986. Since 1987, landings have varied between 4,400 and 6,800 mt but have declined during the past three years. Commercial landings in 1993 were 4,300 mt, the lowest since 1981.

The NEFSC autumn bottom-trawl survey biomass index declined during the period of heavy exploitation by distant-water fleets reaching a minimum in 1968-69. With the appearance of the strong 1973 and 1974 year classes, biomass indices increased during the mid-1970s, but declined during the late 1970s. Biomass indices have subsequently increased significantly (with fluctuation), and recent recruitment levels appear to be at or above those of the mid-1970s.

During 1973-1982, fishing mortality rates (F) for fully recruited fish (age 3+) fluctuated between 0.38 and 1.1 and generally increased from 1982 (0.45) through 1988 (0.70). Although VPA estimates are not available for the 1989-1993 period, estimates of mortality based on spring and autumn NEFSC survey abundance indices suggest recent F's may be about 0.4.

Substantial mortality of age 1 and 2 (<25 cm) fish occurs through discarding

"The high discard mortality on juvenile fish results in a substantial loss in the long term yield from the adult component of the stock and a reduction in spawning biomass per recruit."

in the large mesh (>5.5 in. mesh) and small mesh (<3.5 in. mesh) otter trawl fisheries and in the northern shrimp fishery. Discard estimates over the 1989-1992 period range from 1,700 mt to 7,200 mt. In terms of numbers of fish, the quantities of discarded silver hake have been quite large; ranging from 17 million fish in 1990 to 76 million in fish 1989. The high discard mortality on juvenile fish results in a substantial loss in the long term yield from the adult component of the stock and a reduction in spawning biomass per recruit.

Although bottom-trawl survey indices suggest silver hake biomass over the past 15 years has remained at or above levels observed prior to 1975, results from the virtual population analysis show a significant decline (through 1986) in stock biomass levels compared with the pre-1975 period, despite the rather low level of landings. Further, substantial increases in recruitment in recent years have not yet translated into an increase in mature fish biomass (age 3+). Until these inconsistencies are resolved, the precise level of exploitation remains uncertain. However, since it is not likely that F will decline substantially below 0.4 to 0.5 in the near future (*i.e.*, decline below the overfishing level of F = 0.36) and given the rapid removal of recruits from the stock in recent years, it appears that this stock cannot support increased fishing and must be considered fully exploited.

Southern Georges Bank - Middle Atlantic

Following the introduction of distant-water fleets in 1962, total landings increased rapidly to a peak of 307,100 mt

Silver Hake
Northern Georges Bank

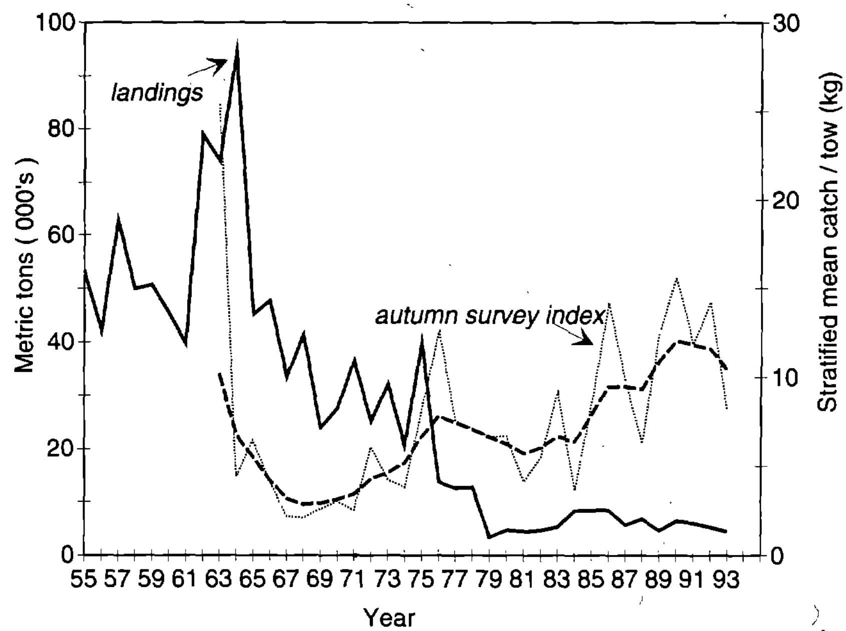


Table 4.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year										
	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	6.6	8.3	8.3	8.5	5.7	6.8	4.6	6.4	6.1	5.3	4.4
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	0.2	-	-	-	-	-	-	-	-	-	-
Total nominal catch	6.8	8.3	8.3	8.5	5.7	6.8	4.6	6.4	6.1	5.3	4.4

Gulf of Maine-
Northern Georges Bank
Silver Hake

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	22.3 cm (8.8 in.), males 23.1 cm (9.1 in.), females
Assessment level	=	Age structured
Overfishing definition	=	31% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.36

M = 0.40 **$F_{0.1}$ = 0.39** **$F_{31\%}$ = 0.36** **F_{1993} $F_{31\%}$**

"The estimated numbers of fish discarded has been quite large; ranging from 10 million in 1991 to 81 million fish in 1989."

in 1965, declined sharply through 1970 (27,500 mt), and increased to a secondary peak of 109,900 mt in 1974. Landings declined thereafter and have remained below 14,000 mt since 1984. Prior to inception of MFCMA, distant-water fleet landings accounted for about 87% of the total commercial landings. Catches by distant-water fleets were taken primarily as bycatch in the squid fishery during the early and mid-1980s, but this bycatch has been insignificant since 1987. Landings during the past five years have varied between 10,100 and 13,600 mt and averaged 12,000 mt. In 1993, commercial landings were 12,800 mt. Recreational landings have been insignificant since 1986.

The NEFSC autumn trawl survey biomass index has shown a declining trend since 1985. Survey indices in the past three years have been at near record low levels.

Prior to the distant-water fishery, fishing mortality (F) was relatively low, ranging from 0.09 to 0.41 (average = 0.24) between 1955 and 1962. With increased fishing effort on the stock beginning in 1963, F rose rapidly and reached 0.98 in 1965. Fishing mortality decreased to 0.5 during 1978-1980, but increased to more than 1.0 during 1983-1987. Although VPA estimates of fishing mortality and stock size are not available from 1988 onward, NEFSC survey data suggest that F has been close to 1.2 in recent years.

Significant mortality of age 1 and 2 (<25 cm) fish occurs through discarding in the large mesh (>5.5 in. mesh) and small mesh (<3.5 in.) otter trawl fisheries. Discard estimates over the 1989-1992 period range from 1,300 mt to 10,000 mt. The estimated numbers of fish discarded has been quite large; ranging from 10 million in 1991 to 81 million fish in 1989. The high discard mortality on juvenile

Silver Hake
Southern Georges Bank-Middle Atlantic

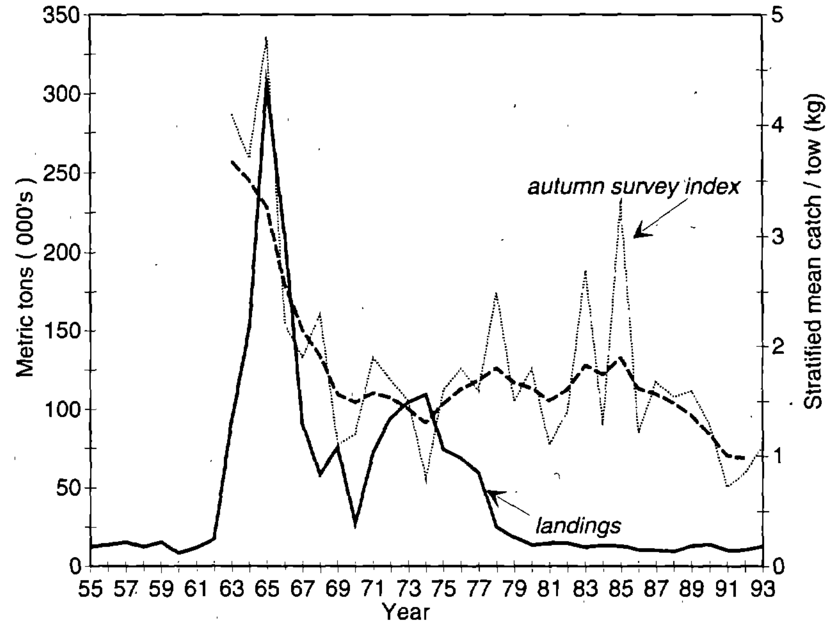


Table 4.2 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	0.8	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	12.0	12.7	11.8	9.4	9.8	9.2	13.2	13.6	10.1	10.3	12.8
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	34.9	0.4	1.3	0.5	-	-	-	-	-	-	-
Total nominal catch	47.7	13.1	13.1	10.0	9.8	9.2	13.2	13.6	10.1	10.3	12.8

Southern Georges Bank - Middle Atlantic Silver Hake

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Minor
Management	=	Multispecies FMP
Status of exploitation	=	Over exploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	22.7 cm (8.9 in.), males 23.2 cm (9.1 in.), females
Assessment level	=	Age structured
Overfishing definition	=	42% MSP
fishing mortality rate corresponding to overfishing definition	=	0.38

$M = 0.40$ $F_{0.1} = 0.45$ $F_{42\%} = 0.34$ $F_{1993} > 1.0$

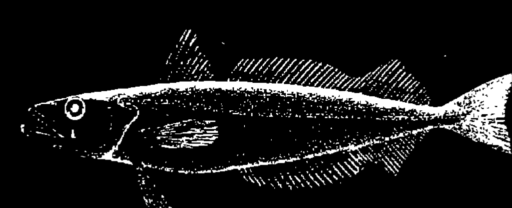
fish results in a substantial loss in long term yield from the adult component of the stock and a reduction in spawning biomass per recruit.

Bottom trawl survey results indicate that the stock abundance of silver hake is low and continues to decline. The age structure of the population is severely truncated with few fish older than age 4. Although landings are relatively low compared to historical levels, F appears to be high (>1.0) and far in excess of the F associated with the overfishing definition (*i.e.*, 42% MSP, F = 0.34). The stock is overexploited and will continue to be so until the exploitation pattern is improved (*i.e.*, catches of juveniles are minimized), and fishing mortality markedly reduced.

Recently, a "juvenile" whiting fishery has developed in response to an export market for small silver hake that have traditionally have been discarded. Concerns have been raised about the impact of this fishery on the status of the stocks and on the traditional whiting fisheries.

Silver hake processing, probably Gloucester, Mass., circa 1960
BrighamCollection, NMFS/NEFSC Photo Archive

Silver hake
NMFS/NEFSC photo by Brenda Figuerido



For further information

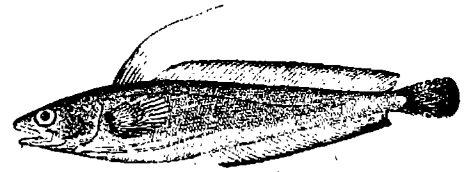
Helser, T. E., and R. M. Mayo. 1994. Estimation of discards in the silver hake fisheries and a re-analysis of the long-term yield from the stocks. NOAA/NMFS/NEFSC: Woods Hole, MA. *NEFSC Ref. Doc.* 94-01.

Helser, T. E., F. P. Almeida, and D. E. Waldron. 1995. Biology and Fisheries of northwest Atlantic hake (silver hake: *M.bilinearis*). *In* Hake: Fisheries, Products and Markets, J. Alheit and T. J. Pitcher, eds., pp. 203-237. London: Chapman and Hall.

NEFC [Northeast Fisheries Center]. 1990. Report of the Eleventh Stock Assessment Workshop (11th SAW), Fall 1990. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Ref. Doc.* 90-09.

NEFSC [Northeast Fisheries Science Center]. 1994. Report of the 17th Northeast Regional Stock Assessment Workshop, Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: DOC/NOAA/NM/NEFSC. *NEFSC Ref. Doc.* 94-06.

Red Hake



by T. Helser

The red hake, *Urophycis chuss*, is distributed from the Gulf of St. Lawrence to North Carolina, but is most abundant between Georges Bank and New Jersey. Research vessel bottom trawl surveys indicate that red hake have a broad geographic and depth distribution throughout the year, undergoing extensive seasonal migrations. Red hake winter in the deep waters of the Gulf of Maine and along the outer continental shelf and slope south and southwest of Georges Bank. Spawning occurs from May through November, with major spawning areas located on the southwest part of Georges Bank and in the Southern New England area south of Montauk Point, Long Island. Red hake feed primarily on crustaceans, but adult red hake also feed extensively on fish. The maximum length reached by red hake is approximately 50 cm (19.7 in.). Maximum age is reported to be about 12 years, but few fish survive beyond 8 years of age. Two stocks have been assumed, divided north and south in the central Georges Bank region.

Otter trawls are the principal commercial fishing gear used to catch red hake. Recreational catches are of minor importance. Fishing is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Total commercial landings in 1993 (taken exclusively by the United States) were 1,600 mt, 27% less than in 1992 (2,200 mt). Commercial landings remain far below historic levels.

Red hake on deck
R/V Albatross cruise, circa 1960
NMFS/NEFSC photo

Gulf of Maine - Northern Georges Bank

Landings from the Northern red hake stock in 1993 were 700 mt, the

"This stock is underexploited and could support substantially higher catches."

lowest annual catch during the 1960-1993 period. Trends in landings from this stock have shown three distinct periods. The first period, from the early 1960s through 1971, was characterized by relatively low landings ranging from about 1,000 to 5,600 mt. The second period, from 1972 to 1976, showed a sharp increase, with landings ranging from 6,300 to 15,300 mt. During this period approximately 93% of the total annual landings were taken by the distant-water fishery (DWF) on northern Georges Bank. Following implementation of the Magnuson Fisheries Conservation and Management Act (MFCMA) in 1977 and the exclusion of the distant water fleets, total landings dropped sharply. From 1977 to the present, annual landings from this stock have averaged only 1,100 mt and have been 900 mt or less since 1988.

NEFSC autumn bottom trawl survey indices increased from the early 1970s until 1990. The survey index declined during the past three years, but this decline does not appear to be due to the fishery, given the low level of landings. Survey data indicate that most year classes of red hake have been moderate in strength since 1985. The combination of low landings and modest year classes has allowed the stock to maintain itself at moderate to high levels of biomass. This stock is underexploited and could support substantially higher catches.

Southern Georges Bank-Middle Atlantic

Nominal 1993 landings from the southern red hake stock were 900 mt, slightly lower than in 1992 when 1,300 mt were taken. Historically, total landings from this stock peaked in the mid-1960s (108,000 mt in 1966) due to development of the DWF. Annual land-

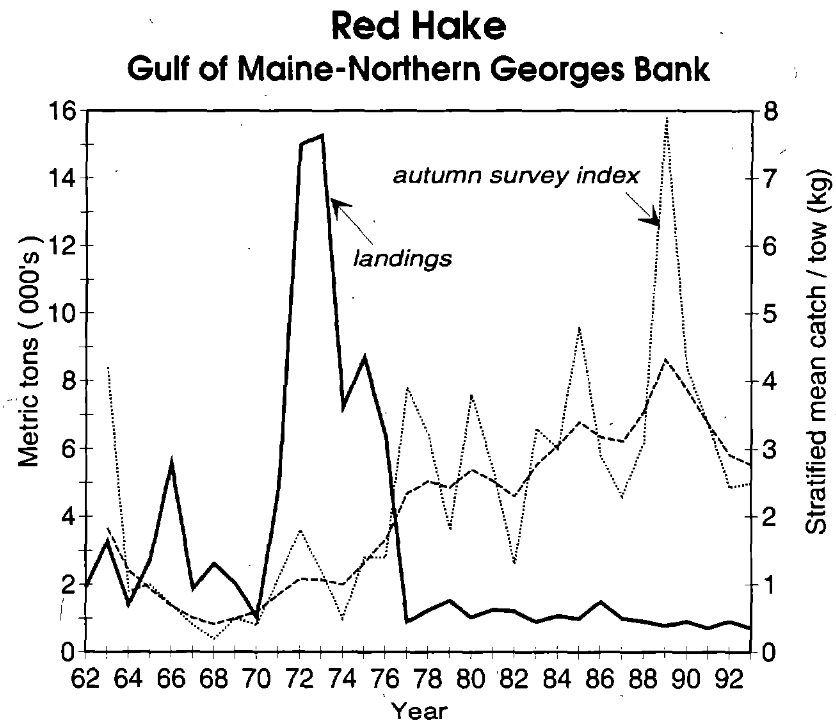


Table 5.1 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.0	1.1	1.0	1.5	1.0	0.9	0.8	0.8	0.7	0.9	0.7
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	2.0	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.0	1.1	1.0	1.5	1.0	0.9	0.8	0.8	0.7	0.9	0.7

Gulf of Maine-Northern Georges Bank Red Hake

Long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Underexploited
Age at 50% maturity	=	1.8 years, females 1.4 years, males
Size at 50% maturity	=	27 cm (11 in.), females 22 cm (9 in.), males
Assessment level	=	Yield per recruit
Overfishing definition	=	3-year moving average of NEFSC autumn bottom trawl survey index falls within lowest quartile of the time series
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.4$ $F_{0.1} = 0.5$ F_{max} = None $F_{1993} < F_{0.1}$

"...the declining trend in survey values from 1983 onward does not appear to be fishery related..."

DWF landings averaged 10% of the total annual landings (compared to 83% from 1965-1976) due to restrictions placed on foreign fishing after the implementation of the MFCMA. Since 1985, landings of red hake have been exclusively domestic.

United States commercial landings increased from 4,300 mt in 1960 to a high of 32,600 mt in 1964, but declined sharply to 4,000 mt in 1966. United States landings ranged between 2,000 and 7,000 mt during 1967 to 1979. Since 1985 commercial landings from this stock have been very low, varying between 600 and 1,300 mt per year.

The NEFSC autumn bottom trawl survey index was relatively constant between 1968 and 1982. Subsequently, the survey indices declined, reaching a record low in 1987. From 1988 to 1991, the survey index increased, but has since dropped sharply to historically low levels. However, the declining trend in survey values from 1983 onward does not appear to be fishery related; landings during the past decade have been low (less than 2,000 mt per year) compared with the late 1960s and early 1970s (more than 20,000 mt in most years) when the survey index was stable. As such, the stock is considered to be underexploited.

For further information

NEFC [Northeast Fisheries Center]. 1986. Report of the Second Stock Assessment Workshop. Woods Hole, MA: NOAA/NMFS/NEFC. *Lab. Ref. Doc.* 86-09.

NEFSC [Northeast Fisheries Science Center]. 1990. Report of the Eleventh Stock Assessment Workshop (11th SAW), Fall 1990. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFC Ref. Doc.* 90-09.

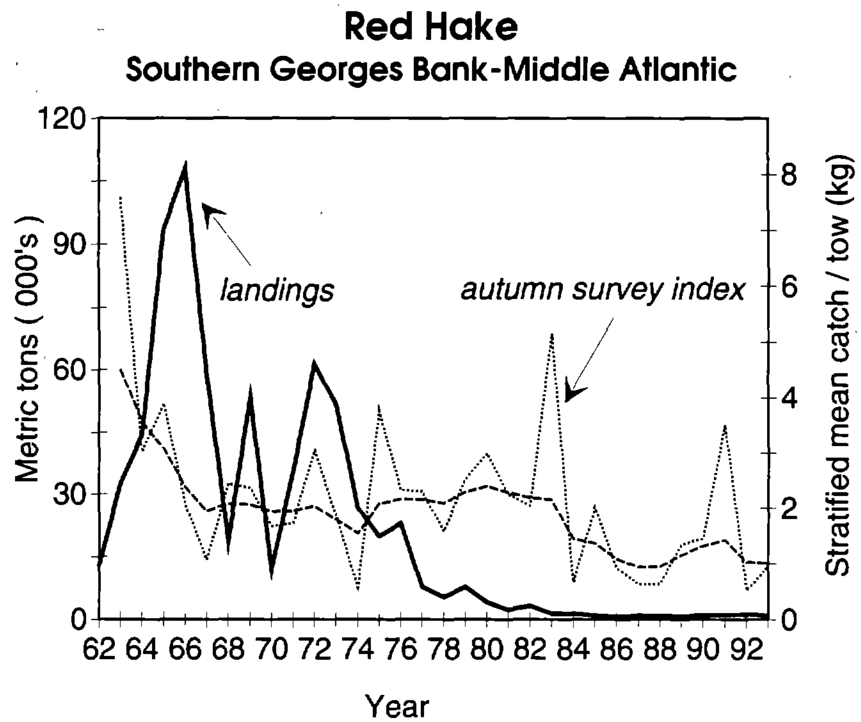


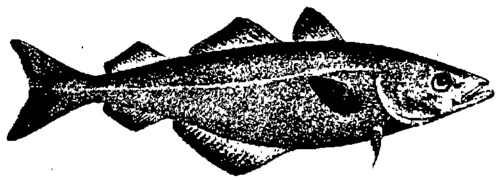
Table 5.2 Recreational catches and commercial landings (thousand metric tons)

Category	Year: 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	0.2[1]	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.2	<0.1
Commercial											
United States	3.4[1]	1.2	0.8	0.6	0.9	0.9	0.8	0.8	0.9	1.1	0.9
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	0.6	0.1	0.1	-	-	-	-	-	-	-	-
Total nominal catch	10.2	1.3	0.9	0.6	0.9	0.9	0.8	0.8	1.1	1.3	0.9

Southern Georges Bank - Middle Atlantic
Red Hake

Long-term potential catch	=	Unknown
Importance of recreational fishery	=	Minor
Management	=	Multispecies FMP
Status of exploitation	=	Underexploited
Age at 50% maturity	=	1.7 years, females 1.8 years, males
Size at 50% maturity	=	25 cm (10 in.), females 24 cm (9 in.), males
Assessment level	=	Yield per recruit
Overfishing definition	=	3-year moving average of NEFSC autumn bottom trawl survey index falls within lowest quartile of the time series
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.4$ $F_{0.1} = 0.5$ $F_{max} = \text{None}$ $F_{1993} < F_{0.1}$



Pollock

by R. Mayo

Pollock, *Pollachius virens*, occur on both sides of the North Atlantic; in the Northwest Atlantic, they are most abundant on the Scotian Shelf and in the Gulf of Maine. One major spawning area exists in the western Gulf of Maine, and several areas have been identified on the Scotian Shelf. Tagging studies suggest considerable movement of pollock between the Scotian Shelf and Georges Bank and, to a lesser extent, between the Scotian Shelf and the Gulf of Maine. Electrophoretic analyses of pollock tissue samples from the Scotian shelf and western Gulf of Maine showed no significant differences between areas, although differences in some morphometric and meristic characteristics were significant. Accordingly, pollock from Cape Breton and south continue to be assessed as a unit stock by U.S. scientists.

Spawning occurs in winter and sexual maturation is essentially complete by age 6, although more than 50% of fish are mature by age 3. Juvenile harbor pollock are common in inshore areas, but move offshore as they grow older. Pollock attain lengths up to 110 cm (43 in.) and weights of 16 kg (35 lb).

Traditionally, pollock were taken as a bycatch in the demersal otter trawl fishery, but directed otter trawl effort increased steadily during the 1980s, peaking in 1986 and 1987. Fishing effort by Canadian and U.S. trawlers directed at pollock has declined substantially in recent years. Similar changes in effort have also occurred in the winter gill net fishery.

Mixed haul of groundfish, larger specimens are pollock, R/V *Atlantis*, 1927
O.E. Sette Collection
NMFS/NEFSC Photo Archive

Since 1984, the U.S. fishery has been restricted to that fraction of the stock occurring in areas of the Gulf of Maine and Georges Bank west of the line delimiting the U.S. and Canadian fishery zones. The domestic portion of the fishery is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. The Canadian fishery is managed under fleet-specific quotas; the two management regimes do not interact. The total nominal catch of pollock in 1993 was 26,800 mt, 36% less than in 1992 (41,400 mt), and the lowest annual harvest since 1970. Most of the decrease was due to a sharp reduction in Canadian landings reflecting a reduced 1993 TAC of 21,000 mt for the Canadian fishery. United States commercial landings, although unrestricted by management regulations, declined by 21% in 1993 (7,200 mt to 5,700 mt).

Nominal commercial catches from the entire Scotian Shelf, Gulf of Maine, and Georges Bank region increased from

"The most recent strong year class was produced in 1988 and is expected to become fully recruited to the fishery in 1995. The 1989 through 1991 year classes, however, appear to be below average."

an annual average of 38,200 mt during 1972-76 to 68,900 mt by 1986. Nominal catches for Canada increased steadily from 24,700 mt in 1977 to an average of 43,900 mt during 1985-87. United States catches increased from an average of 9,700 mt during 1973-77 to more than 18,000 mt annually between 1984 and 1987, peaking at 24,500 mt in 1986. Nominal catches by distant-water fleets, however, declined from an annual average of 9,800 mt during 1970-73 to less than 1,100 mt per year during 1981-88. The distant-water fleet catch increased to 1,800 mt in 1989, and has averaged 1,900 mt per year since then. Most of this catch has been taken by the Soviet/Russian fleet on the Scotian Shelf.

Estimated U.S. annual recreational catches have fluctuated between 100 and 1,300 mt since 1979. No information is available for the Canadian recreational harvest, although it appears to be of minor importance. The total nominal catch from the stock, including recreational, has been steadily declining since 1986; the 1993 total represents a 61% reduction from the 1986 peak.

Total stock size, after increasing throughout the late 1970s and early 1980s, has since markedly declined. Biomass indices for the Gulf of Maine-Georges Bank portion of the stock, derived from NEFSC autumn bottom trawl surveys, increased during the mid-1970s but declined sharply during the early 1980s and have remained relatively low since 1984. Indices derived from Canadian bottom trawl surveys conducted on the Scotian Shelf increased during the 1980s but declined sharply during the early 1990s. Commercial catch per unit effort (CPUE) indices for U.S. trawlers fishing predominantly in the Gulf of Maine increased

Pollock
Scotian Shelf-Gulf of Maine-Georges Bank

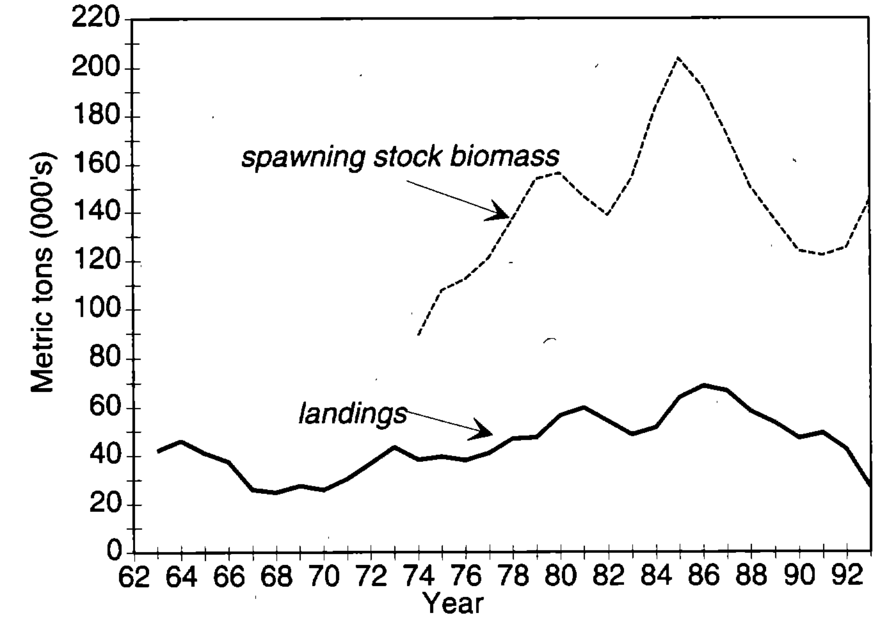


Table 6.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year										
	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	0.8	0.2	0.7	0.2	0.1	0.2	0.4	0.1	0.1	<0.1	<0.1
Commercial											
United States	14.0	17.9	19.5	24.5	20.4	15.0	10.6	9.6	7.9	7.2	5.7
Canada	30.0	33.5	43.3	43.2	45.3	41.8	41.0	36.2	37.8	32.1	20.3
Other	1.6	0.3	0.5	1.1	0.8	1.3	1.8	1.3	3.3	2.1	0.8
Total nominal catch	46.4	51.9	64.0	69.0	66.6	58.3	53.8	47.2	49.1	41.4	26.8

Gulf of Maine, Georges Bank, Scotian Shelf
Pollock

Long-term potential catch	=	37,000 mt
SSB for long-term potential catch	=	122,000 mt
Importance of recreational fishery	=	Minor
Management	=	Multispecies FMP
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	2.2 years
Size at 50% maturity	=	40 cm (16 in.)
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.65

$M = 0.20$ $F_{0.1} = 0.20$ $F_{med} = 0.47$ $F_{20\%} = 0.65$
$F_{1993} \cong 0.35$

during the late 1970s, but declined after 1983 and have remained consistently low since 1987 at less than one-half the 1977-1983 average. Canadian commercial CPUE indices from the Scotian Shelf also increased during the late 1970s-early 1980s, but have declined steadily since 1985; recent CPUE indices for both fleets remain well below historic levels.

Spawning stock biomass increased from 90,000 mt in 1974 to over 200,000 mt in 1985. Between 1986 and 1991, however, SSB declined by 36%. The increases in stock biomass during the 1970s resulted from recruitment and growth of several relatively strong year classes, notably those of 1971, 1975, and 1979. Recruitment conditions were favorable throughout the 1970s and early 1980s, with moderate to strong year classes appearing regularly every three to four years. Year classes produced between 1983 and 1986 were all average or below average, but the 1987 and 1988 year classes were well above the long-term mean. The most recent strong year class was produced in 1988 and is expected to become fully recruited to the fishery in 1995. The 1989 through 1991 year classes, however, appear to be below average.

The record high landings during the mid-1980s (in excess of 63,000 mt per year between 1985 and 1987) resulted in relatively high fishing mortality rates ranging from 0.62 to 0.85 during the latter part of the decade. Fishing mortality in 1992 declined slightly from the 1991 level (0.85 to 0.72). Projections have indicated a substantial reduction in F in 1993 to about 0.3-0.4 due to the combined effect of reduced catch and effort in the Canadian sector, and the continued strong recruitment of the 1987 and 1988 year classes to the fishable stock. The 1991 and 1992 levels of F, however, were well above $F_{0.1}$ (0.20), considerably greater than F_{med} (0.47) and slightly above $F_{20\%}$ (0.65). As such, the stock is considered to be fully exploited.

Pollock, Bureau of Commercial Fisheries research cruise, circa 1955
Brigham Collection
NMFS/NEFSC Photo Archive

Pollock, Bureau of Commercial Fisheries survey cruise, circa 1965
Brigham Collection,
NMFS/NEFSC Photo Archive

Pollock, NMFS/NEFSC survey cruise, 1992
NMFS/NEFSC Photo
by Brenda Figuerido

For further information

Annand, C., D. Beanlands and J. McMillan. 1988. Assessment of Divisions 4VWX and Subarea 5 pollock, *Pollachius virens*. *CAFSAC* [Canadian Atlantic Fisheries Scientific Advisory Committee] *Res. Doc.* 88/71.

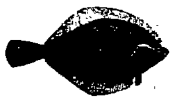
Mayo, R. K., J.M. McGlade, and S. H. Clark. 1989. Patterns of exploitation and biological status of pollock *Pollachius virens* L. in the Scotian Shelf, Gulf of Maine, and Georges Bank area. *J. Northw. Atl. Fish. Sci.* 9: 13-36.

Mayo, R.K., S.H. Clark, and M.C. Annand. 1989. Stock assessment information for pollock *Pollachius virens* L. in the Scotian Shelf, Georges Bank, and Gulf of Maine regions. *NOAA* [National Oceanic and Atmospheric Administration] *Tech. Mem. NMFS-F/NEC-65.*

Mayo, R.K. and B.F. Figuerido. 1993. Assessment of pollock, *Pollachius virens* (L.), in Divisions 4VWX and Subareas 5 and 6, 1993. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-13.

Trippel, E.A. and L.L. Brown. 1994. Assessment of pollock *(Pollachius virens)* in Divisions 4VWX and Subdivision 5Zc for 1993. DFO [Department of Fisheries and Oceans] *Atlantic Fisheries Res. Doc.* 94/67.

Yellowtail Flounder



by P. Rago

Yellowtail flounder, *Pleuronectes ferrugineus,* range from Labrador to Chesapeake Bay. Off the U.S. coast, commercially important concentrations are found on Georges Bank, off Cape Cod, and in Southern New England, generally at depths between 37 and 73 m (20 to 40 fathoms). The U.S. fleet also fishes for yellowtail in the northern Gulf of Maine, the Mid-Atlantic Bight, and on the Grand Banks of Newfoundland outside the Canadian 200-mile limit. Yellowtail can attain lengths of 47 cm (18.5 in.) and weights of 1.0 kg (2.2 lb), but high fishing mortality has greatly reduced the average size and age of fish in the stocks. Yellowtail appear to be relatively sedentary, although seasonal movements have been documented. Spawning occurs during spring and summer, peaking in May. Larvae drift for a month or more, then assume adult characteristics and become demersal.

Historical tagging studies and contemporary examination of geographical patterns of landings and survey data indicate relatively discrete stocks in Southern New England, Georges Bank, and Cape Cod. Intermingling among these groups of fish is probably low but has not been quantified. Annual survey abundance indices for Georges Bank are significantly correlated with Southern New England, but neither stock is correlated with the Cape Cod stock.

The principal fishing gear used to catch yellowtail flounder is the otter trawl. Current levels of recreational and foreign fishing are insignificant. The fishery is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Total landings of yellowtail flounder in 1993 were 3,800 mt, the lowest on record. These landings were 15% of the average value during 1974-1983 and 6% of the historical maximum in 1969.

Georges Bank

Total landings of yellowtail from Georges Bank averaged 16,300 mt during 1962-1976 but declined to an average of 5,800 mt between 1978 and 1981. Strong recruitment from the 1977 and 1980 year classes and high fishing effort allowed landings to exceed 10,500 mt in 1982 and 1983. Since 1985, landings have been 3,000 mt or less. Landings fell to a record low of 1,100 mt in 1989, increased to 2,900 mt in 1992 but declined to 2,300 mt in 1993.

Abundance indices for yellowtail flounder from both the NEFSC autumn and spring surveys have declined at average rates of about 10% per year since 1963. Several large year classes have temporarily reversed the overall rate of decline but the general trend has persisted. Between 1963 and 1969, autumn survey indices averaged 26 fish per tow; in the last five years the average was less than 3 yellowtail per tow. Declines in average weight per tow have been less pronounced, but suggest that current biomass levels are about 10% of levels observed in the 1960s.

Instantaneous fishing mortality rates have exceeded 1.0 (58% exploitation rate) in 16 of the past 21 years. The current minimum size limit (13 in.) and mesh regulations delay full recruitment to the fishery until age 4. Discarding of small yellowtail is an important source of mortality owing to intense fishing pressure and the discrepancy between minimum size limits and trawl selectivity properties. The average fishing mortality rate during the last 10 years has exceeded 1.3 (67% exploitation rate), four times greater than $F_{0.1}$ (0.28) and twice as large as the fishery mortality rate associated with the overfishing definition for this stock (*i.e.*, $F_{20\%}$ = 0.58).

Yellowtail
NMFS/NEFSC photo by Brenda Figuerido

"Discarding of small yellowtail is an important source of mortality owing to intense fishing pressure and the discrepancy between minimum size limits and trawl selectivity properties."

Spawning stock biomass levels of more than 5,000 mt in 1989-1990 and in 1992 were due entirely to recruitment of moderate year classes (1987 and 1990, respectively). These levels are less than a third of those observed as recently as 1982 (17,300 mt), a fifth of the 1973 biomass (25,000 mt), and most likely, a much smaller fraction of earlier levels.

This stock is overexploited and at a low level of abundance with few age groups present. Rebuilding of the stock will require reduction in fishing mortality to near zero and several years of improved recruitment. The Stock Assessment Review Committee (1994a) concluded that this stock had collapsed.

Southern New England

Landings of yellowtail flounder from the Southern New England stock averaged 20,000 mt during 1963-1968 but

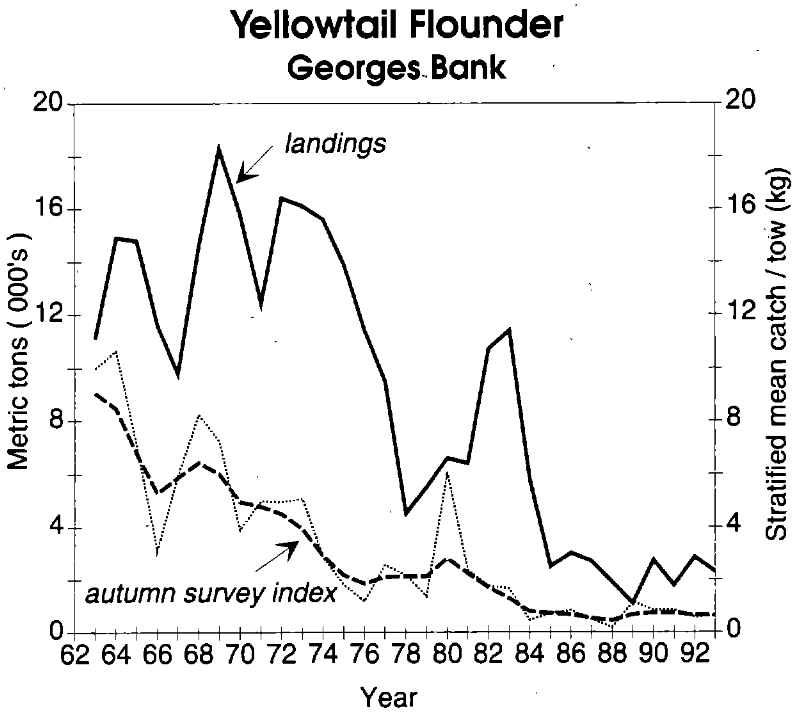


Table 7.1 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	9.3	5.8	2.5	3.0	2.7	1.9	1.1	2.7	1.8	2.9	2.1
Canada	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	<0.1	0.2
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	9.4	5.8	2.5	3.0	2.7	1.9	1.1	2.7	1.8	2.9	2.3

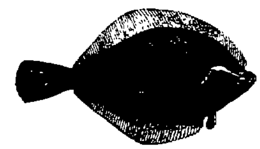
Georges Bank Yellowtail Flounder

Long-term potential catch	=	16,000 mt
SSB for long-term potential catch	=	65,000 mt
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	27 cm (11 in.)
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%}$=0.58

M = 0.20 **$F_{0.1}$ = 0.25** **$F_{20\%}$ = 0.58** **F_{max} = 0.63**

F_{1993} = 1.20

"Recent estimates suggest that the discarded biomass per recruit exceeds the average landings per recruit by a factor of two."



declined abruptly after 33,000 mt were landed in 1969. Landings fell by 75% to 8,900 mt in 1971 and have exceeded that level only three times in the past 24 years. Landings increased rapidly between 1981 and 1983 to 17,000 mt, due to strong recruitment of the 1980 year class. Landings subsequently declined to a low of only 900 mt in 1988. Another short-lived recovery occurred in 1990 when the strong 1987 year class became fully recruited. The apparent recoveries in 1983 and 1990 have produced landings roughly one-half of the preceding maximum values. In 1993, landings totaled only 500 mt, a record low, and less than half of the previous record low of 900 mt in 1988.

NEFSC autumn survey abundance and biomass indices were at historically high levels between 1963 and 1972, but declined sharply in 1973. Since then, the low level of survey indices has been briefly punctuated by the recruitment of the strong 1980 and 1987 year classes. Survey catches in the intervening years were among the lowest on record. Recruitment of the 1987 year class boosted the 1989 index to its highest level since 1983 but this increase was ephemeral. By 1992, the index had fallen to the lowest level in the 30-year series. The average rates of decline in the spring and autumn surveys are statistically identical and indicate an average rate of decline of 11% per year. Current stock size is about 5% of levels observed in the late 1960s.

Instantaneous fishing mortality rates on the fully recruited ages fluctuated between 0.6 and 1.1 from 1973 to 1979. Since then, fishing mortality rates have averaged 1.6 per year (74% exploitation rate). In the last five years, yellowtail older than four years have virtually disappeared from both the commercial landings and trawl surveys. During this same period, fishing mortality has removed nearly 80% of population biomass each year. The implications of these high exploitation rates are clear--the commercial viability of the stock is in danger. Under prevailing levels of depressed abundance and extremely high fishing mortality, any increases in future landings will depend totally on strong year classes. Spawning stock biomass in 1993, however, was at its lowest level on record (1,000 mt compared to 22,000 mt in 1989, and a long term average of 9,000 mt). Thus, even favorable environmental conditions for recruitment may not be sufficient to begin a recovery.

Discarding of undersized yellowtail flounder is a more serious problem in Southern New England than on Georges Bank. Recent estimates suggest that the discarded biomass per recruit exceeds the average landings per recruit by a factor of two. Greater fishing effort, small mesh trawl fisheries (< 5.5 in. mesh), and slower individual growth rates contribute to this economic inefficiency. The fate of the 1987 year class dramatically illustrates the magnitude of the discarding problem. Of the 77 million fish caught from this cohort, more than 46 million were discarded. Even as 4-year-olds, more than 30% of the year class was discarded.

This stock is overexploited and at an extremely low level of abundance. Fishing mortality during 1990-1992 averaged 2.2 (83% exploitation rate), four times greater than fishing mortality corresponding to the overfishing definition for the stock (*i.e.*, $F_{20\%} = 0.49$). The Stock Assessment Review Committee (1994b) concluded that this stock had collapsed and that measures should be taken to reduce fishing mortality to levels approaching zero.

Cape Cod

Traditionally, landings of yellowtail flounder from the Cape Cod stock have been a small fraction of the landings from Southern New England and Georges Bank. In 1993, for the first time, landings

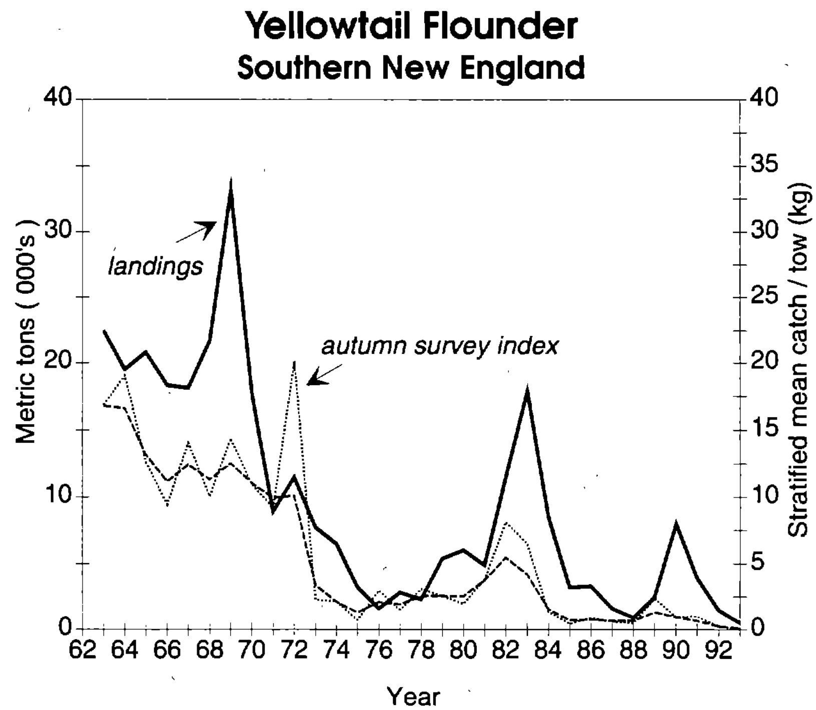


Table 7.2 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	6.0	7.9	2.7	3.3	1.6	0.9	2.5	8.0	3.9	1.5	0.5
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	6.0	7.9	2.7	3.3	1.6	0.9	2.5	8.0	3.9	1.5	0.5

Southern New England Yellowtail Flounder

Long-term potential catch	=	23,000 mt[1]
SSB for long-term potential catch	=	75,000 mt
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	26 cm (10 in.)
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%} = 0.49$

$M = 0.20$ $F_{0.1} = 0.22$ $F_{max} = 0.48$ $F_{20\%} = 0.49$

$F_{1993} \cong 2.20$

[1]Includes potential from Cape Cod and Mid-Atlantic groups

"In 1993, for the first time, landings from the Cape Cod stock (800 mt) exceeded those from Southern New England. "

from the Cape Cod stock (800 mt) exceeded those from Southern New England. This situation however, is more indicative of a decimated Southern New England stock than a rebuilding of the Cape Cod stock.

Landings of Cape Cod yellowtail fluctuated between 1,500 and 2,000 mt in the 1960s, increased during the 1970s, attained a record-high of 5,000 mt in 1980, and then declined, reaching a record low level of 800 mt in 1992 and 1993.

The NEFSC autumn survey indices have been highly variable, but have reflected the general pattern of landings. As observed for Southern New England and Georges Bank stocks, the relatively strong 1987 year class dominated index values in 1989. Survey values in 1992 were similar to 1989 levels, but declined in 1993.

Recent declines in landings and relatively low survey indices (compared to those in the mid-1970s) suggest that stock biomass has been reduced by the high catches of the late 1970s and early 1980s. Given these factors, the stock is considered to be overexploited.

Middle Atlantic

Trends for the Mid-Atlantic stock of yellowtail flounder have been generally similar to those observed for Southern New England. Landings declined from more than 8,000 mt in 1972 to less than 1,000 mt between 1976 and 1980. As a result of improved recruitment in the early 1980s, landings increased from 300 mt in 1980 to 2,200 mt in 1984. Landings have since returned to the low levels of the late 1970s with only 200 mt landed in 1993.

Prior to 1973, average biomass per tow in NEFSC autumn survey indices in the Mid-Atlantic region was comparable to levels on Georges Bank. Subsequent

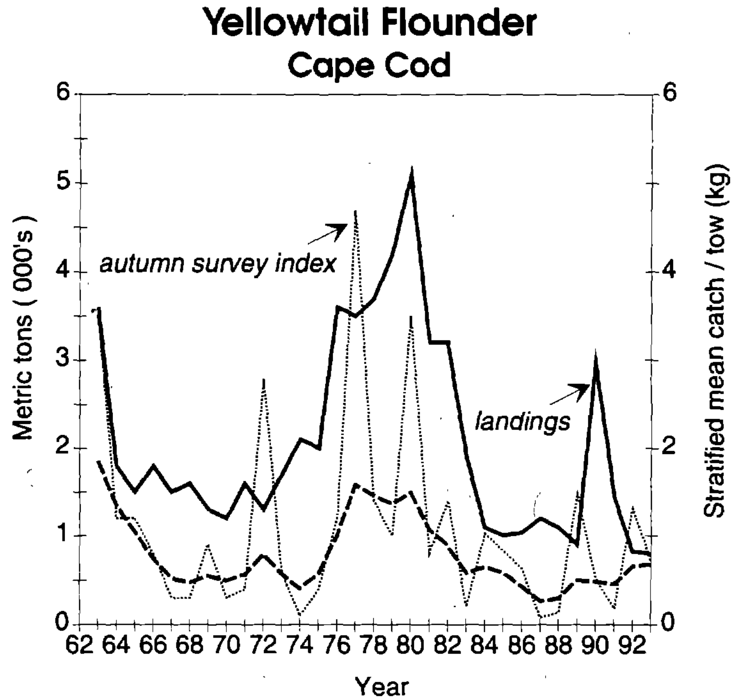


Table 7.3 Recreational catches and commercial landings (thousand metric tons)

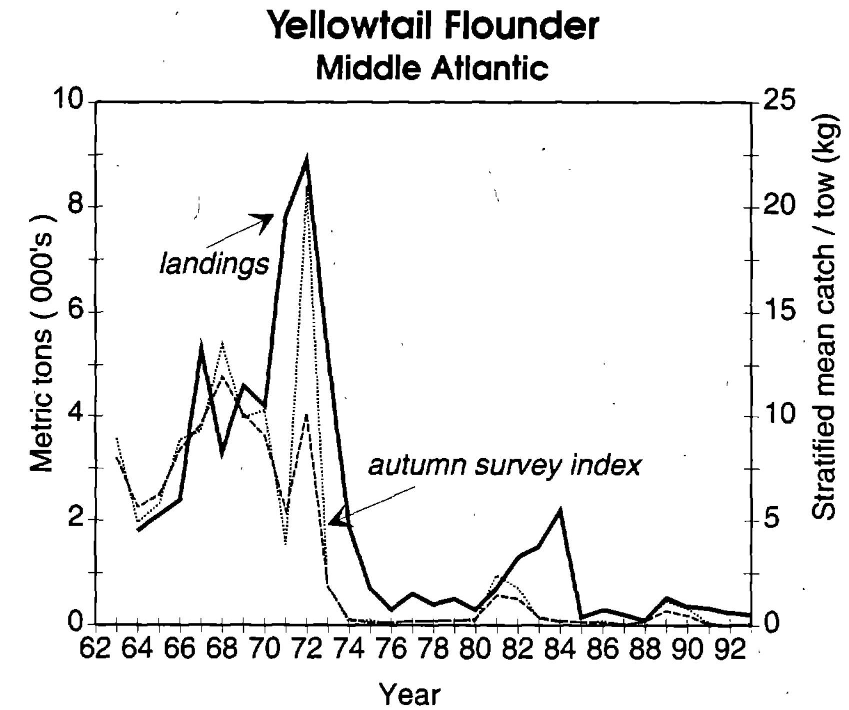
Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	3.2	1.1	1.0	1.0	1.2	1.1	0.9	3.0	1.5	0.8	0.8
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.2	1.1	1.0	1.0	1.2	1.1	0.9	3.0	1.5	0.8	0.8

Cape Cod Yellowtail Flounder

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	27 cm (11 in.)
Assessment level	=	Yield per recruit
Overfishing definition	=	N/A
Fishing mortality rate corresponding to overfishing definition	=	N/A

M = 0.20 **$F_{0.1}$ = 0.21** **F_{max} = 0.55** **F_{1993} = Unknown**

"Qualitatively, survey and catch data suggest persistently low abundance."



to the removal of more than 8,000 mt in 1972, survey indices fell to extraordinarily low values. The *maximum* value since 1973 is far less than the *minimum* value measured in the first decade of the survey (1963-1972). Survey indices improved slightly in 1981-82 and again in 1989-90 but these brief increases were followed by indices near zero.

The quality of available assessment data is insufficient to permit a quantitative estimate of stock abundance or exploitation. Qualitatively, survey and catch data suggest persistently low abundance. Exploitation rates have not been estimated but are probably high, and hence the stock is considered to be overexploited.

Table 7.4 Recreational catches and commercial landings (thousand metric tons)

Category	Year										
	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	.	.	.	.	.	.	.	.	.	.	.
Commercial											
United States	0.8	2.2	0.2	0.3	0.2	<0.1	0.5	0.4	0.3	0.2	0.2
Canada	.	.	.	.	.	.	.	.	.	.	.
Other	.	.	.	.	.	.	.	.	.	.	.
Total nominal catch	0.8	2.2	0.2	0.3	0.2	<0.1	0.5	0.4	0.3	0.2	0.2

Middle Atlantic
Yellowtail Flounder

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	26 cm (10 in.)
Assessment level	=	Yield per recruit
Overfishing definition	=	N/A
Fishing mortality rate corresponding to overfishing definition	=	N/A

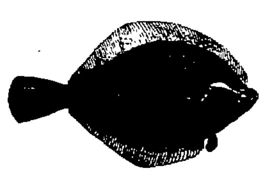
$M = 0.20$ $F_{0.1} = 0.21$ $F_{max} = 0.55$ F_{1993} = Unknown

For further information

NEFSC [Northeast Fisheries Science Center]. 1991. Report of the 12th Northeast Regional Stock Assessment Workshop (12th SAW), Spring 1991 Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 91-03.

NEFSC [Northeast Fisheries Science Center]. 1994a. Report of the 17th Northeast Regional Stock Assessment Workshop (17th SAW), Fall 1993. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-03.

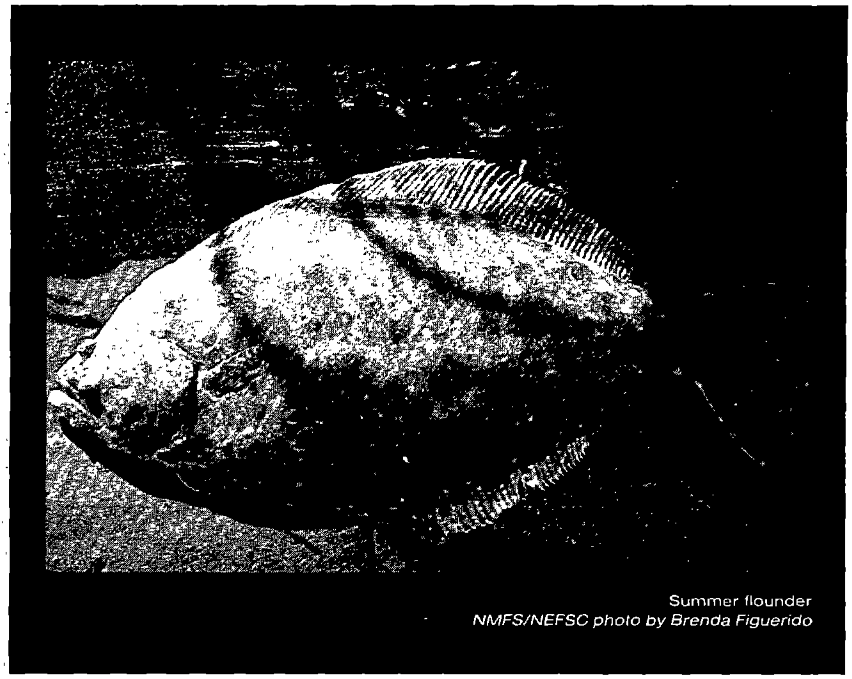
NEFSC [Northeast Fisheries Science Center]. 1994b. Report of the 18th Northeast Regional Stock Assessment Workshop (18th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-22.



Summer Flounder 

by M. Terceiro

The summer flounder or fluke, *Paralichthys dentatus*, occurs from the southern Gulf of Maine to South Carolina. Important commercial and recreational fisheries for summer flounder exist within the Mid-Atlantic Bight (Cape Cod to Cape Hatteras). Summer flounder are concentrated in bays and estuaries from late spring through early autumn. An offshore migration to the outer continental shelf is undertaken in autumn. Spawning occurs during the offshore autumn migration and into the winter, and the larvae are transported toward coastal areas by prevailing water currents. Development of post-larvae and juveniles occurs primarily within bays and estuarine areas, notably Pamlico Sound and Chesapeake Bay. Historical length data indicate that female summer flounder may potentially live up to 20 years, but males rarely exceed 7 years. Growth rates differ appreciably between the sexes, with females attaining weights up to 11.8 kg (26 lb).



Summer flounder
NMFS/NEFSC photo by Brenda Figuerido

The resource is managed under the Summer Flounder Fishery Management Plan (FMP) as a single stock unit from the southern border of North Carolina northeast to the U.S.-Canada border. Amendment 2 to the FMP made several major changes in fishery regulations beginning in 1993. Among these were annual commercial and recreational fishery landings quotas, a commercial vessel permit moratorium, commercial fishery minimum mesh sizes, minimum fish size regulations, and a recreational fishery possession limit, minimum fish size regulation, and restricted fishing season. The total fishery quota for 1994 was 12,100 mt (up from 9,400 mt in 1993), with the commercial quota at 7,260 mt and the recreational share at 4,840 mt. The FMP set a target fishing mortality rate of 0.53 for 1993-1995, with a target of F_{max} = 0.23 for 1996 and beyond.

Total landings averaged 23,000 mt during 1980-1988, peaking at 30,200 mt in 1984. Since 1989, total annual landings have been much lower, ranging between 6,600 and 10,700 mt. Total landings in 1993 were 9,700 mt, 9% less than in 1992 due to restrictions on the fisheries.

The principal gear used in commercial fishing for summer flounder is the otter trawl. Commercial landings of summer flounder averaged 13,200 mt during 1980-1988, reaching a high of 17,100 mt in 1984. Commercial landings during 1989-1993 have been markedly lower (4,200 to 8,100 mt per year); in 1993, commercial catches declined to 5,700 mt, 22% lower than in 1992.

The recreational fishery for summer flounder harvests a significant proportion of the total catch, and in some years recreational landings have exceeded the commercial landings. Recreational landings have historically constituted about 40% of the total landings. Recreational landings averaged 9,800 mt during 1980-1988, and peaked at 16,400 mt in 1983. Recreational landings decreased dramatically (by 82%) in 1989 to 1,500 mt. Recreational landings have since modestly increased to 4,000 mt in 1993.

Catch curve analysis of NEFSC survey and commercial fishery age composition data collected from 1976 through 1983 indicated that fishing mortality rates during this period were about 0.6 to 0.7 (41 to 46% exploitation rates), well in excess of F_{max} (F = 0.23).

Recent virtual population analyses (VPAs) have used NEFSC survey age composition data, survey age composition data from the states of Massachusetts, Rhode Island, Connecticut, New York, Delaware, Maryland, Virginia, and North Carolina, and commercial and recreational fishery age composition data to estimate fishing mortality rates and stock sizes. Results indicate that recent fishing mortality has been very high, varying between 1.18 and 1.83 (65-78% exploitation rates) during 1984-1992, far in excess of the overfishing definition, F_{max} = 0.23. Under target quota management, fishing mortality declined markedly in 1993 to 0.54, due to recruitment

"Under target quota management, fishing mortality declined markedly in 1993 to 0.54, due to recruitment of the 1991 and 1992 year classes."

of the 1991 and 1992 year classes. The 1993 year class, however, is expected to be one of the poorest on record.

Spawning stock biomass declined 75% from 1983 to 1989 (22,200 mt to 5,400 mt), but has since increased to 14,000 mt in 1993. The age structure of the spawning stock remains truncated, however, with only 12% of the biomass at ages 3 and older. In contrast, about 77% of the spawning stock would be expected to be aged 3 and older if the stock were rebuilt and fished at F_{max} = 0.23. The summer flounder stock remains overfished and is presently at an average level of abundance.

For further information

Northeast Fisheries Center. 1986. Report of the Third NEFC Stock Assessment Workshop. Woods Hole, MA: NOAA/NMFS/NEFC. *Lab. Ref. Doc.* 86-14.

NEFSC [Northeast Fisheries Science Center]. 1993. Report of the Sixteenth Northeast Regional Stock Assessment Workshop (16th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-06.

NEFSC [Northeast Fisheries Science Center]. 1994. Report of the Eighteenth Northeast Regional Stock Assessment Workshop (18th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-22.

Summer Flounder
Georges Bank-Middle Atlantic

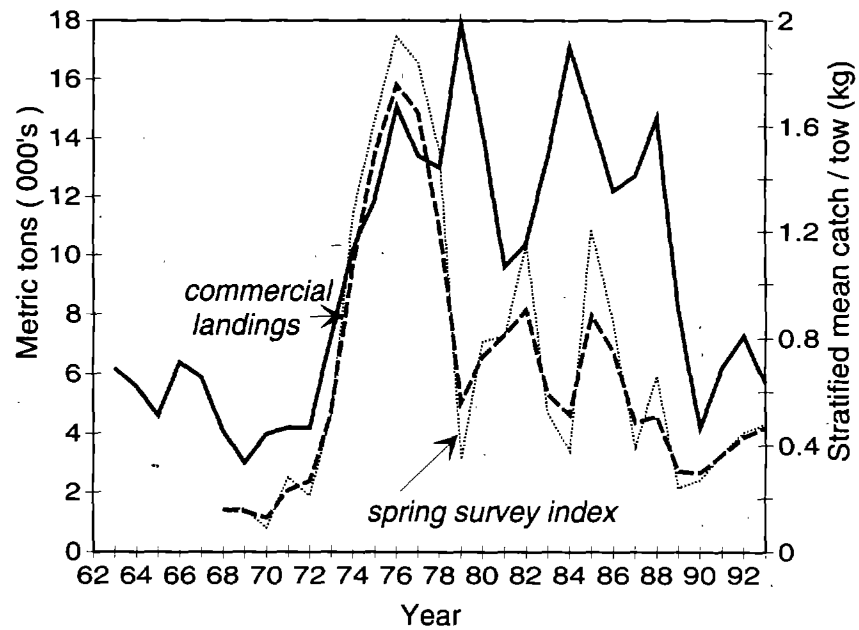


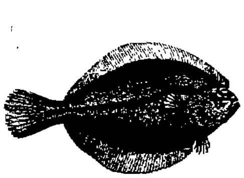
Table 8.1 Recreational and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	6.6	13.1	7.6	8.5	5.7	8.5	1.5	2.4	3.5	3.4	4.0
Commercial											
United States	10.0	17.1	14.7	12.2	12.3	14.7	8.1	4.2	6.2	7.3	5.7
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	16.6	30.2	22.3	20.7	18.0	23.2	9.6	6.6	9.7	10.7	9.7

Georges Bank-Middle Atlantic
Summer Flounder

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Summer Flounder FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	1 year, females
Size at 50% maturity	=	27 cm (10.6 in.)
Assessment level	=	Age structured
Overfishing definition	=	F_{max}
Fishing mortality rate corresponding to overfishing definition	=	0.23

M = 0.20 **$F_{0.1}$ = 0.14** **F_{max} = 0.23** **F_{1993} = 0.54**



American Plaice

by L. O'Brien

The American plaice or dab, *Hippoglossoides platessoides*, is a large-mouthed, "right-handed" flounder, distributed along the Northwest Atlantic continental shelf from southern Labrador to Rhode Island in relatively deep waters. Off the U.S. coast, the greatest commercial concentrations exist between 90 and 182 m (50 and 100 fathoms). Sexual maturity begins between ages 2 and 3, but most individuals do not reach maturity until age 4. Spawning occurs in spring, generally during March through May. Growth is rather slow; 3-year-old fish are normally between 22 and 28 cm (9 to 11 in.) in length, and weigh between 90 and 190 g (0.2 to 0.4 lb). After age 4, females grow faster than males.

The principal commercial fishing gear used to catch American plaice is the otter trawl. The fishery is prosecuted primarily during the second and third quarter of the calendar year. Recreational and foreign catches are insignificant. The U.S. fishery is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Total commercial landings in 1993 were 5,800 mt, 12% less than in 1992 (6,600 mt).

American plaice
NMFS/NEFSC photo by Brenda Figuerido

Landings of American plaice increased from an average of 2,300 mt during 1972-1976 to an average of 12,700 mt per year during 1979-1984. Subsequently, annual landings declined and since 1991 have ranged between 4,000 mt and 7,000 mt.

Between 1960 and 1974, 67% of U.S. landings were from deep-water areas on Georges Bank. Since then, Gulf of Maine landings have greatly exceeded those from Georges Bank. The U.S. 1993 Gulf of Maine catch (3,900 mt) was more than twice as large as that from Georges Bank (1,800 mt).

United States commercial CPUE indices were relatively stable between 1964 and 1969, declined in the early 1970s, and sharply increased to a record-high in 1977 when total landings doubled. Subsequently, annual CPUE indices steadily declined reaching a record-low in 1988. The index has since remained relatively stable at low values.

Abundance and biomass indices from autumn NEFSC surveys reached record-low values in 1987 but increased through 1990 as the strong 1987 year class recruited to the survey gear. The indices declined in 1991 and 1992, but markedly increased in 1993 due to improved recruitment from the 1989 and 1990 year classes.

Virtual population analyses indicate that fishing mortality on fully recruited ages (6-9+) more than doubled between 1981 (F=0 .36) and 1987 (F=0.87), but declined to F=0.47 in 1990. Fishing mortality in 1991 was estimated to be 0.58, which is well above F_{max}=0.29 and the F needed to attain 20% maximum spawning potential ($F_{20\%}$=0.49), the overfishing definition established for this stock. Based on landings data, fishing mortality in 1992 and 1993 was projected to have been above 0.70.

Spawning stock biomass declined from 41,400 mt in 1980-1982 to 7,700 mt in 1987-1989. In 1991, the spawning stock biomass increased to 13,400 mt as the strong 1987 year class began to recruit to the spawning stock. Spawning stock biomass was projected to remain relatively stable in 1992 and 1993.

Discard estimates of American plaice indicate that discarding is highest on age 2 and 3 fish in the northern shrimp fishery and on age 3 and 4 fish in the large mesh otter trawl fishery. Estimates of discarded plaice in the northern shrimp fishery using sea sampling data indicated that by 1991, 40% of the total cumulative catch (in numbers) of the 1987 year class had been discarded. Similarly, in the large mesh fishery, estimates of discarding of plaice indicated that 41% of the total cumulative catch of the 1987 year class had been discarded by 1991.

"The 1990 year class represents the next opportunity to continue increasing harvestable biomass if fishing mortality and discarding are reduced."

The decline in landings that occurred between 1983 and 1989 reflected a declining trend in harvestable biomass, as indicated by both catch per unit effort and survey indices. Although landings increased in 1990-1992, as the 1986 and 1987 year classes recruited to the fishery, landings again declined in 1993 and the stock biomass remains at a medium level. The 1990 year class represents the next opportunity to continue increasing harvestable biomass if fishing mortality and discarding are reduced. However, fishing effort has increased in recent years and levels of both fishing and discard mortality are likely to remain high. Given these conditions, abundance of American plaice is expected to remain at medium levels and the stock will remain overexploited.

For further information

Mayo, R.K., L. O'Brien, and N. Buxton. 1992. Discard estimates of American plaice in the Gulf of Maine northern shrimp fishery and the Gulf of Maine-Georges Bank large mesh otter trawl fishery. Woods Hole, MA: NOAA/NMFS/NEFSC. *SAW 14 Res. Doc.* 14/3. Northeast Fisheries Science Center. 1992. Report of the Fourteenth Northeast Regional Stock Assessment Workshop. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 92-07.

O'Brien, L., R.K. Mayo, N. Buxton, and M. Lambert. 1992. Assessment of American Plaice in the Gulf of Maine - Georges Bank Region 1992. Woods Hole, MA: NOAA/NMFS/NEFSC. *SAW 14 Res. Doc.* 14/2.

Sullivan, L.F. 1982. American plaice, *Hippoglossoides platessoides*, in the Gulf of Maine. Kingston, RI: University of Rhode Island. Master's thesis.

American Plaice
Gulf of Maine-Georges Bank

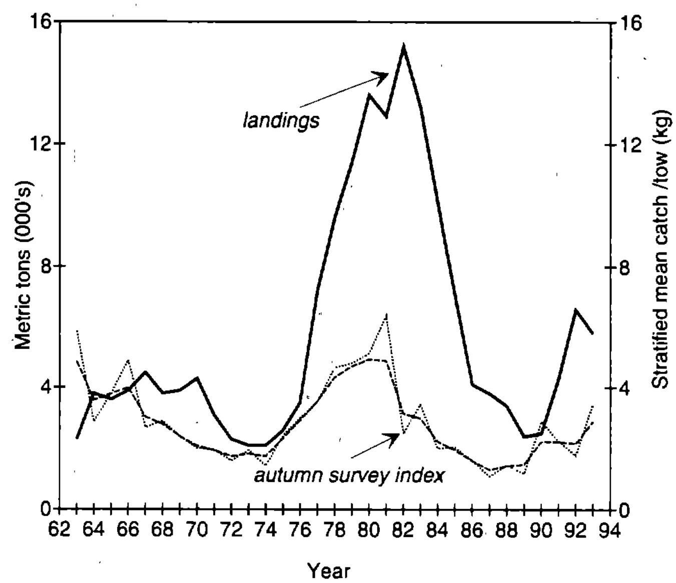


Table 9.1 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	9.1	10.1	7.0	4.1	3.8	3.3	2.3	2.5	4.3	6.6	5.8
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	9.1	10.1	7.0	4.1	3.8	3.4	2.4	2.5	4.3	6.6	5.8

Gulf of Maine-Georges Bank
American Plaice

Long-term potential yield[1]	=	3,600 mt
SSB for long-term potential catch	=	12,000 mt
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	3.0 years, males; 3.6 years, females
Size at 50% maturity	=	22.1 cm (8.7 in.), males; 26.8 cm (10.6 in.), females
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.49

$M = 0.20$ $F_{0.1} = 0.18$ $F_{max} = 0.29$ $F_{20\%} = 0.49$
$F_{1993} = >0.70$

[1]Excluding discards

Witch Flounder

by S. Wigley

Witch flounder at the Portland Fish Auction
NMFS/NEFSC photo by Greg Power, NEFSC Statistics Branch

The witch flounder or gray sole, *Glyptocephalus cynoglossus*, is common throughout the Gulf of Maine and also occurs in deeper areas on and adjacent to Georges Bank and along the shelf edge as far south as Cape Hatteras. Research vessel survey data suggest that the Gulf of Maine population may be relatively discrete from populations in other areas. Witch flounder appear to be sedentary, preferring moderately deep areas; few fish are taken shallower than 27 m (15 fathoms) and most are caught between 110 and 275 m (60 and 150 fathoms). Spawning occurs in late spring and summer. Witch flounder attain lengths up to 78 cm (31 in.) and weights of approximately 2 kg (4.5 lb).

The principal fishing gear used to catch witch flounder is the otter trawl. Recreational catches and foreign catches are insignificant. Fishing is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Total landings in 1993 were 2,600 mt, an increase of 18% from 1992 (2,200 mt).

The U.S. nominal catch has fluctuated between Georges Bank and Gulf of Maine. In recent years most of the U.S. catch has come from the Gulf of Maine. Canadian nominal catches from both areas have been minor (never more than 68 mt annually). Distant-water fleet catches averaged 2,700 mt in 1971-1972, but subsequently declined sharply and have been negligible since 1976. After averaging 2,800 mt during 1973-1981, total nominal catches increased sharply during the early 1980s and peaked at 6,500 mt in 1984. Catches then steadily declined through 1990 when landings reached 1,500 mt, the lowest value since 1964. A Grand Banks fishery for witch flounder developed in 1985 and continued through 1989, which accounted for an annual U.S. harvest of 400 mt; however, few or no landings have been reported from this region since 1990.

The NEFSC autumn survey catches seem to accurately reflect trends in biomass. Heavy exploitation by distant-water fleets in 1971-1972 was followed by a decline in the autumn index from an average of 3.6 kg per tow in 1966-1970 to 0.9 kg per tow in 1976. Biomass increased in 1977-78 but subsequent indices have declined steadily to the lowest levels on record. The 1993 value of 0.5 kg per tow represents only a slight increase over the record low 1992 value of 0.2 kg per tow.

Prior to the 1980s, witch flounder was primarily a bycatch species. In the early 1980s, United States commercial LPUE (landings per unit effort for all trips landing witch flounder) indices increased and peaked in 1983 as effort became more directed toward witch flounder. As abundance continued to decline, catch rates declined, reaching record lows in 1990 and 1991. Despite a modest increase in LPUE, the 1993 index remains among the lowest values observed.

Between 1982 and 1993, 8.7 million witch flounder were discarded in the northern shrimp fishery and large-mesh otter trawl fisheries. Discards in the northern shrimp fishery consist primarily of age 3 witch flounder, while discards in the large mesh otter trawl fishery are largely comprised of fish age 4 and older. At age 5 and older almost all fishing mortality is generated by the landings.

Virtual population analyses indicate that fishing mortality on fully recruited ages (7 to 9+) increased from F=0.19 (16% exploitation rate) in 1982 to F=0.55 (40% exploitation rate) in 1985, declined to 0.24 (20% exploitation rate) in 1990 and 1991 and increased to 0.45 (34% exploitation rate) in 1993. The current F exceeds the overfishing reference level of $F_{20\%} = 0.39$.

Since the mid-1980s, the age structure of the stock has become severely truncated. The 1980 autumn survey

"Since the mid-1980s, the age structure of the stock has become severely truncated."

indicated that 34% of the witch flounder population was age 11 or older. In 1984, 14% of the population was age 11 or older, and by 1993, only 1% of the population was 11 years or older. This trend is also reflected in the commercial landings; 16% of the 1984 landings were age 11 or older, while by 1993, landings of fish age 11 or older had dropped to 8 percent.

Spawning stock biomass (SSB) sharply declined from 26,000 mt in 1982 to about 6,300 mt in 1990 and has fluctuated at about 7,000 mt through 1993. Due to continued growth and maturation of the strong 1990 year class, SSB is expected to increase in the short term (1995 and 1996), but will thereafter decline unless fishing mortality is reduced.

The stock is at a low biomass level and is overexploited.

For further information

Burnett, J. and S. H. Clark. 1983. Status of witch flounder in the Gulf of Maine - 1983. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Lab. Ref. Doc.* 83-36.

Burnett, J., M. R. Ross, and S. H. Clark. 1992. Several biological aspects of the witch flounder (*Glyptocephalus cynoglossus* (L.)) in the Gulf of Maine-Georges Bank region. *J. Northw. Atl. Fish. Sci.* 12:15-25.

NEFSC [Northeast Fisheries Science Center]. 1994. Report of the 18th Northeast Regional Stock Assessment Workshop (18th SAW). Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Docs.* 94-22 and 94-23.

Wigley, S.E. and R.K. Mayo. 1994. Assessment of the Gulf of Maine-Georges Bank Witch flounder stock, 1994. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-17.

Witch Flounder
Gulf of Maine-Georges Bank

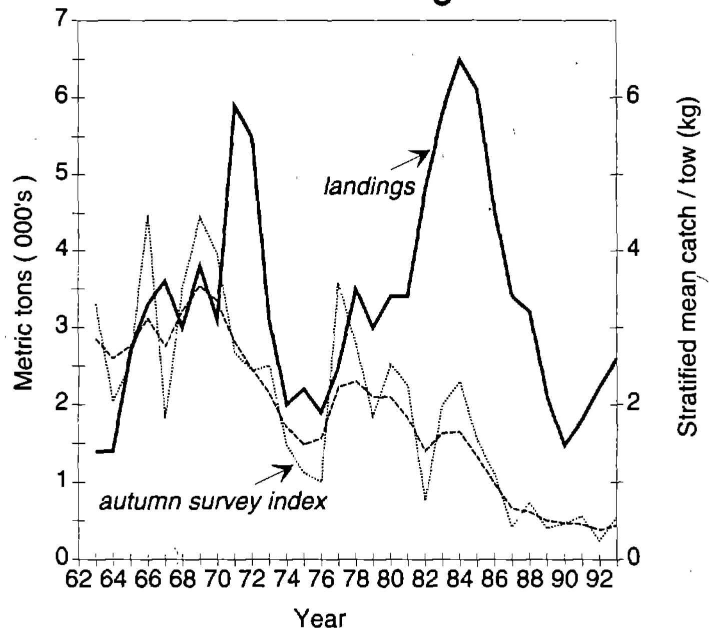


Table 10.1 Recreational and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	3.2	6.5	6.1	4.2	3.5	3.4	2.1	1.5	1.8	2.2	2.6
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.2	6.5	6.1	4.2	3.5	3.4	2.1	1.5	1.8	2.2	2.6

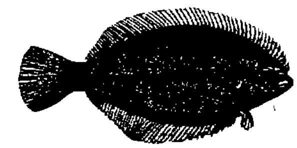
Gulf of Maine - Georges Bank
Witch Flounder

Long-term potential catch	=	<3,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	3.6 years, males 4.4 years, females
Size at 50% maturity	=	25.3 cm (10 in.) males 30.4 cm (12 in.) females
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.39

$M = 0.15$ $F_{0.1} = 0.15$ $F_{max} = 0.27$ $F_{20\%} = 0.39$

$F_{1993} = 0.45$

Winter Flounder



by W. Gabriel

The winter flounder, blackback, or lemon sole, *Pleuronectes americanus,* is distributed in the Northwest Atlantic from Labrador to Georgia. Abundance is highest from the Gulf of St. Lawrence to Chesapeake Bay. Winter flounder may attain sizes up to 58 cm (23 in.) total length. The diet consists primarily of benthic invertebrates. Movement patterns are generally localized. During winter, winter flounder undertake small-scale migrations into estuaries, embayments, and saltwater ponds to spawn, and from these locations move to deeper water during summer. Winter flounder tend to return to the same spawning locations in consecutive years. Restricted movement patterns, and differences in growth, meristic, and morphometric characteristics suggest that relatively discrete local groups exist.

Tagging and meristic studies indicate separate groups of winter flounder north of Cape Cod, east and south of Cape Cod, and on Georges Bank. For descriptive purposes, groups will be described separately for the Gulf of Maine, Southern New England - Middle Atlantic, and Georges Bank; additional studies of stock structure are needed. Winter flounder are typically exploited in coastal locations, although offshore shoal areas, particularly Georges Bank and Nantucket Shoals, support important winter flounder fisheries.

The principal commercial fishing gear used to catch winter flounder is the otter trawl. Recreational catches are significant, especially in the southern parts of the range. The fishery is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Total commercial landings in 1993 (5,300 mt) declined from 1992 levels (6,000 mt), remaining near record-low levels.

Winter flounder
NMFS/NEFSC photo by Brenda Figuerido

Gulf of Maine

Commercial landings from the Gulf of Maine increased from a steady 1,000 mt for the period 1961 to 1975 to nearly 3,000 mt in 1982. Recreational landings estimates, first available in 1979, combined to produce a total catch of 7,100 mt in that year. Total landings dropped precipitously in 1983 to 3,400 mt primarily due to a 70% reduction in recreational landings and a 25% reduction in commercial landings. Since 1988, landings in both fisheries have continued to trend downward. Combined landings in 1993 were only 700 mt, a record low for the 1979-1993 time series. Estimated recreational catches in 1993 (<100 mt) were the lowest observed. Commercial

" Combined landings in 1993 were only 700 mt, a record low for the 1979-1993 time series."

landings of 600 mt were the lowest in the 1964-1993 time period.

Bottom trawl survey abundance indices from the Massachusetts Division of

"The NEFSC autumn survey stock biomass index has generally trended downward since 1977."

Marine Fisheries spring survey of the Massachusetts Bay-Cape Cod Bay areas decreased after 1983, and reached a record-low in 1988. Since 1989, the survey indices have remained stable but at a low level. Commercial catch per unit effort (CPUE) indices (tonnage class 2 otter trawlers) peaked in the late 1960s to early 1970s, averaging 3.0 mt per days fished (df) between 1968 and 1971. The CPUE has since declined steadily, with the 1992-1993 values (0.7 mt/df) the lowest in the 30-year time series.

The continuing low level of landings, CPUE indices, and survey indices indicate that winter flounder abundance in the Gulf of Maine has been reduced substantially. Future improvements in the condition of the stock will depend on decreases in exploitation in both the recreational and commercial fisheries, and on improved recruitment. The stock is considered to be overexploited and at a low biomass level.

Georges Bank

Commercial landings from the Georges Bank region increased from 1,900 mt in 1976 to near record high levels during 1980-84 (average of 3,800 mt/yr). Between 1985 and 1988, landings averaged 2,400 mt/yr; but in recent years (1991-1992) averaged 1,800 mt/yr. No recreational catches have been reported from this stock.

Landings in 1993 (1,700 mt) remained near the lowest on record. Catch per unit effort indices in 1993 were also among the lowest ever observed. The NEFSC autumn survey stock biomass index has generally trended downward since 1977. Survey indices increased slightly in 1992-1993 but were still among

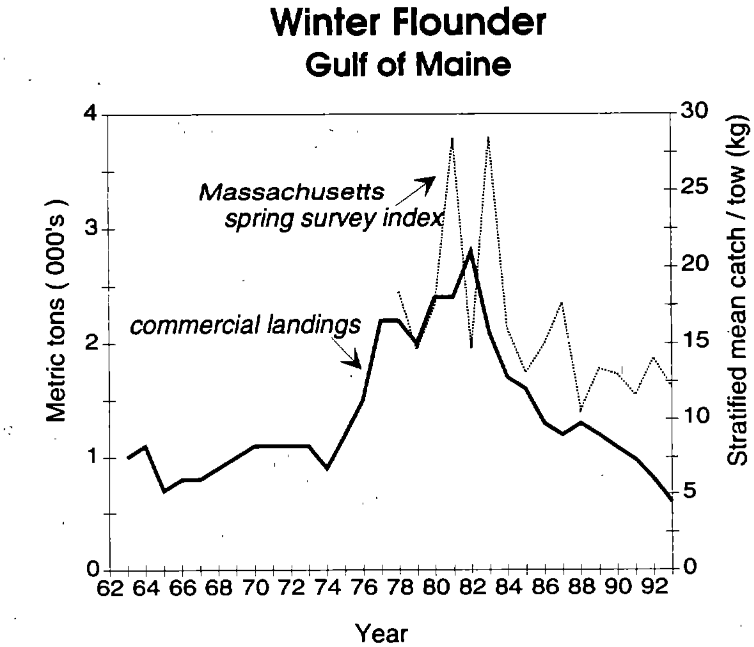


Table 11.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	3.8[1]	1.2	2.0	0.3	1.9	1.0	0.9	0.4	<0.1	0.1	0.1
Commercial											
United States	2.0	1.7	1.6	1.3	1.2	1.3	1.2	1.1	1.0	0.8	0.6
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	5.8	2.9	3.6	1.6	3.1	2.3	2.1	1.5	1.1	0.9	0.7

[1]Based on MRFSS statistics 1979-83

Gulf of Maine
Winter Flounder

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Multispecies FMP FMP for Inshore Stocks of Winter Flounder
Status of exploitation	=	Overexploited
Age at 50% maturity	=	3.4 years
Size at 50% maturity	=	27.6 cm (10.9 in.), males 29.7 cm (11.7 in.), females
Assessment level	=	Index
Overfishing definition	=	20% MSP (NEFMC) 40% MSP (ASMFC)
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = 0.28 $F_{0.1}$ = Unknown F_{max} = Unknown F_{1993} = Unknown

"Continued record low commercial and survey indices in the recent years indicate substantial reductions in stock abundance."

the lowest in the 30-year survey time series.

Although a formal assessment of the Georges Bank stock has yet to be conducted, commercial and survey data both indicate that the stock has declined to record low levels, and is overexploited.

Southern New England-Middle Atlantic

Commercial landings from the southern New England to Mid-Atlantic area increased from roughly 4,000 mt in the mid-1970s to nearly 12,000 mt in 1981. Recreational catches are unknown for that period. Commercial landings have declined steadily from their early 1980s level, while recreational catches increased from 1980 to 1985, and then declined. The combined recreational and commercial landings decreased slightly between 1992 and 1993, from 3,800 mt to a record low of 3,600 mt in the 1979-1993 time series. Commercial landings in 1993 (3,000 mt) reached a new record low, compared to historical averages of 6,800 mt (1964-1991). Recreational landings declined from 2,000 mt in 1989 to approximately 600 mt in 1993, a near record low level.

The NEFSC spring survey indices show trends similar to those of commercial catches since about 1975, increasing through 1981 and thereafter declining. The 1993 survey index was the lowest level in the 30-year time series. Commercial CPUE indices (tonnage class 3 otter trawlers) show a continuous decline from the 1964-1983 average of 2.7 mt per df to a record low 1993 value of 0.6 mt per df.

Continued record low commercial and survey indices in the recent years indicate substantial reductions in stock

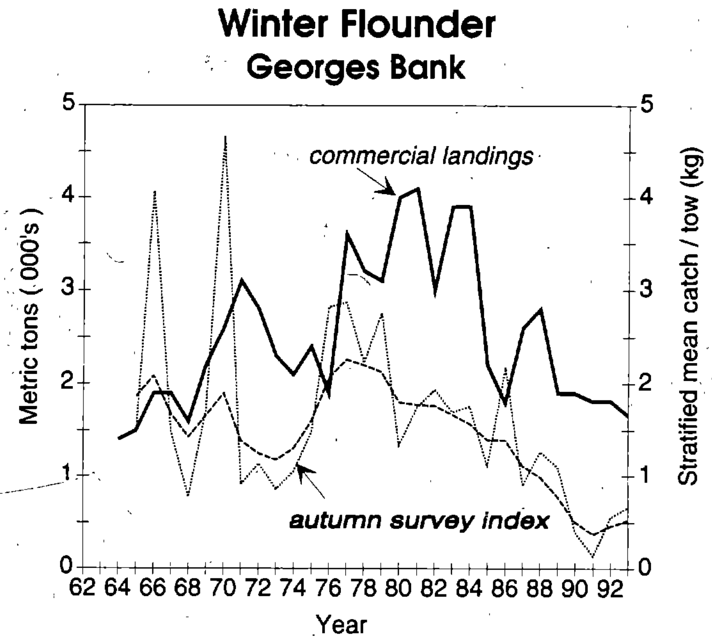


Table 11.2 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	3.1	3.9	2.2	1.8	2.6	2.8	1.9	1.9	1.8	1.8	1.7
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.1	3.9	2.2	1.8	2.6	2.8	1.9	1.9	1.8	1.8	1.7

Georges Bank
Winter Flounder

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	1.9 years
Size at 50% maturity	=	25.6 cm (10.1 in.) male 24.9 cm (9.8 in.) females
Assessment level	=	Index
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	>0.48

M = 0.20 $F_{0.1}$ = Unknown F_{max} = Unknown F_{1993} = Unknown

abundance. There are uncertainties, however, in the stock structure in this region with suggestions of many localized groups. Thus, local fluctuations in catches might be expected since fishing pressure is not applied uniformly throughout the region. However, all of the data available indicate that the stocks are overexploited and at a low biomass level.

For further information

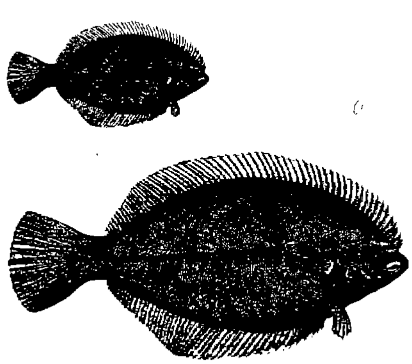
Almeida, F.P. 1989. Allocation of recreational catch statistics using MRFSS intercept data and application to winter flounder. *NOAA Tech. Memo. NMFS-F/NEC* 73.

Foster, K. L. 1987. Status of winter flounder *Pseudopleuronectes americanus* stocks in the Gulf of Maine, Southern New England and Middle Atlantic areas. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Lab. Ref. Doc.* 87-06.

Gabriel, W.L. 1985. Spawning stock biomass per recruit analyses for seven northwest Atlantic demersal finfish species. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Lab. Ref. Doc.* 84-04.

Gabriel, W.L. and K.L. Foster. 1986. Preliminary assessment of winter flounder (*Pseudopleuronectes americanus* Walbaum). Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Lab. Ref. Doc.* 86-16.

NEFSC [Northeast Fisheries Science Center]. 1992. Report of the Thirteenth Regional Stock Assessment Workshop (13th SAW), Fall 1992. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 92-02.



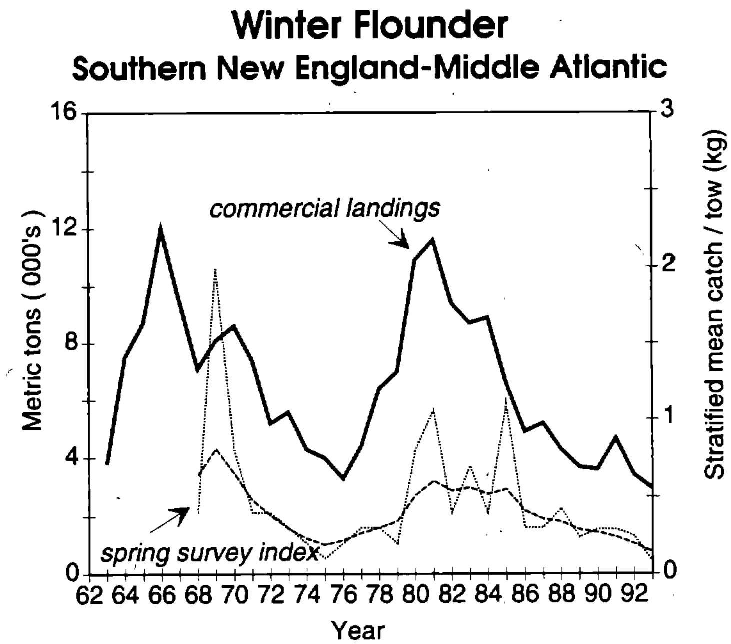


Table 11.3 Recreational catches and commercial landings (thousand metric tons)

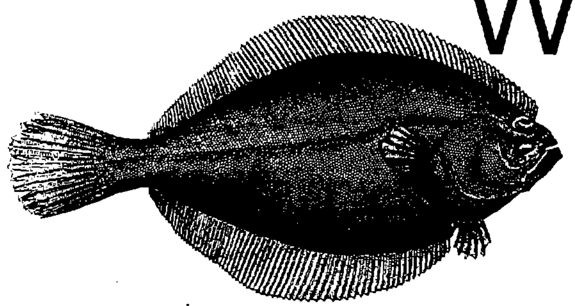
Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	3.9[1]	6.4	7.9	3.3	4.0	3.9	2.0	0.9	1.1	0.4	0.6
Commercial											
United States	7.0	8.9	6.6	4.9	5.2	4.3	3.7	3.6	4.7	3.4	3.0
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	10.9	15.3	14.5	8.2	9.2	8.2	5.7	4.5	5.8	3.8	3.6

[1]Based on MRFSS statistics 1979-83

Southern New England - Middle Atlantic
Winter Flounder

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Significant
Management	=	Multispecies FMP FMP for Inshore Stocks of Winter Flounder
Status of exploitation	=	Overexploited
Age at 50% maturity	=	3.1 years
Size at 50% maturity	=	29.0 cm (11.4 in.), males 27.6 cm (10.9 in.), females
Assessment level	=	Index
Overfishing definition	=	20% MSP (NEFMC) 40% (ASMFC)
Fishing mortality rate corresponding to overfishing definition	=	>0.57 (NEFMC) >0.32-1.01 (ASMFC)

M = 0.28-0.42 $F_{0.1}$ = Unknown F_{max} = Unknown F_{1993} = Unknown



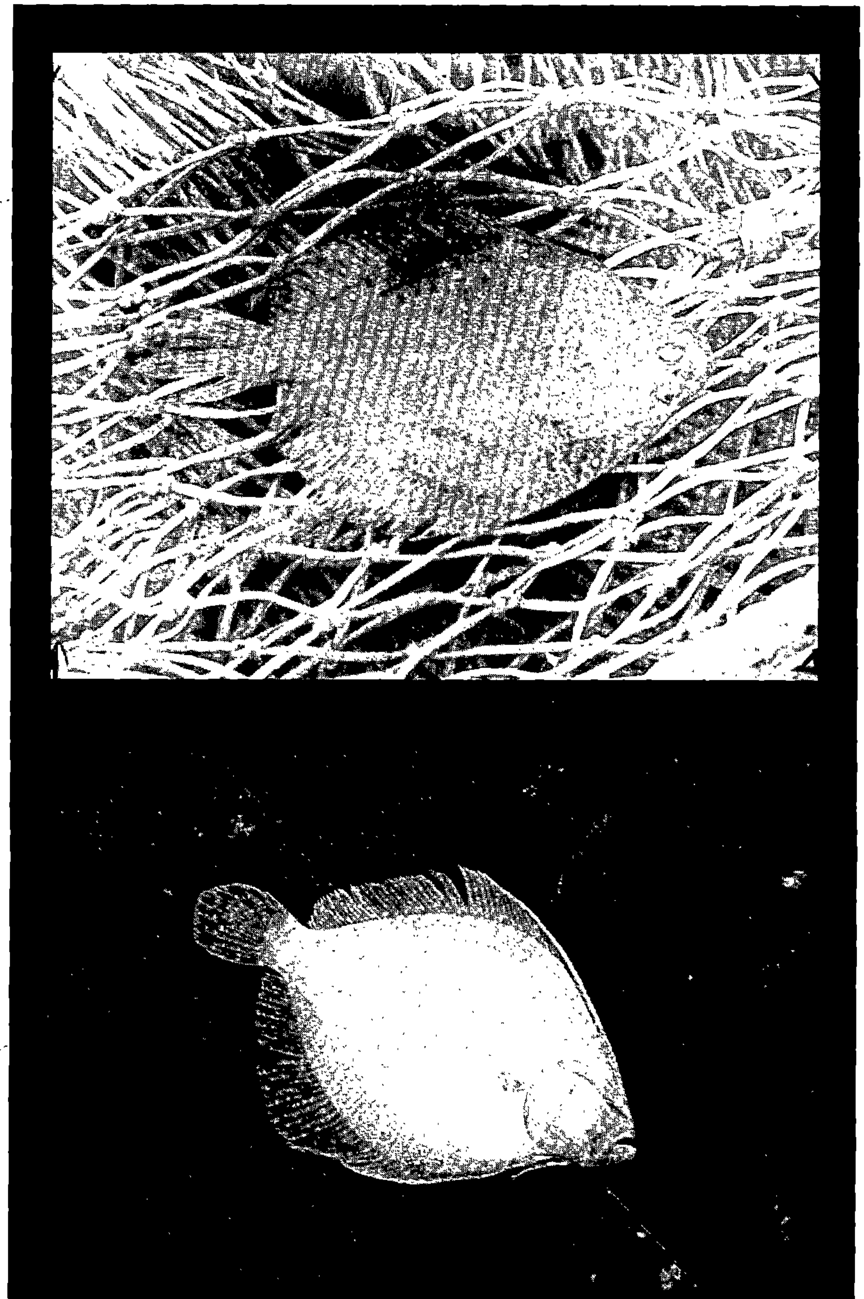
Windowpane Flounder

by W. Gabriel

Windowpane or sand flounder, *Scophthalmus aquosus*, is a thin-bodied, left-handed flounder distributed along the Northwest Atlantic continental shelf from the Gulf of St. Lawrence to Florida. The greatest commercial concentrations exist in waters less than 46 m (25 fathoms) from Georges Bank and Southern New England. Sexual maturity occurs between ages 3 and 4. Spawning occurs from late spring to autumn, peaking in July-August on Georges Bank and September in Southern New England. Windowpane commonly attain lengths up to 41 cm (16.1 in.).

No stock structure information is presently available. A provisional summary of information is given for two areas corresponding to survey strata, based on suggested differences in growth, maturity, and abundance trends between fish from Georges Bank and Southern New England. Because the proportion of landings contributed by the Gulf of Maine and Mid-Atlantic areas is low (less than 7 percent), information from these two areas is combined with that from Georges Bank and Southern New England areas, respectively.

The principal commercial fishing gear for windowpane flounder is the otter trawl. Recreational and foreign catches are insignificant, although historic foreign catches in the industrial fishery category may have been substantial. The fishery is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Landings in 1993 (1,600 mt) were 24 percent lower than in 1992 (2,100 mt), and were about 40 percent lower than the 1988-1992 average (2,800 mt).



Windowpane flounder
NMFS/NEFSC photo by Brenda Figuerido

"Increased landings since the mid-1980s probably reflect an expansion of the fishery offshore, as well as the targeting of windowpane flounder as an alternative to other depleted flatfish stocks."

Windowpane were first commercially exploited in 1943-45 during the end of World War II. Between then and 1975, windowpane were harvested as part of an industrial fishery. Separate commercial landings data for this species have only been available since 1975. Total landings declined from 2,000 mt in 1975 to a low of 900 mt in 1980. Annual landings increased to a peak of 4,200 mt in 1985 and have since declined to 1,600 mt in 1993.

Gulf of Maine-Georges Bank

Annual landings from the Gulf of Maine-Georges Bank area have fluctuated between 400 and 2,900 mt. Landings in 1993 were 1,200 mt, 20% less than in 1992 and 59% less than the record-high 1991 catch. No recreational catches have been reported from this area.

Increased landings since the mid-1980s probably reflect an expansion of the fishery offshore, as well as the targeting of windowpane flounder as an alternative to other depleted flatfish stocks. The NEFSC autumn offshore indices, although highly variable, have declined since 1984. Preliminary indices of commercial catch-per-unit-effort (CPUE) show a declining trend since 1975. These data suggest that stock abundance has fallen in recent years and that the stock is presently overexploited.

Windowpane Flounder
Gulf of Maine-Georges Bank

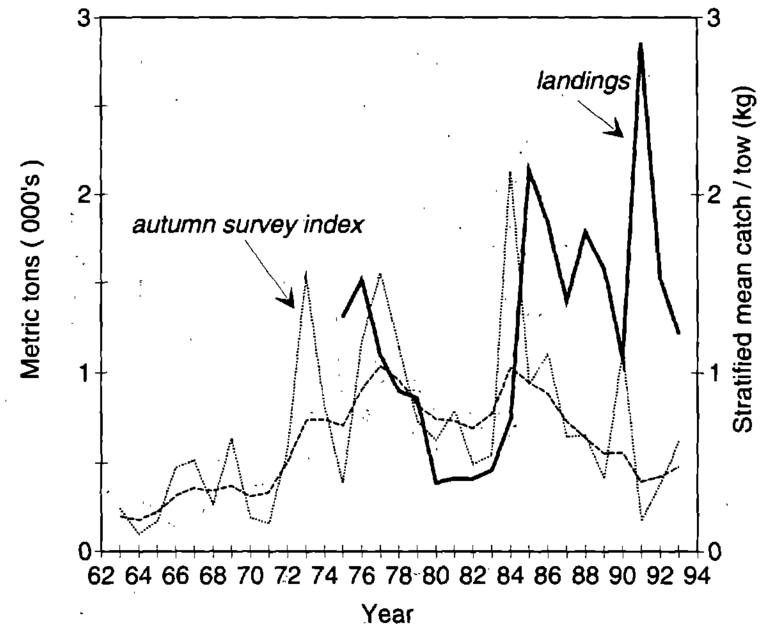


Table 12.1 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	0.8	0.7	2.1	1.8	1.4	1.8	1.6	1.1	2.9	1.5	1.2
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.8	0.7	2.1	1.8	1.4	1.8	1.6	1.1	2.9	1.5	1.2

Gulf of Maine - Georges Bank
Windowpane Flounder

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	3.0 Years
Size at 50% maturity	=	22 cm (8.7 in.)
Assessment level	=	Index
Overfishing definition	=	3-year moving average of NEFSC autumn bottom trawl survey index falls within the lowest quartile of the time series
Fishing mortality rate corresponding to overfishing definition	=	N/A

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1993} = Unknown

"Both NEFSC autumn offshore survey indices and preliminary indices of commercial CPUE have declined since the early 1980s to record low levels."

Windowpane Flounder
Southern New England-Middle Atlantic

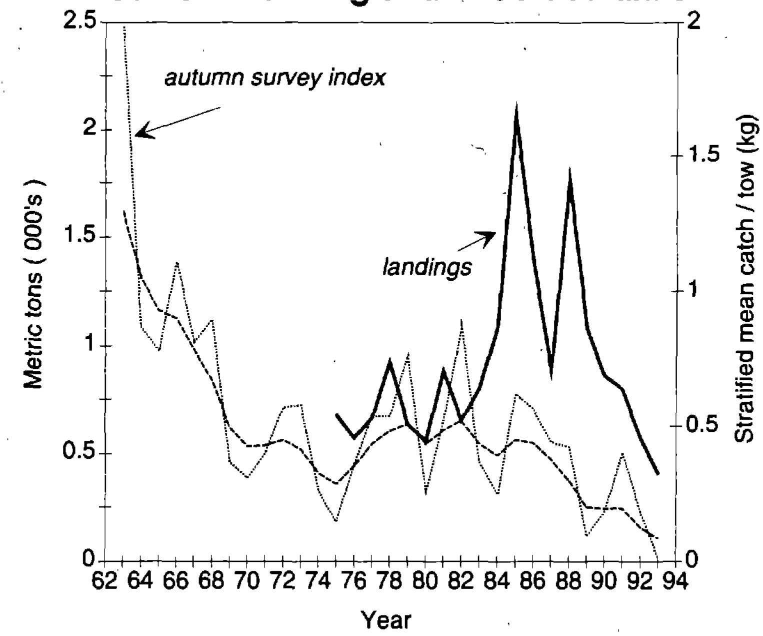


Table 12.2 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	0.7	1.1	2.1	1.4	0.9	1.8	1.1	0.9	0.8	0.6	0.4
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.7	1.1	2.1	1.4	0.9	1.8	1.1	0.9	0.8	0.6	0.4

Southern New England-Middle Atlantic

Commercial landings from the Southern New England-Middle Atlantic area averaged 700 mt per year during 1975-1983. Landings levels increased during 1984-1989, peaking at 2,100 mt in 1985 and 1,800 mt in 1988. Landings have since declined to a record-low of 400 mt in 1993.

Both NEFSC autumn offshore survey indices and preliminary indices of commercial CPUE have declined since the early 1980s to record low levels. These data imply that the stock is at a low biomass level and is overexploited.

Southern New England-Middle Atlantic
Windowpane Flounder

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	3.0 years
Size at 50% maturity	=	21 cm (8.3 in.)
Assessment level	=	Index
Overfishing definition	=	3-year moving average of NEFSC autumn bottom trawl survey index falls within the lowest quartile of the time series
Fishing mortality rate corresponding to overfishing definition	=	N/A

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1993} = Unknown

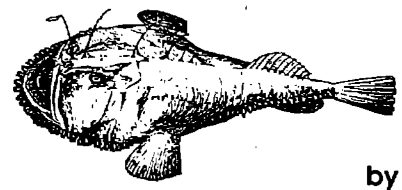
For further information

Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. *Fish. Bull.* [U.S.] 53.

Moore, E.L. 1947. Studies on the marine resources of Southern New England, VI: The sand flounder, *Lophopsetta aquosa* (Mitchill); a general study of the species with special emphasis on age determination by means of scales and otoliths. *Bull. Bingham Oceanogr. Collect. Yale Univ.* 11(3):1-79.

O'Brien, L., Burnett, J. and R.K. Mayo. 1993. Maturation of nineteen species of finfish off the northeast coast of the United States, 1985-1990. *NOAA Tech. Rep. NMFS-NEC* 113.

Goosefish



by J. Idoine

Goosefish, also called monkfish or angler, *Lophius americanus*, range from the Grand Banks and northern Gulf of St. Lawrence south to Cape Hatteras, North Carolina. Individuals may be found from inshore areas to depths greater then 800 m (435 fathoms). Highest concentrations occur between 70 to 100 m (38 to 55 fathoms), and in deeper water at about 190 m (100 fathoms). Seasonal migrations occur and appear to be related to spawning and food availability.

The goosefish has been described as mostly mouth with a tail attached, and reports of goosefish eating prey almost as big as themselves are common. Growth is fairly rapid and similar for both sexes up to age 4, 47 to 48 cm (19 in.). After this, females grow a bit more rapidly and seem to live longer, about 12 years, reaching a size of slightly more than 100 cm (39.4 in.). Males have not been found older than age 9, approximately 90 cm (35.4 in.), with few older than age 6.

Sexual maturity occurs between ages 3 and 4. Spawning may take place from spring through early autumn (depending on latitude). Females lay a nonadhesive, buoyant mucoid egg raft or veil that can be as large as 12 m (39 ft) long and 1.5 m (5 ft) wide. Incubation ranges from 7 to 22 days, after which the larvae spend several months in a pelagic phase before settling to a benthic existence at a size of about 8 cm (3.1 in).

Goosefish, NEFSC Resource Surveys, 1966 (above, Brigham Collection); and with John Galbraith, 1992 (bottom, photo by Kathy Sosebee)

Until recently, goosefish were harvested almost exclusively as a bycatch in the groundfish trawl fisheries and the sea scallop dredge fishery. Now, however, goosefish are being increasingly targeted in response to the dwindling supplies of traditional groundfish species and new markets for goosefish parts (tails, whole fish, livers, cheeks and belly flaps). Over the last 10 years, calculated live weight for all reported landings of goosefish have risen steadily from around 2,600 mt in 1982 to 13,900 mt in 1991, and to 19,000 mt in 1993.

The landed weight of goosefish tails increased from less than 500 mt per year during the 1960s to greater than 6,000 mt in 1992 and 1993. From 1964 to the mid-1970s, the majority of goosefish were taken in otter trawls in the southern Gulf of Maine and northwestern Georges Bank regions. In the late 1970s, otter trawl landings increased from Southern New England. At the same time, increasing numbers of goosefish tails were landed by scallop vessels fishing on Georges Bank and in the mid-Atlantic. At present, scallop dredges account for about 42% of the landed tails. In the last five years, the number of otter trawl and dredge trips that have landed goosefish has in-

"In the last five years, the number of otter trawl and dredge trips that have landed goosefish has increased, as the fishery for goosefish has become more directed."

creased, as the fishery for goosefish has become more directed.

The NEFSC autumn survey biomass index has shown a sharply declining trend over the last 15 years. The average catch per tow over the last 10 years is 0.96 kg/tow, compared to an average value of 2.20 kg/tow during 1963-1981. Since 1987 the survey index has been less than 1.0 kg/tow and in 1993 declined to 0.66 kg, the lowest on record. Additionally, the average size of goosefish caught in the survey has decreased in almost all areas. Given the record low survey index abundance, the sharp increases in landings in recent years, and the small size of the animals now being taken in the fishery, the stock appears to be overexploited.

For further information

Armstrong, M.P. 1987. Life history of the goosefish, *Lophius americanus.* Williamsburg, Virginia: College of William and Mary. Master's thesis.

Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. *Fish. Bull.* [U.S.] 53.

Grosslein, M.D. and T.R. Azarovitz. 1982. Goosefish, *Lophius americanus. In* Fish distribution. *MESA New York Bight Atlas Monograph 15.* Albany, New York: New York Sea Grant Institute.

NEFSC [Northeast Fisheries Science Center]. 1992. Report of the Fourteenth Northeast Regional Stock Assessment Workshop (14th SAW). Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 92-07.

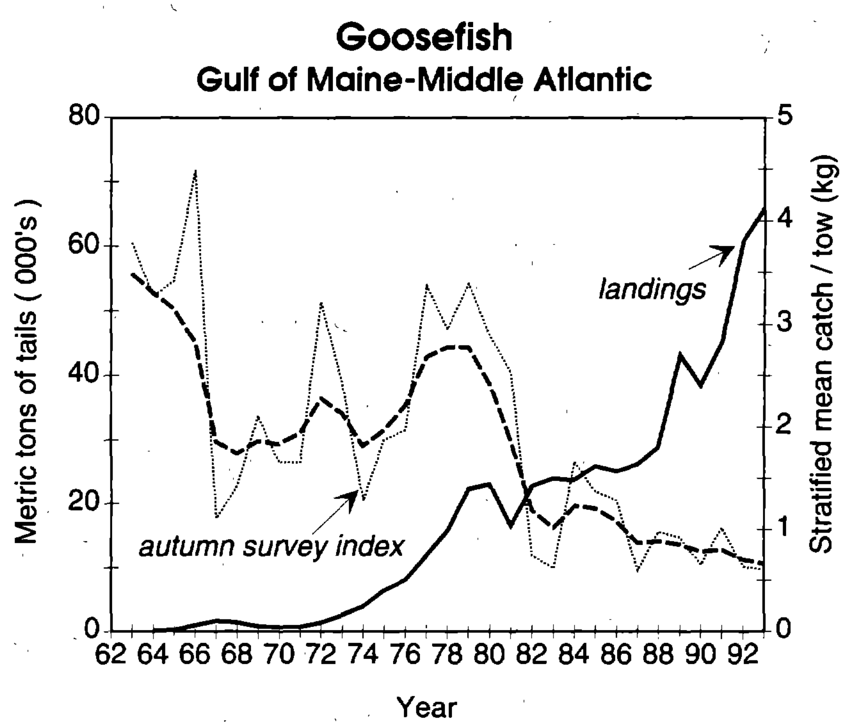


Table 13.1 Recreational catches and commercial landings (thousand metric tons)

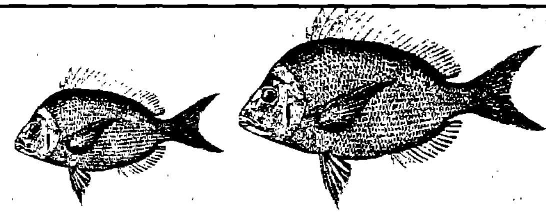
Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	2.6	2.6	3.0	2.4	6.9	8.1	11.6	10.6	12.8	16.0	18.6
Canada	<0.1	0.3	1.3	0.3	0.7	0.9	1.2	1.6	1.0	0.5	0.4
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	2.6	2.9	4.3	2.8	7.7	9.0	12.8	12.2	13.9	16.5	19.0

Gulf of Maine - Middle Atlantic
Goosefish

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	None
Status of exploitation	=	Overexploited
Age at 50% maturity	=	4 years, females 3 years, males
Size at 50% maturity	=	49 cm (19.3 in.), females 37 cm (14.6 in.), males
Assessment level	=	Index
Overfishing definition	=	None
Fishing mortality rate corresponding to overfishing definition	=	None

M = 0.20 $F_{0.1}$ = Unknown F_{max} = 0.20 F_{1993} = Unknown

Scup



by W. Gabriel

Scup or porgy, *Stenotomus chrysops*, occur primarily in the Mid-Atlantic Bight from Cape Cod to Cape Hatteras. Seasonal migrations occur during spring and autumn. In summer, scup are common in inshore waters from Massachusetts to Virginia, while in winter, scup are found in offshore waters between Hudson Canyon and Cape Hatteras at depths ranging from 70 to 180 m (38 to 98 fathoms). Sexual maturity is essentially complete by age 3 at a total length of 21 cm (8.25 in.); spawning occurs during summer months. Although ages up to 20 years have been reported, recent catches have consisted of largely immature fish, ages 0-2 (<7 in.) Scup attain a maximum length of about 40 cm (16 in.). Tagging studies have indicated the possibility of two stocks, one in Southern New England waters and the other extending south from New Jersey. However, because the separation of stocks is not well-defined spatially, this separation is not used here.

Scup
NMFS/NEFSC
photos by
Brenda
Figuerido

The principal commercial fishing gear is the otter trawl. Recreational catches are significant. With the exception of local regulation within individual state waters, the fishery is not yet subject to management although a fishery management plan is under development. Total landings declined in 1993 to 5,700 mt, the lowest in the 1979-1993 period, with markedly reduced landings reported in both commercial and recreational fisheries.

Commercial landings fluctuated between 18,000 and 27,000 mt (includes distant-water fleet [DWF] landings) annually between 1953 and 1963, but declined to about 4,000 mt during the early 1970s. Nominal catches by DWFs peaked at 5,900 mt in 1963, but declined to less than 100 mt per year after 1975. Beginning in the early 1970s, commercial catches steadily increased, reaching a peak of 9,800 mt in 1981. Thereafter, commercial landings declined, falling to a record low level (3,700 mt) in 1989. Landings increased in 1990 and 1991 (6,900 mt in 1991) but declined in 1992 and 1993 to 6,000 mt and 4,400 mt respectively.

Most of the increase in landings during the 1970s was due to increased fixed-gear and otter trawl catches in the Southern New England-New Jersey area. The Virginia winter trawl fishery, which produced landings in excess of 5,000 mt in the early 1960s, has averaged less than 350 mt in the past 10 years.

Recreational catches have accounted for 20 to 50% of total annual catches during the past 10 years. The 1993 recreational catch (1,300 mt) was 38% less than in 1992 (2,100 mt) and 58% below the 1981-1991 average (3,100 mt).

Spawning stock biomass has declined steadily since 1990 to a record low of 4,600 mt in 1993. Although absolute

"Spawning stock biomass has declined steadily since 1990 to a record low of 4,600 mt in 1993."

estimates of spawning stock biomass are only available for 1984-1993, NEFSC survey data indicate that much higher levels of stock biomass occurred during the 1970s.

Recruitment declined from an average of 140 million fish at age 0 in 1984-1985 to an average of 83 million during 1986-1993. The 1991 and 1992 year classes were among the weakest observed (67 and 72 million, respectively) in the 1984-1993 time series, while the 1993 year class is estimated to be about average.

Fishing mortality rates have been very high during the past 10 years, averaging 1.36 (69% exploitation rate) between 1984-1993, and in 1993, fishing mortality was estimated at 1.32 (68% exploitation rate). These rates are far in excess of biological reference points ($F_{0.1}$=0.14, 12% exploitation rate; F_{max}=0.24, 19% exploitation rate; $F_{20\%}$=0.28, 22% exploitation rate). The stock is overexploited and at a low biomass level. In the absence of strong year classes, continued exploitation at current fishing mortality rates will lead to further declines in SSB.

For further information

Mayo, R. K., 1982. An assessment of the scup, *Stenotomus chrysops* (L.), population in the Southern New England and Mid-Atlantic regions. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Lab. Ref. Doc.* 82-46.

Northeast Fisheries Center. 1989. Report of the 7th NEFC Stock Assessment Workshop. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Lab. Ref. Doc.* 89-04.

NEFSC [Northeast Fisheries Science Center]. 1995. Report of the 19th Northeast Regional Stock Assessment Workshop (19th SAW), Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Docs.* 95-08, 95-09.

Scup
Southern New England-Middle Atlantic

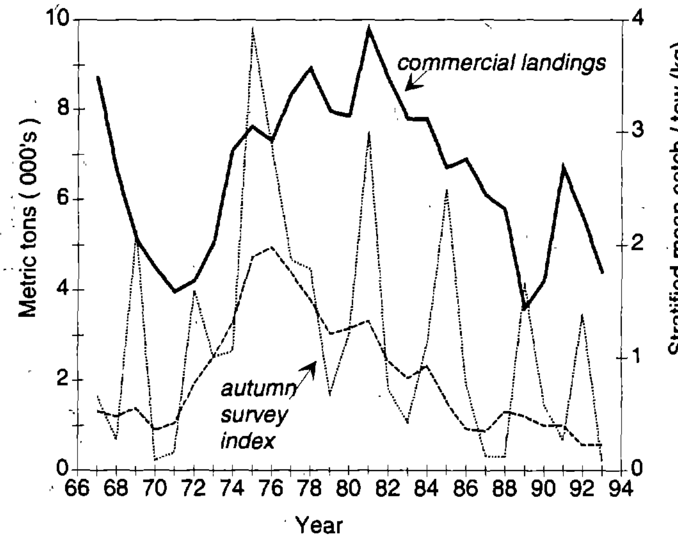


Table 14.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	3.1[1]	1.4	3.3	5.9	3.0	2.4	3.2	2.0	3.6	2.1	1.3
Commercial											
United States	8.1	7.8	6.7	6.9	6.1	5.7	3.7	4.3	6.9	6.0	4.4
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	0.2	-	<0.1	<0.1	<0.1	-	-	-	-	-	-
Total nominal catch	11.4	9.2	10.0	12.8	9.1	8.1	6.9	6.3	10.5	8.1	5.7

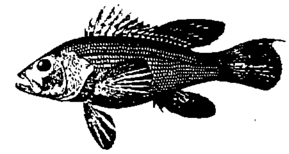
[1]Based on 1979-1983 MRFSS statistics

Southern New England - Middle Atlantic Scup

Long-term potential catch	=	10,000 to 15,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Some state regulations
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	15.5 cm (6.1 in.)
Assessment level	=	Age structured
Overfishing definition	=	Under development
Fishing mortality rate corresponding to overfishing definition	=	Under development

M = 0.20 **$F_{0.1}$ = 0.14** **F_{max} = 0.24** **$F_{20\%}$ = 0.28**
F_{1993} = 1.32

Black Sea Bass



by G. Shepherd

Black sea bass, *Centropristis striata*, occur off the northeastern United States along the entire Atlantic coast, and consist of two stocks, one north and the other south of Cape Hatteras, North Carolina. The northern group of black sea bass winter along the 100 m (55 fathom) depth contour off Virginia and Maryland, then migrate north and west into the major coastal bays and become associated with structured bottom habitat (reefs, oyster beds, wrecks).

Spawning begins in March off North Carolina and occurs progressively later (until October) further north. Most black sea bass begin life as females and later transform into males. Both sexes reach 50 percent maturity by age 2 with the median size at maturity for males and females at 19.0 and 19.1 cm (7.5 in.), respectively. Transformation from female to male generally occurs between ages 2 and 5. Females are rarely found older than 8 years (>35 cm or 14 in.), while males may live up to 15 years (>60 cm or 24 in.). Black sea bass are omnivorous, feeding on crustaceans, molluscs, echinoderms, fish, and plants.

The principal commercial fishing gears used to catch black sea bass are otter trawls and fish pots. Recreational fishing is as significant. Currently there is no management outside state waters. Total catch increased in 1993 to 3,400 mt, up from 2,600 mt in 1992.

Reported commercial landings north of Cape Hatteras fluctuated around 2,600 mt from 1887 until 1948, when landings increased to 6,900 mt. Landings peaked at 9,900 mt in 1952, declined steadily to 600 mt in 1971, and then increased to 2,400 mt in 1977. Between 1980 and 1993, commercial landings have ranged from 1,100 to 1,900 mt, and averaged 1,500 mt per year. Commercial landings in 1993 were 1,300 mt. The only reported catch by distant-water fleets was 1,500 mt in 1964.

Black sea bass
NMFS/NEFSC photo by Brenda Figuerido

Estimated recreational landings, occurring primarily in the middle Atlantic states, are comparable in magnitude to those from the commercial fishery. Recreational landings have averaged 2,100 mt per year since 1979, and accounted for 31 to 87% of the total annual landings of black sea bass. Recreational landings in 1993 were 2,100 mt, (62% of the total 1993 catch).

Standardized catch-per-unit-effort (CPUE, metric tons per day fished in trips landing 25 percent or more black sea bass) in the Mid-Atlantic trawl fishery peaked at 3.6 in 1984 but declined to 1.2 in 1986. Following an increase to 2.6 in 1988, CPUE has since declined to a low of 1.0 mt in 1993.

NEFSC spring survey indices increased during the early 1970s, peaking in 1977, but declined sharply between 1979 and 1982 to record-low levels. Survey indices modestly increased during 1985 to 1988 and have since remained at about the 1985-1988 levels. All of the recent survey values, however,

"The prerecruit index for 1993 was low, continuing the recent trend of below average recruitment."

are well below those seen during the mid-1970s. Prerecruit indices (fish <12 cm) from the autumn inshore bottom trawl survey indicate above-average year classes occurred in 1977, 1982, and 1986. The prerecruit index for 1993 was low, continuing the recent trend of below average recruitment.

Size composition data from commercial landings indicate that black sea bass recruit fully to the trap and trawl fisheries by ages 2 and 3, respectively. Based on yield per recruit analysis, maximum yield per recruit is attained when fish are harvested at age 6 at F=0.30.

Although reliable estimates of fishing mortality are not yet available, recent CPUE and survey indices have been relatively moderate to low, indicating that the stock appears to be overexploited.

For further information

Musick, J.A. and L.P.Mercer. 1977. Seasonal distribution of black sea bass, *Centropristis striata*, in the Mid-Atlantic Bight with comments on the ecology of fisheries of the species. *Trans. Am. Fish. Soc.* 106(1):12-25.

NEFC [Northeast Fisheries Science Center]. 1990. Report of the Eleventh Stock Assessment Workshop (11th SAW), Fall 1990. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Ref. Doc.* 90-09.

Shepherd, G. R. and J. S. Idoine. 1993. Length-based analyses of yield and spawning stock biomass per recruit for black sea bass, *Centropristis striata*, a protogynous hermaphrodite. *Fish. Bull.* [U.S.] 91:328-337.

Black Sea Bass
Gulf of Maine-Middle Atlantic

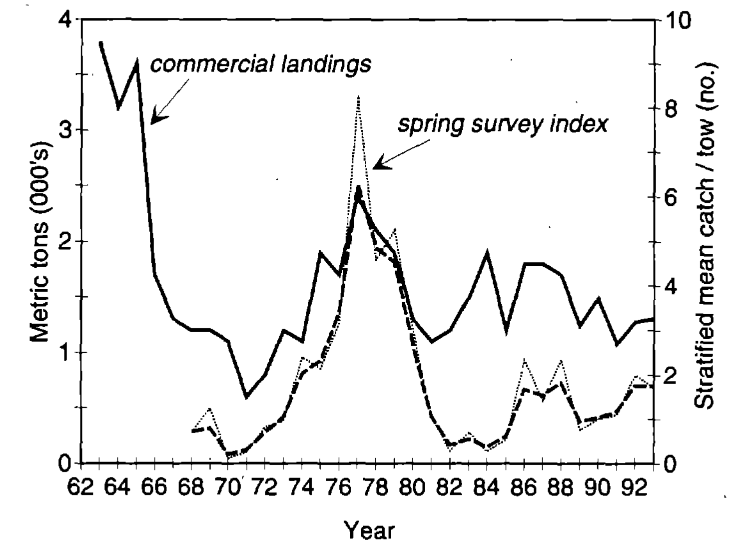


Table 15.1 Recreational and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	2.4[1]	0.7	1.5	6.3	0.9	1.8	1.6	1.4	2.1	1.2	2.1
Commercial											
United States	1.6	1.9	1.2	1.8	1.8	1.7	1.2	1.5	1.1	1.3	1.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	4.0	2.6	2.7	8.1	2.7	3.5	2.8	2.9	3.2	2.6	3.4

[1]1979-1983

Gulf of Maine - Mid-Atlantic
Black Sea Bass

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Some state regulations
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	19 cm (7.5 in.)
Assessment level	=	Yield per recruit
Overfishing definition	=	Under development
Fishing mortality rate corresponding to overfishing definition	=	Unknown

$M = 0.2$ $F_{0.1} = 0.11$ $F_{max} = 0.17$ $F_{1993} => F_{max}$

Ocean Pout

by S. Wigley

The ocean pout, *Macrozoarces americanus*, is a demersal eel-like species ranging from Labrador to Delaware that attains lengths of up to 98 cm (39 in.), and weights of 5.3 kg (14.2 lb). Ocean pout prefer depths of 15 to 80 m (8 to 44 fathoms) and temperatures of 6° to 7°C (43° to 45°F). Tagging studies and NEFSC bottom trawl survey data indicate that ocean pout do not undertake extensive migrations, but rather move seasonally to different substrates. During winter and spring, ocean pout feed over sand or sand-gravel bottom and are vulnerable to otter trawl fisheries. In summer, ocean pout cease feeding and move to rocky areas, where spawning occurs in September and October. The demersal eggs are guarded by both parents until hatching. During this period, ocean pout are not available to commercial fishing operations. Catches typically increase when adults return to their feeding grounds in late autumn and winter. The diet consists primarily of invertebrates, with fish being only a minor component.

Ocean pout in an aquarium
NMFS/NEFSC photo

Stock identification studies suggest the existence of two stocks: one occupying the Bay of Fundy-northern Gulf of Maine region east of Cape Elizabeth, and a second stock ranging from Cape Cod Bay south to Delaware. The southern stock is characterized by faster growth rates, and to date has supported the commercial fishery.

The principal fishing gear used to catch ocean pout is the otter trawl, and the fishery occurs primarily between December and May each year. The fishery in the EEZ is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan; the state of Massachusetts regulates the inshore fishery in Cape Cod Bay. Total landings in 1993 were only 225 mt, the lowest since 1963.

Commercial interest in ocean pout has fluctuated widely. Ocean pout were marketed as a food fish during World War II, and landings peaked at 4,500 mt in 1943. However, an outbreak of a protozoan parasite that caused lesions on ocean pout eliminated consumer demand for this species as food. From 1964 to 1974, an industrial fishery developed, and nominal catches by the U.S. fleet averaged 4,700 mt. Soviet vessels began harvesting ocean pout in large quantities in 1966 and total nominal catches peaked at 27,000 mt in 1969. Foreign catches declined substantially afterward, and none have been reported since 1974. United States nominal catches declined to an average of 600 mt annually during 1975 to 1983.

Catches increased in 1984 and 1985 to 1,300 mt and 1,500 mt respectively, due to the development of a small directed fishery in Cape Cod Bay supplying the fresh fillet market. Landings remained relatively constant through 1991, averaging about 1,450 mt annually; however, due to declining market demands, landings in 1992 and 1993 dropped to 500 mt and 225 mt, respectively. Landings from southern New England continue to dominate the catch, accounting for 65% of the total 1993 U.S. harvest, reversing landing patterns observed in 1986-87 when the Cape Cod Bay fishery was dominant.

Due to the ocean pout's pattern of seasonal distribution, the NEFSC spring survey index is more useful than the autumn survey for evaluating relative

"Survey length composition data suggest that the 1987 year class was a relatively strong one, however, subsequent cohorts appear weak."

abundance. The Massachusetts spring inshore survey appears to be useful in identifying strong year classes. From 1968 to 1975 (encompassing peak levels of foreign fishing and the domestic industrial fishery), commercial landings and NEFSC spring survey indices followed similar trends; both declined from very high values in 1968-69 to lows of 300 mt and 1.6 kg/tow, respectively, in 1975. Between 1975 and 1985, survey indices increased to record high levels, peaking in 1981 and 1985. Since 1985, survey catch per tow indices have generally declined, and are presently below the long-term survey average (4.0 kg/tow); the spring 1993 index was 3.1 kg/tow. Survey length composition data suggest that the 1987 year class was a relatively strong one, however, subsequent cohorts appear weak.

The population appears to be fully exploited and at a medium biomass level.

For further information

NEFC [Northeast Fisheries Science Center]. 1990. Report of the Eleventh Stock Assessment Workshop (11th SAW), Fall 1990. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Ref. Doc.* 90-09.

Olsen, Y. H., and Merriman, D. 1946. Studies on the marine resources of southern New England, IV: The biology and economic importance of the ocean pout, *Macrozoarces americanus* (Bloch and Schneider). *Bull. Bingham Oceanogr. Collec.* 9:1-184.

Orach-Meza, F. L., 1975. Distribution and abundance of ocean pout, *Macrozoarces americanus* (Bloch and Schneider), in the western North Atlantic Ocean. Kingston, RI: University of Rhode Island. Master's thesis.

Ocean Pout
Middle Atlantic-Gulf of Maine

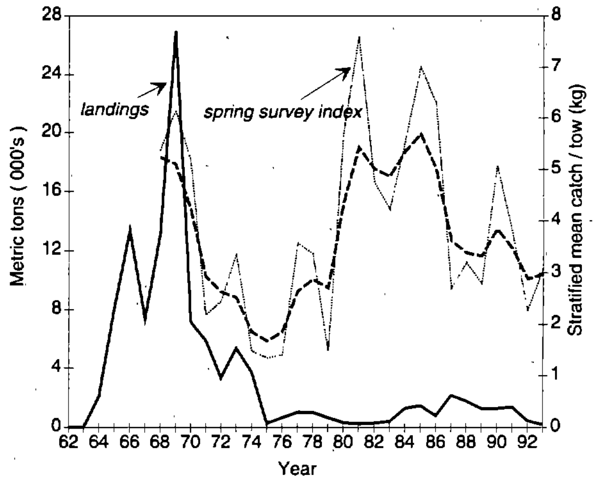


Table 16.1 Recreational and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	0.8	1.3	1.5	0.8	2.2	1.8	1.3	1.3	1.4	0.5	0.2
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.8	1.3	1.5	0.8	2.2	1.8	1.3	1.3	1.4	0.5	0.2

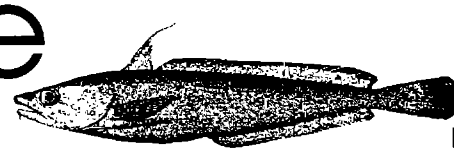
Mid-Atlantic - Gulf of Maine
Ocean Pout

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP and state regulations
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	Unknown
Size at 50% maturity[1]		
Gulf of Maine	=	26.2 cm (10 in.), females; 30.3 cm (12 in.), males
Southern New England	=	31.3 cm (12 in.), females: 31.9 cm (13 in.), males
Assessment level	=	Index
Overfishing definition	=	3-year moving average of NEFSC autumn bottom trawl survey index falls within lowest quartile of the time series
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1993} = Unknown

[1] Ocean pout appear to have a three-year egg development period

White Hake



by K. Sosebee

The white hake, *Urophycis tenuis*, a boreal species that occurs from Newfoundland to Southern New England, is found on muddy bottom throughout the Gulf of Maine. Stock boundaries are uncertain although fish from two spawning groups exist in U.S. waters. The two groups mix continuously in the Gulf of Maine and are not readily distinguishable in the commercial landings. Depth distribution of white hake varies by age and season; juveniles typically occupy shallower areas than adults, but individuals of all ages tend to move inshore or shoalward in spring and summer, dispersing to deeper areas in autumn. Most trawl catches are taken at depths of 110 m (60 fathoms) or more, although hake are taken as shallow as 27 m (15 fathoms) during summer gillnetting.

In the Gulf of Maine - Southern New England region, spawning occurs in winter and spring, although the season and the extent of spawning is not clearly defined. The second spawning event takes place in shallow waters of the Scotian Shelf. White hake attain a maximum length of 135 cm (53 in.) and weights of up to 21 kg (46 lb), with females being larger. Ages of more than 20 years have been documented. Juveniles feed primarily upon shrimp and other crustaceans, but adults feed almost exclusively on fish, including juveniles of their own species.

White hake
NMFS/NEFSC photo by Brenda Figuerido

The principal fishing gear used to catch white hake are otter trawls and gill nets. Recreational catches are insignificant, and foreign catches are of minor importance. Canadian catches have increased in recent years. Fishing is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan (FMP). Total landings in 1993 were 9,100 mt, 5% less than in 1992 but still the second highest on record. Of the 10 major groundfish species covered by the Multispecies FMP, white hake was first in 1993 in quantity of landings from the Gulf of Maine, exceeding both cod and pollock.

United States catches have primarily been taken in the western Gulf of Maine, both incidentally to directed operations for other demersal species and as an intended component in mixed-species fisheries. Since 1968, the U.S. fishery has accounted for approximately 90 percent of the Gulf of Maine-Georges Bank white hake catch. Canadian landings, however, increased markedly in 1992 (1,100 mt) and 1993 (1,700 mt).

Total catches of white hake increased from about 1,000 mt during the late 1960s to 8,300 mt in 1985. Catches declined during 1986 to 1989, but have since sharply risen, reaching a record-high of 9,600 mt in 1992. The increase evident throughout the 1970s and early 1980s reflects both a general increase in incidental catches associated with the greater fishing power of the expanded New England otter trawl fleet and an increase in directed fishing effort toward white hake. Small white hake are difficult to distinguish from red hake,

"Any increases in fishing mortality will result in a decline in long-term yields."

Urophycis chuss, resulting in an unknown (but presumed small) degree of bias in reported nominal catches.

The NEFSC autumn survey biomass indices were relatively high during the 1970s, declined during the early 1980s, but have since shown a steady increase. Since the most recent 3-year average of the NEFSC autumn biomass index (11.7 kg/tow) is above the current overfishing definition (25th percentile of a 3-year moving average of NEFSC autumn biomass indices: 8.4), the stock is presently not overfished.

Fishing mortality peaked in 1988 at F=0.56, declined to 0.34 in 1989, and has since fluctuated around the 1985-1993 average of F=0.40. Fishing mortality throughout the 1985-1993 period has exceeded F_{max} (F=0.22).

Exploitable biomass has remained relatively stable since 1985, ranging from 11,600 mt in 1987 to a peak of 17,300 mt in 1993. Recruitment has varied considerably from 1.9 million (1985) to 9.6 million (1992) fish, with the 1994 level (5.7 million) being about average.

The Gulf of Maine-Georges Bank white hake stock is at a medium biomass level and is fully exploited. Any increases in fishing mortality will result in a decline in long-term yields.

For further information

NEFSC [Northeast Fisheries Science Center]. 1995. Report of the 19th Northeast Regional Stock Assessment Workshop (19th SAW). Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Docs.* 95-08, 95-09.

Sosebee, K. A., L. O'Brien, and L. C. Hendrickson. 1995. A preliminary analytical assessment for white hake in the Gulf of Maine - Georges Bank region. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 95-03.

White Hake
Gulf of Maine-Georges Bank

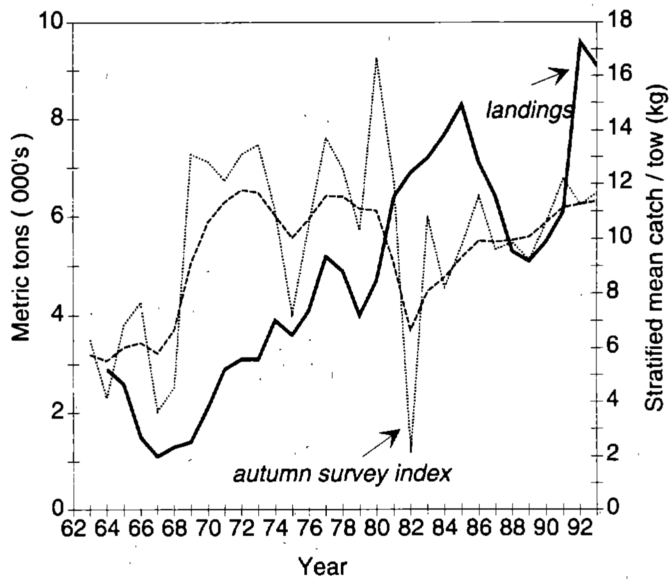


Table 17.1 Recreational catches and commercial landings (thousand metric tons)

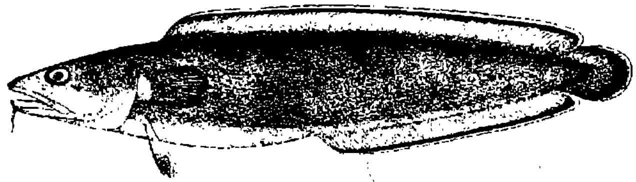
Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	4.7	6.7	7.3	6.1	5.8	4.8	4.5	4.9	5.6	8.5	7.4
Canada	0.4	1.0	0.9	1.0	0.6	0.5	0.6	0.5	0.6	1.1	1.7
Other	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-
Total nominal catch	5.1	7.7	8.2	7.1	6.4	5.3	5.1	5.4	6.2	9.6	9.1

Gulf of Maine - Georges Bank
White Hake

Long-term potential catch	=	7,700 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	1.4 years
Size at 50% maturity	=	34 cm (13.4 in.)
Assessment level	=	Age Structured (DeLury)
Overfishing definition	=	3 year moving average of NEFSC autumn survey biomass index falls within lowest quartile of the time series

M = 0.20 $F_{0.1}$ = 0.13 F_{max} = 0.22 F_{1993} = 0.42

Cusk



by L. O'Brien

The cusk, *Brosme brosme*, is a deepwater species that is found in rocky, hard bottom areas throughout the Gulf of Maine. Spawning occurs in spring and early summer; eggs rise to the surface where hatching and larval development occur. Juveniles move to the bottom at about 5 cm (2 in.) in length where they become sedentary and rather solitary in habit. Individuals commonly attain lengths up to 90 cm (35 in.) and weights up to 9.0 kg (20 lb). The stock structure of cusk is unknown. Although little information is available for Gulf of Maine fish, cusk from the Scotian Shelf area are relatively slow growing and late maturing. Maximum age is greater than 14 years and sexual maturity is attained at ages 4.7 (43.5 cm) for males and 6.5 (50.7 cm) for females.

The principal fishing gears used to catch cusk are line trawl, otter trawl, gill net, and longline. Fish caught by these gears range in size from 35 to 110 cm. Recreational fishing is insignificant and foreign catches are minor. The fishery is not under management. Total catches in 1993 were 2,000 mt.

During the late 1960s and early 1970s, annual landings were relatively stable at about 1,700 mt per year, but increased in the late 1970s - early 1980s, peaking at 3,800 mt in 1981. Subsequently, landings gradually declined reaching a low of 1,500 mt in 1988. Landings increased from 1989 to 1992 and then declined in 1993. Since 1970, the majority of the U.S. catch has been taken from the Gulf of Maine, however, in 1993, the bulk of landings was taken from Georges Bank. Nearly all of the Canadian catch continues to be from Georges Bank. The 1993 U.S. catch was 1,400 mt and accounted for 70% of the total harvest. Canadian landings in 1993 were 600 mt.

Cusk
NMFS/NEFSC photo by Brenda Figuerido

"Although the NEFSC autumn survey index has fluctuated considerably during the time series, there has been an overall declining trend since the late 1960s."

Historically, otter trawls have accounted for between 50 and 87% of the annual U.S. landings. In 1985-1986, longline landings of cusk markedly increased (to 23% of the total landings) as a result of a new auto-longline fishery. This fishery ceased operations in 1987, however, and longline gear accounted for only 5% of the total landings during 1987-1989. The fishery became active again in 1990-1991 and accounted for 17% of the landings, and has since ceased activity. Line trawls accounted for the majority (54%) of the landings in 1993.

Although the NEFSC autumn survey index has fluctuated considerably during the time series, there has been an overall declining trend since the late 1960s. The 1993 autumn index was slightly higher than the record low value of 1992.

Annual landings have generally declined since 1981, while survey indices of abundance have generally declined since 1985. The stock appears to be overexploited, although the current level of assessment is too low to allow the status of the stock to be predicted with confidence.

For further information

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. *Fish. Bull.* [U.S.] 53.

Oldham, W.S. 1972. Biology of Scotian Shelf cusk, *Brosme brosme*. *ICNAF* [International Commission for Northwest Atlantic Fisheries] *Res. Doc.* 9:85-98.

Cusk
Gulf of Maine-Georges Bank

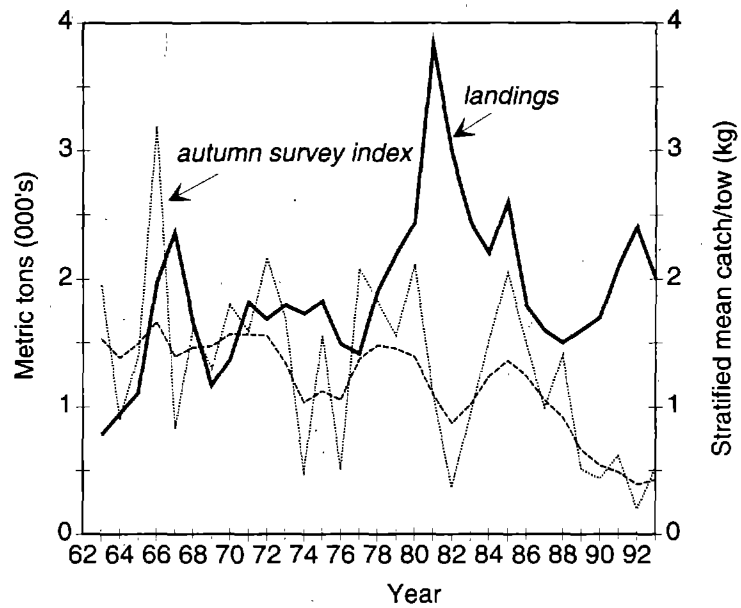


Table 18.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year: 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	1.6	1.7	2.3	1.8	1.4	1.1	0.9	1.2	1.5	1.6	1.4
Canada	0.7	0.5	0.3	0.1	0.3	0.4	0.7	0.5	0.6	0.8	0.6
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	2.3	2.2	2.6	1.9	1.7	1.5	1.6	1.7	2.1	2.4	2.0

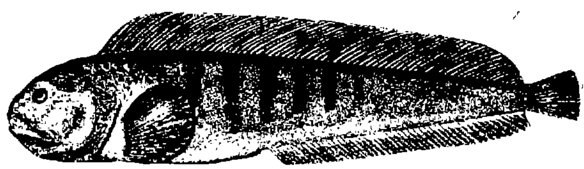
Gulf of Maine-Georges Bank Cusk

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	None
Status of exploitation	=	Overexploited
Age at 50% maturity	=	4.7 years, males; 6.6 years, females
Size at 50% maturity	=	43.5 cm (17.1 in.), males; 50.7 cm (19.9 in.), females
Assessment level	=	Index
Overfishing definition	=	N/A

M = Unknown **$F_{0.1}$ = Unknown** **F_{max} = Unknown**

F_{1993} = Unknown

Wolffish



by J. Idoine

The wolffish or catfish, *Anarhichas lupus*, is a cold-water species of relatively minor importance in Gulf of Maine fisheries. Research vessel surveys indicate that populations on Georges Bank and in the western Gulf of Maine are discrete from wolffish in the Browns Bank - Scotian Shelf area. West of the Scotian Shelf, abundance appears to be highest in the southwestern portion of the Gulf of Maine from Jeffreys Ledge to the Great South Channel at depths of 80 to 120 m (45 to 65 fathoms). Wolffish are sedentary and rather solitary in habit, and populations tend to be localized. Little is known about the biology of this species. Individuals may attain lengths of 150 cm (59 in.) and weights of 18 kg (40 lb). They prey heavily on shellfish.

Wolffish have been taken primarily as bycatch in the otter trawl fishery, although the species may also be an intended component in some mixed fishery situations. Recreational catches are insignificant, and foreign catches of minor importance. The species is unmanaged. Landings for 1993 totaled 600 mt.

Since 1970, the U.S. nominal commercial catch has been about evenly divided between Georges Bank and the Gulf of Maine. In the last two decades, U.S. vessels have taken more than 85% of the total Georges Bank-Gulf of Maine catch; the remainder was taken by Canadian fishermen. Total Georges Bank-Gulf of Maine landings increased from 200 mt in 1970 to approximately 1,200 mt in 1984 and have since declined sharply to an average of 500 mt since 1990. Canadian landings since 1990 have been insignificant.

After fluctuating considerably from 1968 to 1982, the NEFSC spring survey index has shown a consistent downward

Wolffish
Brigham Collection, NMFS/NEFSC Photo Archive

"Total Georges Bank-Gulf of Maine landings increased from 200 mt in 1970 to approximately 1,200 mt in 1984 and have since declined sharply to an average of 500 mt since 1990."

trend; the 1992 index value was the lowest in the time series. In 1993, the index rose slightly. The 1989-1993 average, (0.5 kg/tow) is considerably lower than the average for preceding years (2.3 kg).

The decline in landings and in NEFSC trawl survey indices since 1984 indicate that biomass has been substantially reduced. This stock is clearly overexploited and depleted.

For further information

Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. *Fish. Bull.* [U.S] 53.

Nelson, G.A., and M.R. Ross. 1992. Distribution, growth and food habits of the Atlantic wolffish (*Anarhichas lupus*) from the Gulf of Maine-Georges Bank region. *J. Northw. Atl. Fish. Sci.* 13:53-61.

Atlantic Wolffish
Gulf of Maine-Georges Bank

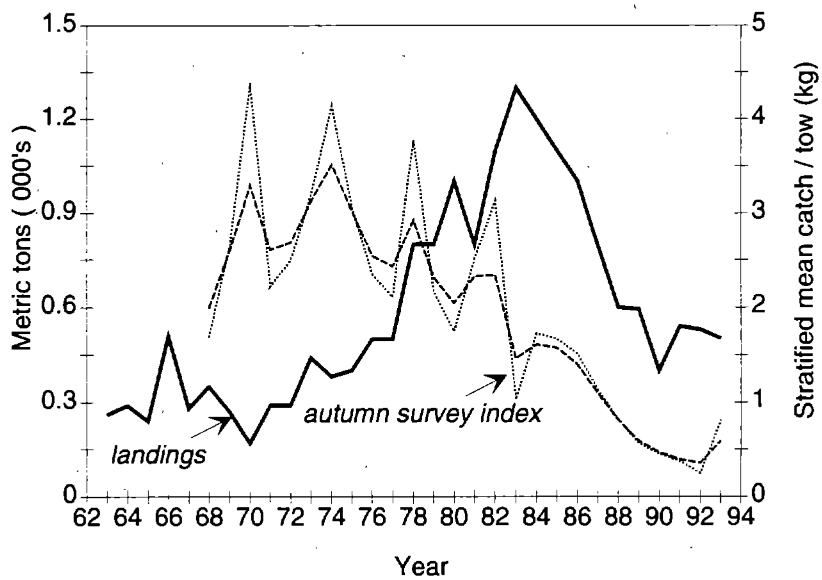


Table 19.1 Recreational catches and commercial landings (thousand metric tons)

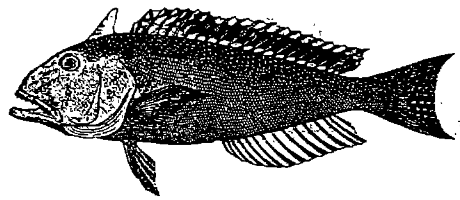
Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	0.6	1.1	1.0	0.9	0.7	0.5	0.5	0.4	0.5	0.5	0.5
Canada	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.7	1.2	1.1	1.0	0.8	0.6	0.6	0.5	0.5	0.5	0.5

Gulf of Maine - Georges Bank
Atlantic Wolffish

Long-term potential catch	=	<1,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	None
Status of exploitation	=	Overexploited
Age at 50% maturity	=	Unknown
Size at 50% maturity	=	Unknown
Assessment level	=	Index
Overfishing definition	=	N/A
Fishing mortality rate corresponding to overfishing definition	=	N/A

M = Unknown **$F_{0.1}$ = Unknown** **F_{max} = Unknown**
F_{1993} = Unknown

Tilefish



by G. Shepherd

Tilefish, *Lopholatilus chamaeleonticeps*, inhabit the outer continental shelf from Nova Scotia to South America and are relatively abundant in the Southern New England to Mid-Atlantic area at depths of 80 to 440 m (44 to 240 fathoms). They are generally found in and around submarine canyons where they occupy burrows in the sedimentary substrate. Tilefish are relatively slow growing and long-lived, with a maximum age and length of 35 years and 110 cm (43.3 in.) fork length in females and 26 years and 112 cm (44.1 in.) fork length in males. At lengths exceeding 70 cm (27.6 in.), the predorsal adipose flap, characteristic of this species, is larger in males and can be used to distinguish the sexes. Tilefish of both sexes are mature at ages of 5 to 7 years.

Nominal catches were first recorded in 1915 (148 mt); a record total of 4,500 mt was taken in 1916, but only 5 mt were reported for 1920. Landings later increased to 1,000 to 1,500 mt during the early 1950s, followed by a decline to 30 mt in 1968-69; landings then increased to 3,800 mt in 1979 followed by a decline to only 500 mt in 1989. Landings have subsequently increased to 1,800 mt in 1993. A small recreational fishery developed during the late 1960s in New York and New Jersey but landings never exceeded 100 mt, and recent recreational catches have been virtually nonexistent.

Tilefish, Middle Atlantic recreational charter, Circa 1965
NEFSC file photo

Beginning in the early 1970s, a directed commercial longline fishery expanded rapidly in the Mid-Atlantic and longlines have since been the predominant gear type used. Primary ports have included Barnegat, NJ, Montauk, NY, and Portland, ME. During the early development of the fishery, the catch per unit effort (CPUE) declined from 6.5 mt per standard day fished (df) in 1973 to 1.8 mt in 1982. Since the mid-1980s, CPUE has ranged from 1.6 mt per df in 1987 to 0.7 mt in 1991. The 1993 CPUE was 1.0 mt.

A yield per recruit analysis calculated in the early 1980s estimated $F_{0.1}$ = 0.17 and F_{max} = 0.27, based on age at recruitment to the fishing gear of 4. Estimates of F from a virtual population analysis (VPA) during the late 1970s and early 1980s increased from 0.20 (1977) to 0.74 (1981). Estimates of F from VPA are not available for more recent years, but the current level of F appears equal to or greater than the 1981 level. Long-term potential catch for tilefish estimated from a nonequilibrium surplus production model was about 1,200 mt.

Landings and CPUE data indicate that tilefish were overexploited during the height of the longline fishery (between 1977 and 1982). Landings during this period were well above levels corresponding to long-term potential yield,

"Reduced CPUE since the early 1980s reflects a significant decline in abundance and continued overexploitation."

and fishing mortality rates were three times higher than F_{max}. This period was marked by steadily declining values in CPUE, and declines in total landings, average size, and size at first maturity in males. Reduced CPUE since the early 1980s reflects a significant decline in abundance and continued overexploitation.

For further information

Grimes, C.B., C.F. Idelberger, K.W. Able, and S.C. Turner. 1988. The reproductive biology of tilefish, *Lopholatilus chamaeleonticeps* Goode and Bean, from the United States Mid-Atlantic Bight, and the effects of fishing on the breeding system. *Fish. Bull.,* [U.S.] 86(4):745-76.

NEFSC (Northeast Fisheries Science Center). 1993. Report of the 16th Northeast Regional Stock Assessment Workshop (16th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-18.

Turner, S.C., C.B. Grimes, and K.W. Able. 1983. Growth, mortality, and age/size structure of the fisheries for tilefish, *Lopholatilus chamaeleonticeps*, in the Middle Atlantic-Southern New England region. *Fish. Bull* [U.S.] 81(4):751-763.

Turner, S.C. 1986. Population dynamics of and impact of fishing on tilefish, *Lopholatilus chamaeleonticeps*, in the Middle Atlantic-Southern New England region during the 1970s and early 1980s. New Brunswick , N.J.: Rutgers University. Ph.D. dissertation.

Tilefish
Georges Bank-Middle Atlantic

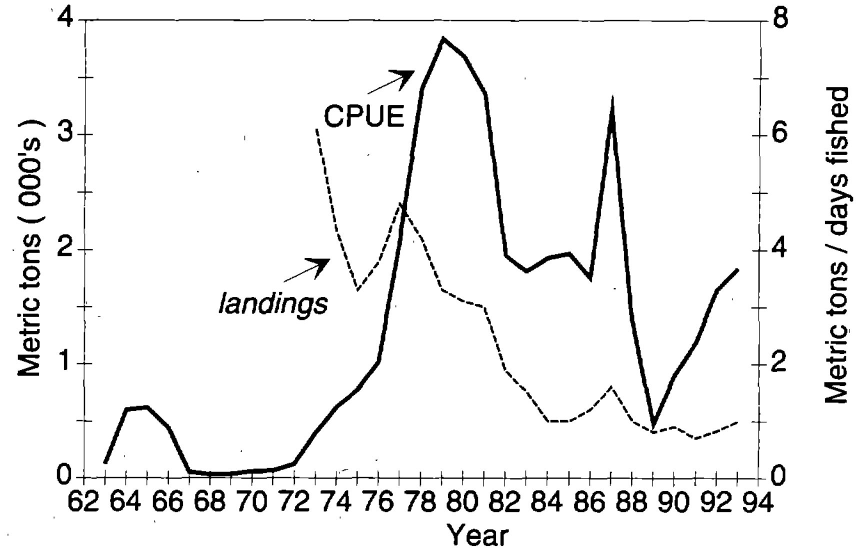


Table 20.1 Recreational catches and commercial landings (1,000 mt)

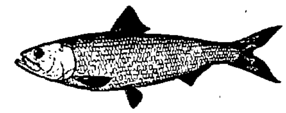
Category	Year										
	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	2.3	1.9	2.0	1.8	3.2	1.4	0.5	0.9	1.2	1.6	1.8
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	2.3	1.9	2.0	1.8	3.2	1.4	0.5	0.9	1.2	1.6	1.8

Georges Bank - Middle Atlantic Tilefish

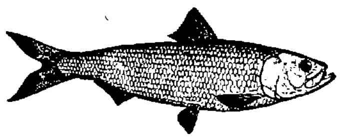
Long-term potential catch	=	1,200 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	None
Status of exploitation	=	Overexploited
Age at 50% maturity	=	5 to 7 years
Size at 50% maturity	=	50 cm (20 in.), females 60 cm (24 in.), males
Assessment level	=	Yield per recruit
Overfishing definition	=	None
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.15$ $F_{0.1} = 0.17$ $F_{max} = 0.27$ $F_{1993} = \geq 0.74$

Atlantic Herring

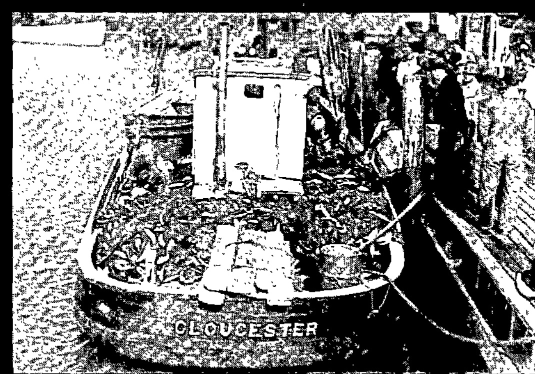


by K. Friedland



The Atlantic herring, *Clupea harengus*, is widely distributed in continental shelf waters from Labrador to Cape Hatteras. Important commercial fisheries for juvenile herring (ages 1 to 3) have existed since the last century along the coasts of Maine and New Brunswick. Development of large-scale fisheries for adult herring is comparatively recent, primarily occurring in the western Gulf of Maine, on Georges Bank, and on the Scotian Shelf. Gulf of Maine herring migrate from feeding grounds along the Maine coast during autumn to the southern New England - Mid-Atlantic region during winter, with larger individuals tending to migrate farther distances. Tagging experiments have also provided evidence of intermixing of Gulf of Maine-Scotian Shelf herring during different phases of the annual migration.

Spawning in the Gulf of Maine occurs during late August-October, beginning in northern locations and progressing southward. Atlantic herring are not fully mature until ages 4 to 5. Recent evidence suggests a density-dependent effect on growth and maturation, indicating that the average age at maturity may vary annually. The eggs are demersal and are typically deposited on rock or gravel substrates. Primary spawning locations off the northeastern United States occur on the Maine coast, Jeffreys Ledge and Nantucket Shoals; Georges Bank formerly supported an extensive spawning ground. Incubation is temperature dependent, but usually requires 7 to 10 days. Larvae metamorphose by late spring into juvenile brit herring that may form large aggregations in coastal waters during summer. By age 2, juvenile herring are fully vulnerable to coastal fixed-gear fisheries (stop seines and weirs), which have declined greatly in recent years.



Herring gillnetter, Gloucester harbor, circa 1938
O.E. Sette Collection, NMFS/NEFSC Photo Archive

Coastal Stock Complex

In the past, the herring resource along the East Coast of the United States has been divided into the Gulf of Maine and Georges Bank stocks. There is genetic and tagging evidence that both supports and refutes this stock division. Of greater concern to those managing the resource is the fact that fishery-independent measures of abundance for herring include fish originating from both spawning areas. Consequently, the herring from the Gulf of Maine and from Georges Bank have been combined for assessment into a single coastal stock complex. This approach has many advantages over the separate stock approach, but also poses a number of challenges for the future assessment and management of herring.

Total landings for the coastal stock complex have changed substantially over the past two decades. Landings averaged 88,800 mt during the years 1988 to 1992, whereas two decades ago they exceeded 300,000 mt. This change is best understood by examining the changes in regional fisheries that exploit the stock.

The fishery in the Gulf of Maine consists of fixed and mobile gear fisheries in coastal waters. Landings in the coastal fishery have averaged 43,000 mt over the last two decades. There has been a great deal of annual variability in the landings, but there is little evidence of any long-term trend. There is a trend, though, in the distribution of landings between the two principal gear types: mobile and fixed gear. Over the past five years, more than 90 percent of Maine herring landings were taken by mobile gear, compared with less than 50 percent during the 1970s. This shift appears to be related to reduced availability of herring to the fixed-gear fisheries. In addition, mobile gear landings include increasing catches made by mid-water trawlers. Due to recent declines in export markets for adult herring, a significant proportion of the catch has not been used for human consumption.

The herring fishery on Georges Bank was initiated in 1961 with increased foreign fishing activity off the northeast coast of the United States. Landings peaked in 1968 at 373,600 mt and subsequently declined to only 43,500 mt in 1976 as the stock collapsed. There has been no directed fishery for Atlantic herring on Georges Bank since that time.

Estimates of stock biomass (ages 2 and older) for the coastal stock complex were in excess of 1 million mt before the collapse associated with the Georges Bank fishery. After the collapse, stock size estimates were less than 100,000 mt. In the early 1980s, fishing by distant-water fleets ended and the stock complex began to rebuild. Today, stock complex biomass appears to be exceeding precollapse levels, but caution must be exercised in interpreting this situation. Because there is no offshore fishery, recent estimates of stock size depend on abundance levels suggested by survey trawl catches and larval herring densities. The suggestion that stock abundance is higher than during the late 1970s appears reasonable; but exact levels are difficult to ascertain.

The status of the coastal stock complex has improved significantly, but unevenly, in recent years. The recent rebuilding of the stock complex is attributed to increased spawning on coastal spawning grounds and Nantucket Shoals. The Georges Bank spawning contingent, which represents the largest historic component of the stock complex, has not fully recovered from its collapse during the early 1970s.

An interim plan has been accepted by the Atlantic States Marine Fisheries Commission (ASMFC) which provides guidance on the allocation of herring to international waters processors, and a joint ASMFC and New England Fishery Management Council plan for herring is being developed. The plan will include guidance for the orderly redevelopment of the offshore fishery.

For further information

Anthony, V.C. and G. Waring. 1980. The assessment and management of the Georges Bank herring fishery. *Rapp. P.-V. Reun. Cons. Int. Explor. Mer* 177:72-111.

Fogarty, M.J. and S.H. Clark. 1983. Status of herring stocks in the Gulf of Maine region for 1983. Woods Hole, MA: NOAA/NMFS/NEFC. *Lab. Ref. Doc.* 83-46.

NEFSC [Northeast Fisheries Science Center]. 1993. Report of the 16th Northeast Regional Stock Assessment Workshop (16th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-18.

Atlantic Herring
Coastal Stock Complex

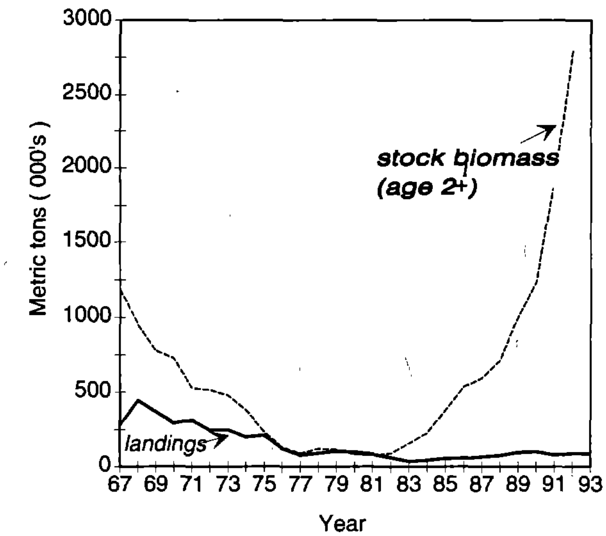


Table 21.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	47.4	34.1	27.7	29.2	39.7	41.1	53.0	63.0	54.7	59.7	54.6
Canada	2.1	8.7	27.9	27.9	27.3	33.4	44.1	38.8	24.6	32.0	31.5
Other	33.7	-	-	-	-	-	-	-	-	-	-
Total nominal catch[1]	83.2	42.8	55.6	57.1	67.0	74.5	97.1	101.8	79.3	91.7	86.1

[1]Age groups 1 and older.

Coastal Stock Complex
Atlantic Herring

Long-term potential catch[1]	=	150,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Under ASMFC Interim Plan
Status of exploitation[1]	=	Underexploited
Age at 50% maturity	=	3 years
Size at 50% maturity	=	26.0 cm (10.2 in.)
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.29

M = 0.20 **$F_{0.1}$ = 0.19** **F_{max} = 0.34** **F_{1993} = 0.04**

[1]Average age 2+ biomass at 20% MSP

Atlantic Mackerel

by E. Anderson

Atlantic mackerel, *Scomber scombrus*, is a fast swimming, pelagic, schooling species distributed in the Northwest Atlantic between Labrador and North Carolina. There are two major spawning components of this population: a southern group that spawns primarily in the Mid-Atlantic Bight during April and May, and a northern group that spawns in the Gulf of St. Lawrence in June and July. Both groups winter between Sable Island (off Nova Scotia) and Cape Hatteras in waters generally warmer than 7°C (45°F), with extensive northerly (spring) and southerly (autumn) migrations to and from spawning and summering grounds. Maximum observed size in recent years is about 47 cm or 18.5 in (fork length) and 1.3 kg (3 lb) in weight. Sexual maturity begins at age 2 and is usually complete by age 3. Maximum age is about 20 years.

Picking mackerel from a gill net, *F/V Kingfisher*, circa 1942
O.E. Sette Collection, NMFS/NEFSC Photo Archive

Mackerel are subjected to seasonal fisheries, both commercial and recreational, throughout most of their range. United States commercial landings have been taken mainly between January and May in southern New England and Mid-Atlantic coastal waters and between May and December in the Gulf of Maine. United States recreational catches occur mainly between April and October. Canadian landings from off Nova Scotia and Newfoundland have typically occurred between May and November. The intensive distant-water fishery conducted between 1968 and 1977 occurred mainly between December and April from Georges Bank to Cape Hatteras.

Mackerel in the Northwest Atlantic were managed by nationally-allocated catch quotas between 1973 and 1977 by the International Commission for the Northwest Atlantic Fisheries. Following implementation of the Magnuson Fishery Conservation and Management Act in 1977, mackerel in U.S. waters were initially managed under a preliminary management plan and since February, 1980 under the Mid-Atlantic Fishery Management Council's Mackerel, Squid, and Butterfish Plan. Management is based on total allowable catch limits, which have been increased over the 1980s.

Mackerel landings increased dramatically beginning in the late 1960s, reaching a peak of roughly 400,000 mt in 1973. Landings subsequently declined to roughly 30,000 mt in the late 1970s, increased steadily from 1980 to 1988 (82,700 mt), and have since declined steadily to 32,100 mt in 1993, a 16% decline from 1992. Increases in landings in the 1980s were due to larger U.S. and foreign joint venture fishing operations.

The United States accounted for only 16% of the 1993 international catch from the northwest Atlantic mackerel stock, including about 4,700 mt of commercial (the lowest level since 1983) and 500 mt of recreational catch. Canadian landings increased slightly from 25,500 mt in 1992 to 26,900 mt in 1993, the highest level reported since 1986. There was no distant-water fleet catch in either 1992 and 1993 because of the elimination of TALFF.

Year classes from 1975 to 1980 were all relatively weak. Cohorts since 1981 have been much stronger (except for 1983), particularly the 1982 year class, which is the largest since 1967. The 1984 to 1988 cohorts also appear to be relatively strong.

Total stock biomass (ages 1 and older) increased from around 300,000 mt during 1962-1965 to 1.6 million mt in 1969 before dropping to a stable low level during 1977-1981, averaging 776,000 mt per year. The total stock has increased since 1981, reaching nearly an estimated 3 million mt in 1990 and remaining at that approximate level since. Spawning stock biomass (50% of age 2 fish and 100% of age 3 and older) increased from about 600,000 mt in 1982 to more than

"Catches can be increased substantially without adversely affecting spawning stock biomass."

2.0 million mt in 1990 and has remained at or above that level since.

Rebuilding of the mackerel stock from relatively low levels in the late 1970s and early 1980s has been aided by relatively low catches during 1978-1993 (average of 49,400 mt) as well as improved recruitment from the 1981 to 1982 and 1984 to 1988 year classes. Catches can be increased substantially without adversely affecting spawning stock biomass. Given the large biomass and the recent decreases in the growth rate of individual fish, the population is underexploited and can sustain substantially more fishing.

For further information

Anderson, E.D. and A.J. Paciorkowski. 1980. A review of the Northwest Atlantic mackerel fishery. *Rapp. P.-V. Reun. Cons. Int. Explor. Mer* 177:175-211.

Overholtz, W.J. and B.L. Perry. 1985. Update of the status of the Northwest Atlantic mackerel stock for 1985. Woods Hole, MA: NOAA/NMFS/NEFC. *Lab. Ref. Doc.* 85-13.

Overholtz, W.J., S.A. Murawski, W.L. Michaels, and L.M. Dery. 1988. The effects of density dependent population mechanisms on assessment advice for the northwest Atlantic mackerel stock. *NOAA Tech. Memo. NMFS-F/NEC-62.*

Overholtz, W.J., S.A. Murawski, and W.L. Michaels. 1990. Impact of compensatory responses on assessment advice for the Northwest Atlantic mackerel stock. *Fish. Bull.* [U.S.] 89:117-128.

NEFSC [Northeast Fisheries Science Center]. 1991. Report of the Twelfth Northeast Regional Stock Assessment Workshop (12th SAW), Spring 1991. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 91-03.

Atlantic Mackerel
Labrador-North Carolina

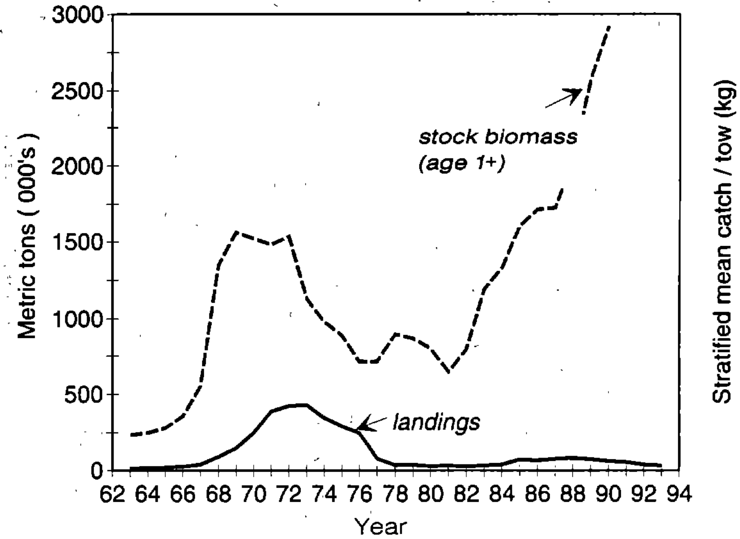


Table 22.1 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	3.9	2.6	3.3	3.9	5.6	4.2	2.3	2.0	2.0	0.4	0.5
Commercial											
United States	2.3	6.0	6.6	9.6	12.3	12.3	14.6	31.3	25.7	12.4	4.7
Canada	19.9	18.2	30.9	31.1	22.2	23.3	18.7	18.2	22.2	25.5	26.9
Other	89.3	15.0	32.4	25.4	35.1	42.9	36.8	9.1	5.3	-	-
Total nominal catch	115.4	41.8	73.2	70.0	75.2	82.7	72.4	60.6	55.2	38.3	32.1
Optimum yield	N/A	101.7	83.6	225.3	154.6	106.0	74.0	83.0	114.0	100.0	100.0

Labrador to North Carolina
Atlantic Mackerel

Long-term potential catch	=	134,000[1] mt
SSB for long-term potential catch	=	1.0-1.2 million mt
Importance of recreational fishery	=	Moderate
Management	=	Mackerel, Squid, and Butterfish FMP
Status of exploitation	=	Underexploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	32.7 cm (12.9 in.) fork length
Assessment level	=	Age structured
Overfishing definition	=	Minimum SSB of 600,000 mt and $F_{0.1}$ fishing rate
Fishing mortality rate corresponding to overfishing definition	=	Variable

M = 0.20 $F_{0.1}$ = 0.27 F_{max} = 0.96 F_{1993} = <0.05

[1]Assuming constant recruitment at level of geometric mean of 1961-1984 year classes and fishing mortality at $F_{0.1}$

Atlantic Butterfish

by J. Brodziak

The Atlantic butterfish (*Peprilus triacanthus*) is a small, bony, food fish weighing up to .5 kg with a thin oval body and delicious oily flesh. Butterfish are short-lived and grow rapidly. Few live to be more than 3 years of age, and most are sexually mature at age 1. Atlantic butterfish range from Florida to Newfoundland, but are primarily found from Cape Hatteras to the Gulf of Maine where the population is considered to be a unit stock.


Butterfish with sand lance
NMFS/NEFSC photo by Brenda Figuerido

The butterfish stock migrates in response to seasonal changes in water temperature. During summer, butterfish move northward and inshore to feed and spawn. Spawning occurs during June to August and peaks progressively later at higher latitudes. During winter, the stock moves southward and offshore to avoid cool waters. Butterfish are primarily pelagic and form loose schools that feed upon small fish, squid, and crustaceans. Butterfish have a high natural mortality rate and are preyed upon by many species including silver hake, bluefish, swordfish, and long-finned squid. During summer, juvenile butterfish associate with jellyfish to avoid predators.

Butterfish have been landed by domestic fishermen since the 1800s. From 1920 to 1962, the annual domestic harvest averaged 3,500 mt. In the 1960s foreign distant water fleets began to exploit butterfish; and from 1965 to 1976, butterfish landings increased to an average of 10,000 mt per year with a peak of 19,500 mt in 1973. During 1977 to 1987 when foreign fishing was being phased out, butterfish landings averaged 6,100 mt. From 1987 to 1992, annual landings averaged 2,500 mt.

In 1993, a total of 4,500 mt of butterfish were landed, an increase of 60% from 1992 and the highest domestic harvest since 1987. Otter trawls were the primary fishing gear used to capture butterfish and accounted for 98% of the 1993 landings. Most of the 1993 total (84%) was taken off Southern New England and in the New York Bight; and most landings occurred in Rhode Island ports (79%).

The butterfish stock is managed by the Mid-Atlantic Fishery Management Council (MAFMC) under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. For 1993, the maximum optimum yield and the allowable biological catch for butterfish was 16,000 mt while the domestic allowable harvest was 10,000 mt; these regulations are in effect for 1994 as well.

Relative abundance indices from the NEFSC autumn research vessel survey indicate that butterfish stock biomass was slightly above its long-term average in the autumn of 1993. The catch per tow index (total weight for all ages) from this survey was 9.9 kg per tow, an increase of 120% over 1992. This increase was primarily due to the recruitment of the strong 1992 year class. The 1993 butterfish prerecruit index (mean number of age-0 fish per tow) was also above average in 1993. The fact that this index has been above average since 1987 suggests that reproductive conditions have continued to be favorable for this short-lived, fast-growing species.

Butterfish landings have averaged less than 30% of the domestic allowable harvest of 10,000 mt since 1987, and recent yields from this stock are well below historical yields. Data collected at sea by fishery observers suggest that much

"The fact that this index has been above average since 1987 suggests that reproductive conditions have continued to be favorable for this short-lived, fast-growing species."

of the fishing-induced mortality of butterfish is attributable to discarding at sea, and discarding may be a factor in the recent low levels of yield. Regardless of this factor, demand for Atlantic butterfish exports in the important Japanese market has decreased in recent years (MAFMC 1992). This has probably had a negative impact on the fishery, with the exception of 1993. Overall, it appears that the butterfish stock could support an increase in landings up to the domestic allowable harvest level of 10,000 mt. However, such an increase seems unlikely unless the market for butterfish improves.

For further information

MAFMC [Mid-Atlantic Fishery Management Council]. 1992. 1993-1994 allowable biological catch, optimum yield, domestic annual harvest, domestic annual processing, joint venture processing, and total allowable level of foreign fishing recommendations for Atlantic mackerel, *Loligo*, *Illex*, and butterfish. Dover, DE:MAFMC.

Murawski, S. and G. Waring. 1979. A population assessment of butterfish, *Peprilus triacanthus*, in the Northwest Atlantic Ocean. *Trans. Am. Fish. Soc.* 108:427-439.

NEFSC [Northeast Fisheries Science Center]. 1994. Report of the 17th Northeast Regional Stock Assessment Workshop (17th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-06.

Butterfish
Gulf of Maine-Middle Atlantic

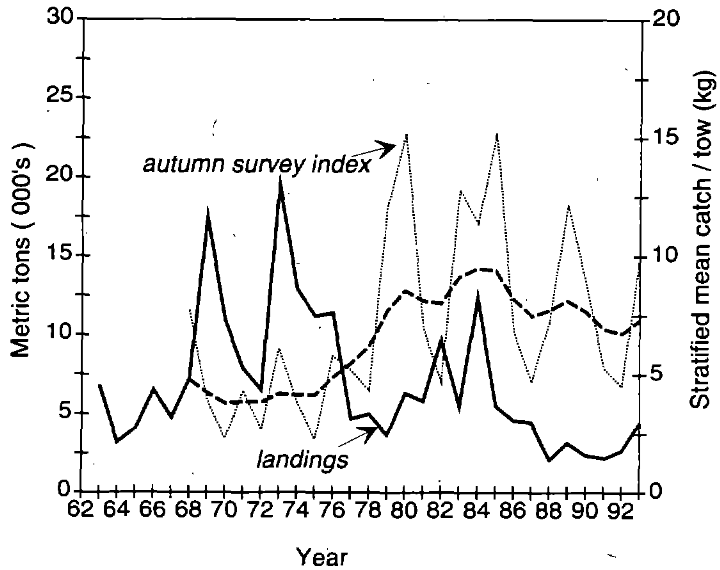


Table 23.1 Recreational and commercial catches (thousand metric tons)

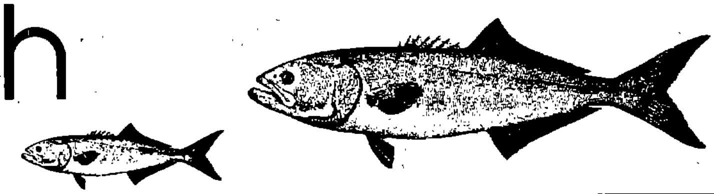
Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	3.8	12.0	4.7	4.4	4.5	2.1	3.2	2.4	2.2	2.8	4.5
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	3.8	0.4	0.8	0.2	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0
Total nominal catch	7.6	12.4	5.5	4.6	4.5	2.1	3.2	2.4	2.2	2.8	4.5
Total allowable catch	-	11.0	<16.0	<16.0	<16.0	10.0	10.0	10.0	10.0	10.0	10.0

Gulf of Maine - Middle Atlantic
Butterfish

Long-term potential catch	=	16,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Mackerel, Squid, and Butterfish FMP
Status of exploitation	=	Underexploited
Age at 50% maturity	=	0.9 years
Size at 50% maturity	=	12 cm fork length
Assessment level	=	Yield per recruit
Overfishing definition	=	3-year moving average of autumn prerecruit index falls within lowest quartile of this time series

$M = 0.80$ $F_{0.1} = 1.60$ $F_{max} > 2.50$ F_{1993} = Unknown

Bluefish



by M. Terceiro

The bluefish, *Pomatomus saltatrix*, is a migratory, pelagic species found throughout the world in most temperate coastal regions, except the eastern Pacific. Along the U.S. Atlantic coast, bluefish are found from Maine to Florida, migrating northward in the spring and southward in the fall. Bluefish are voracious predators that feed on a wide variety of fish and invertebrates. They may reach ages of about 12 years and sizes in excess of 100 cm (39 in.) and 14 kg (31 lb).

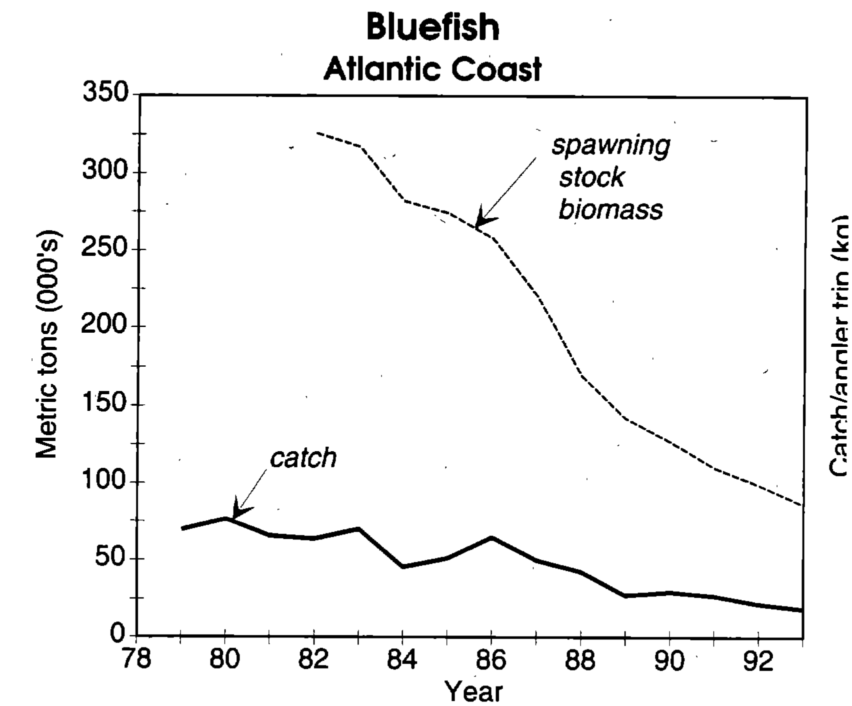
Bluefish, NEFSC Resource Survey cruise
NMFS/NEFSC photo by Brenda Figuerido

Angler with bluefish, Woods Hole, Mass., circa 1960
Brigham Collection, NMFS/NEFSC Photo Archive

Atlantic coast bluefish spawn mainly in the spring in the South Atlantic Bight and during summer in the Middle Atlantic Bight. Recent studies suggest that fish from the two spawning seasons mix extensively on the fishing and spawning grounds and probably comprise a single genetic stock. A unit stock of bluefish along the Atlantic coast is assumed for management purposes. A fishery management plan for bluefish developed by the Mid-Atlantic Fishery Management Council and the Atlantic States Marine Fisheries Commission was approved by the Secretary of Commerce in early 1990. Total catches of bluefish from Maine to Florida peaked in 1980 at an estimated 76,500 mt. Total catches have generally declined from 1980 to the present, but with some fluctuations. Total catch decreased 15% from 1992 to 1993 (22,000 to 18,800 mt). The recreational component of the fishery, which has historically constituted 80 to 90% of the total catch, peaked in 1980 at nearly 70,000 mt. Most of the recreational catch of bluefish is taken in the Middle Atlantic states (New York to Virginia). The 1993 recreational catch of 14,800 mt represented a decrease of 13% from the previous year (17,000 mt), and accounted for 79% of the total catch. Recreational fishing effort for bluefish, defined as those trips catching or targeting bluefish, declined from a peak of about 14 million trips in 1980 to less than 8 million trips in 1993. The principal commercial fishing gears used to catch bluefish are otter trawls and gill nets. Commercial landings peaked in 1981 at 7,500 mt. Commercial landings decreased 20% in 1993, from 5,000 to 4,000 mt, and accounted for about 21% of the total catch.

During 1994, Atlantic coast bluefish were assessed using an age-structured analysis that provided estimates of spawning stock size, recruitment, and fishing mortality rates. These analyses indicate that bluefish spawning stock biomass has declined from 326,000 mt in 1982 to 86,000 mt in 1993, a decrease of 74%.

"...analyses indicate that bluefish spawning stock biomass has declined from 326,000 mt in 1982 to 86,000 mt in 1993, a decrease of 74%..."



Recruitment at age 0 varied from 75 to 87 million fish during 1983-1984, but has declined substantially since then, with the best recent year classes recruiting to the stock in 1988 (41 million) and 1989 (45 million). Recruitment since 1989 has been below average, and recruitment in 1993 was very poor, at only 4 million fish.

Fishing mortality rates for bluefish increased from about 0.20 in 1982 to about 0.44 in 1987. F declined to about 0.32 by 1989, and then increased to 0.45 in 1993, about twice the level of overfishing established for the stock (F_{msy} = 0.15-0.25). Atlantic coast bluefish are considered to be over-exploited and at a low level of abundance, based on information for the period in which recreational catch and survey abundance indices are available (1974-1993).

Table 24.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year										
	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	56.6	39.3	45.0	59.4	43.5	35.7	23.0	23.7	21.1	17.0	14.8
Commercial											
United States	5.7	5.4	6.1	6.7	6.6	7.2	4.7	6.2	6.2	5.0	4.0
Canada	.	.	.	.	.	.	.	.	.	.	.
Other	.	.	.	.	.	.	.	.	.	.	.
Total nominal catch	62.3	44.7	51.1	66.1	50.1	42.9	27.7	29.9	27.3	22.0	18.8

For further information

Chiarella, L.A., and D.O. Conover. 1990. Spawning season and first-year growth of adult bluefish from the New York Bight. *Trans. Am. Fish. Soc.* 119:455-462.

Graves, J.E., J.R. McDowell, A.M. Beardsley, and D.R. Scoles. 1992. Stock structure of the bluefish *Pomatomus saltatrix* along the mid-Atlantic coast. *Fish. Bull.* [U.S.] 90:703-710.

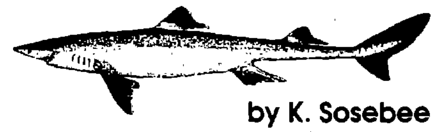
NEFSC [Northeast Fisheries Science Center]. 1994. Report of the 18th Northeast Regional Stock Assessment Workshop (18th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-22.

Atlantic Coast Bluefish

Long-term potential catch	=	30,000 mt
SSB for long-term potential catch	=	250,000 mt
Importance of recreational fishery	=	Major
Management	=	Bluefish FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	1 year
Size at 50% maturity	=	35 cm (13.8 in.)
Assessment level	=	Age structured
Overfishing definition	=	F_{msy}
Fishing mortality rate corresponding to overfishing definition	=	0.15-0.25

M = 0.25 **$F_{0.1}$ = 0.20** **F_{max} = 0.30** **F_{1993} = 0.45**

Spiny Dogfish



by K. Sosebee

Spiny dogfish, *Squalus acanthias*, are distributed in the western North Atlantic from Labrador to Florida. During spring and autumn, they are found in coastal waters between North Carolina and Southern New England. Dogfish are chiefly summer visitors to the Gulf of Maine (including Georges Bank) and more northern waters, and in winter are distributed primarily in deeper waters along the edge of the continental shelf. They tend to school by size and, for large mature individuals, by sex. Dogfish are voracious feeders and are known to attack schools of herring and mackerel, as well as concentrations of haddock, cod, sand lance, and other species. In the Northwest Atlantic, maximum ages reported for males and females are 35 and 40 years, respectively. The species bears live young, with a gestation period of about 18 to 22 months, producing 2 to 15 pups with an average of 6.

Dogfish, *R/V Albatross III*, circa 1965
Brigham Collection, NMFS/NEFSC Photo Archive

The principal commercial fishing gears used for catching dogfish are otter trawls and sink gillnets. Dogfish are frequently caught as bycatch and discarded during groundfish operations, particularly in the Mid-Atlantic - Southern New England area. Foreign fishing is presently insignificant, but recreational fishing is of moderate importance. At present, there is no fishery management plan, but one is expected to be implemented within two years.

Total landings peaked at 25,600 mt in 1974, declined sharply to a fairly stable average of about 6,200 mt per year during 1977-1989, and then increased sharply to over 18,000 mt in 1990; landings in 1992 and 1993 were 19,300 mt and 22,600 mt, respectively. Distant water fleets accounted for virtually all of the reported total from 1966 to 1977. The U.S. commercial landings during 1979-1989 averaged 4,500 mt per year, but then climbed sharply to 14,900 mt in 1990 and to 20,200 mt in 1993. Landings in 1994 are expected to be comparable to 1993 due to a strong European market demand. U.S. recreational catches increased from about 350 mt per year in 1979-1980 to about 1,700 mt in 1989-1991, with the 1993 estimate being 1,200 mt. Quantitative estimates of discards are unavailable except for 1993 (13,500 mt), but may have been at least as high as reported landings.

Minimum swept-area total biomass estimates of spiny dogfish based on NEFSC spring bottom trawl survey catches increased steadily from about 120,000 mt in 1968 to about 650,000 mt in 1994. Minimum swept-area estimates of fishable biomass (80 cm) peaked at about 295,000 mt in 1989 and declined to about 250,000 mt in 1994. Absolute estimates of fishing mortality are not available, but relative rates have increased fivefold since the late 1980s.

The U.S. fishery for dogfish is similar to the European fisheries in being selective for large individuals [larger than 2.3 kg (5.1 lb), 83 cm (33 in.)], which are mainly mature females, to meet processing and marketing requirements. However, smaller individuals, consisting of both mature and immature males as well as immature females, are also taken as bycatch and discarded.

A conservative estimate of the maximum sustainable yield for the species is between 23,000 and 46,000 mt, based on a biomass dynamics model of the fishable

"Since this species bears small numbers of live young and has a protracted gestation period, directed fisheries for mature females could impact significantly upon recruitment."

portion of the stock. This suggests that current landings may be near the MSY level. However, these estimates do not take account of the large amounts of dogfish discard.

Declining abundance as evidenced by trends in commercial catch per unit effort and research vessel survey indices, apparent increases in fishing mortality and declines in average length in commercial landings, all suggest that this stock is at or near full exploitation levels. Since this species bears small numbers of live young and has a protracted gestation period, directed fisheries for mature females could impact significantly upon recruitment. The potential for rapid overexploitation of sharks has been observed in U.S. west coast and European fisheries.

For further information

Brodziak, J., P.J. Rago, and K. Sosebee. 1994. Application of a biomass dynamics model to the spiny dogfish stock in the Northwest Atlantic. Woods Hole: NOAA/NMFS/NEFSC. *Ref. Doc.* 94-18.

NEFSC [Northeast Fisheries Science Center]. 1994. Report of the 18th Northeast Regional Stock Assessment Workshop (18th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *Ref. Doc.* 94-22.

Rago, P.J., K. Sosebee, J. Brodziak, and E.D. Anderson. 1994. Distribution and dynamics of Northwest Atlantic spiny dogfish (*Squalus acanthias*). Woods Hole, MA: NOAA/NMFS/NEFSC. *Ref. Doc.* 94-19.

Spiny Dogfish
Labrador-North Carolina

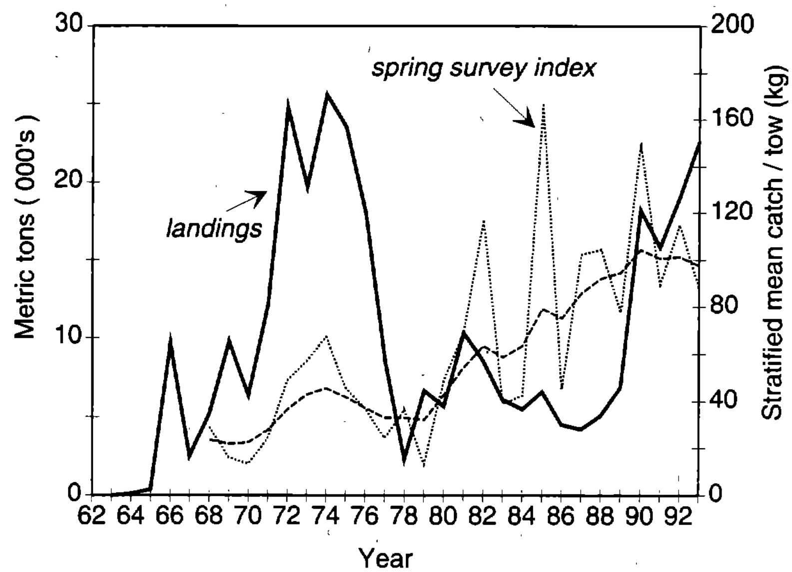


Table 25.1 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	0.8	0.7	1.6	1.4	1.1	1.3	1.8	1.7	1.7	1.2	1.2
Commercial											
United States	3.0	4.4	4.0	2.7	2.7	3.3	4.6	14.9	13.4	17.2	20.4
Canada	0.3	<0.1	<0.1	<0.1	0.3	-	0.2	1.3	0.3	0.8	1.0
Other	7.4	0.4	1.0	0.4	0.1	0.6	0.3	0.4	0.2	0.1	-
Total nominal catch	11.5	5.5	6.6	4.5	4.2	5.2	6.9	18.3	15.6	19.3	22.6

Labrador - North Carolina
Spiny Dogfish

Long-term potential catch	=	23,000 - 46,000 mt
SSB for long-term potential catch	=	141,000 - 286,000 mt
Importance of recreational fishery	=	Moderate
Management	=	None
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	6 years, males 12 years, females
Size at 50% maturity	=	60 cm (23 in.), males 75 cm (30 in.), females
Assessment level	=	Index
Overfishing definition	=	N/A
Fishing mortality rate corresponding to overfishing definition	=	N/A

M = 0.092 **$F_{0.1}$ = 0.04** **F_{max} = 0.06** **F_{1993} = Unknown**

Skates

by T. Helser

Skates, Family Rajidae, are distributed throughout the Northwest Atlantic from near the tide line to depths exceeding 700 m (383 fathoms). Members of this family lay eggs that are enclosed in a hard, leathery case commonly called a mermaid's purse. Incubation time is 6 to 12 months, with the young having the adult form at the time of hatching. There are seven species of *Raja* occurring along the North Atlantic coast of the United States: little skate (*Raja erinacea*), winter skate (*R. ocellata*), barndoor skate (*R. laevis)*, thorny skate (*R. radiata*), brier skate (*R. eglanteria*), leopard skate (*R. garmani*) and smooth-tailed skate (*R. senta*).

The center of distribution for the little and winter skates is Georges Bank and Southern New England. The thorny, barndoor, smooth-tailed, and leopard skates are commonly found in the Gulf of Maine. The brier skate is a southern species, located primarily in the Chesapeake Bight. Skates are not known to undertake large-scale migrations, but they do move inshore and offshore in response to seasonal changes in water temperature, generally offshore in summer and early autumn and *vice-versa* during the winter-spring period.

The principal commercial fishing method used to catch skates is otter trawling. Skates are frequently caught as bycatch during groundfishing operations and discarded. Recreational landings are insignificant. There are currently no regulations governing the harvesting of skates in U.S. waters.

Landings of skates (all species combined) off the northeast United States were 8,100 mt in 1993, a 34 percent decrease from the 12,300 mt landed in 1992. Skates have been reported in New England fishery landings since such data have been recorded (the late 1800s). However, landings (primarily from off Rhode Island), never exceeded several hundred metric tons until the advent of distant-water fleet fishing during the 1960s. Skate landings peaked in 1969 at 9,500 mt, and declined quickly during the 1970s. Landings bottomed out at 500 mt in 1981 and have since increased steadily, partially in response to the increased demand for lobster bait, and, more significantly, to the increased export market for skate wings. Wing landings are composed of winter and thorny skates, which are the two species currently known to be used for human consumption. Bait landings are primarily little skate, based on the areas fished and the known species distribution patterns.

Culling a skate from a mixed tow of hake and spiny dogfish, circa 1935
O.E. Sette Collection, NMFS/NEFSC Photo Archive

Survey abundance indices for skates (again all species combined) are expressed as minimum population estimates from area-swept calculations, smoothed to better reflect resource trends. Over the time series from 1968 to 1994, smoothed survey indices for skates reveal three distinct trends. A slight decline in abundance occurred from 1968 to 1979, when a series low of 81,000 mt was observed.

"In areas of the world where skates are more fully utilized, their numbers have been reduced to extremely low levels "

Since 1980, the survey index has increased significantly, reaching its highest point in the time series, 151,000 mt, in 1987. Since 1987, the smoothed abundance index has again declined somewhat, although values have remained well above the long-term (1968-1992) average of 112,000 mt.

Recent increases in skate landings and the potential for rapidly expanding export markets bring into question the level at which sustainable fisheries for these species can be maintained. Skates have a limited reproductive capacity, and stock size could be quickly reduced through intensive exploitation. In areas of the world where skates are more fully utilized, their numbers have been reduced to extremely low levels (*e.g.*, Irish Sea). Similarly, particularly vulnerable species in the Northwest Atlantic (*e.g.*, barndoor skate) appear to show signs of recruitment overfishing. The abundance of winter skate has declined in recent years on Georges Bank.

For further information

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. *Fish. Bull.* [U.S.] 53.

Holden, M.J. 1973. Are long-term sustainable fisheries for elasmobranchs possible? *Rapp. P.-V. Reun. Cons. Int. Explor. Mer* 164:360-367.

NEFSC [Northeast Fisheries Science Center]. 1990. Report of the 11th Stock Assessment Workshop (11th SAW), Fall 1990. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Ref. Doc.* 90-09.

Waring, G.T. 1984. Age, growth and mortality of the little skate off the northeast coast of the United States. *Trans. Amer. Fish. Soc.* 113:314-321.

Skates
Gulf of Maine-Middle Atlantic

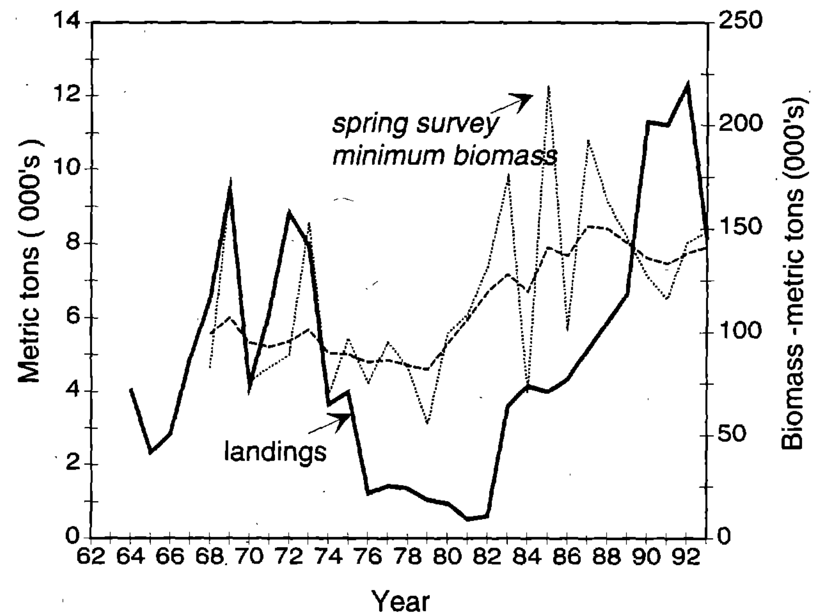


Table 26.1 Recreational catches and commercial landings (thousand metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.6	4.1	4.0	4.2	5.1	5.9	6.6	11.3	11.2	12.3	8.1
Canada	<0.1	-	<0.1	-	<0.1	<0.1	-	-	-	-	-
Other	0.6	-	-	0.1	-	-	-	-	-	-	-
Total nominal catch	2.2	4.1	4.0	4.3	5.1	5.9	6.6	11.3	11.2	12.3	8.1

Gulf of Maine - Middle Atlantic Skates

Long-term potential catch	=	25,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational catch	=	Insignificant
Management	=	None
Status of exploitation	=	Underexploited
		Age at 50% maturity=4 years[1]
Size at 50% maturity	=	40 cm (15.8 in.)[1]
Assessment level	=	Index
Overfishing definition	=	None
Fishing mortality rate corresponding to overfishing definition	=	Unknown

$M = 0.4^1$ $F_{0.1} = 0.49^1$ $F_{max} = 1.0^1$ $F_{1993} = <F_{max}$

[1]Pertains to little skate

Short-finned Squid

by J. Brodziak

The short-finned squid (*Illex illecebrosus*) is a pelagic ommastrephid that ranges from Florida to Labrador in the Western Atlantic. Within its range of commercial exploitation (from Cape Hatteras to Newfoundland), the short-finned squid population is considered to be a unit stock. Short-finned squid are capable of long distance migrations of more than 1,000 miles, and are commonly observed on the continental shelf between Cape Hatteras and Newfoundland during summer and autumn. Major spawning grounds have been identified south of Cape Hatteras, and the Gulf Stream is thought to be an important transport mechanism for larvae and juveniles. Short-finned squid are essentially an annual species, with a life cycle of roughly one year; they grow rapidly and can attain lengths of 35 cm (14 in.) in dorsal-mantle length, although most individuals harvested in the commercial fishery are less than 26 cm (10 in.).

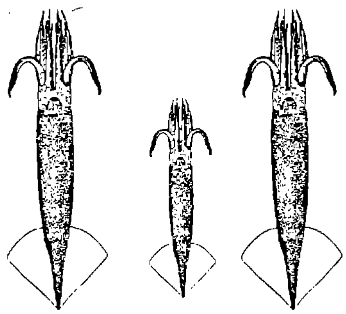
The domestic short-finned squid fishery began in the 1800s. From 1928 to 1966, annual squid landings from Maine to North Carolina (including *Loligo pealei*) averaged roughly 2,000 mt. Directed foreign fishing for short-finned squid in the U.S. Exclusive Economic Zone (EEZ) began in 1972 and was curtailed in 1982. From 1972 to 1982, short-finned squid landings from Cape Hatteras to the Gulf of Maine averaged 19,000 mt. During 1983 to 1992, short-finned squid landings averaged 9,400 mt, roughly half of the average yield during 1972 to 1982.

Short-finned squid
NMFS/NEFSC photos by Brenda Figuerido

In 1993, U.S. short-finned squid landings from Cape Hatteras to the Gulf of Maine were a record 18,000 mt, slightly more than the 1992 total of 17,800 mt. The spatial pattern of short-finned squid landings in 1993 was similar to that of recent years, with most landings coming from offshore waters of the Mid-Atlantic Bight. Fishing effort in 1993 decreased by 15% while landings per unit of effort increased by 15%.

Short-finned squid are managed by the Mid-Atlantic Fishery Management Council under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. In 1993 and 1994, the maximum optimum yield, the allowable biological catch, and the domestic allowable harvest were 30,000 mt. The NEFSC autumn bottom trawl survey abundance index for 1993 was above its long-term average and was more than four times its mean level during the mid-

"The domestic short-finned squid fishery produced a stable yield in 1993."



1980s (1982-1986), when stock abundance and commercial landings per unit of effort were below average.

The domestic short-finned squid fishery produced a stable yield in 1993. Landings from Cape Hatteras to the Gulf of Maine increased slightly, but were 5% below the average level of landings during 1972 to 1982. Landings in 1994 may surpass 1993 levels since relative abundance, as measured by research survey data, has remained near its long-term average. However, availability of short-finned squid varies from year to year because it is a short-lived, highly migratory animal with a range that extends beyond the U.S. EEZ. This stock presently appears to be at an intermediate level of abundance, and the stock is considered to be underexploited.

For further information

Mid-Atlantic Fishery Management Council. 1992. 1993-1994 allowable biological catch, optimum yield, domestic annual harvest, domestic annual processing, joint venture processing, and total allowable level of foreign fishing recommendations for Atlantic mackerel, *Loligo*, *Illex*, and butterfish. Dover, De: MAFMC.

NEFSC [Northeast Fisheries Science Center]. 1994. Report of the 17th Northeast Regional Stock Assessment Workshop (17th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-06.

Short-Finned Squid
Gulf of Maine-Middle Atlantic

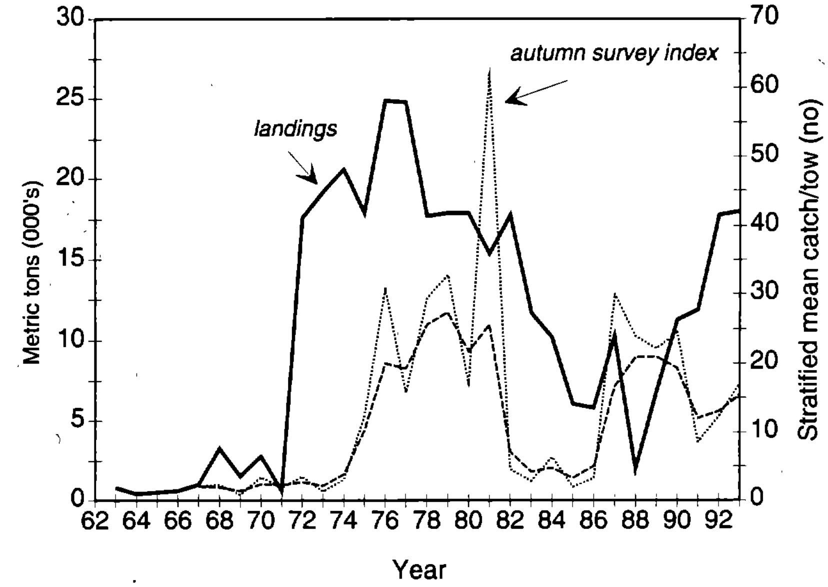


Table 27.1 Recreational and commercial catches (thousand metric tons)

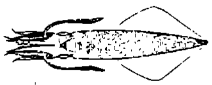
Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.9	9.5	5.0	5.2	10.3	2.0	6.8	11.7	11.9	17.8	18.0
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	16.9	0.7	1.1	0.2	-	<0.1	-	-	-	-	-
Total catch	18.8	10.2	6.1	5.4	10.3	2.0	6.8	11.7	11.9	17.8	18.0
Total allowable catch	-	30.0	30.0	25.0	22.5	22.5	17.0	15.0	30.0	30.0	30.0

Gulf of Maine-Middle Atlantic
Short-Finned Squid

Long-term potential catch	=	30,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Mackerel, Squid, and Butterfish FMP
Status of exploitation	=	Underexploited
Age at 50% maturity	=	<1.0 years
Size at 50% maturity	=	20 cm dorsal-mantle length
Assessment level	=	Index
Overfishing definition	=	3-year moving average of autumn prerecruit index falls within lowest quartile of this time series
Fishing mortality rate corresponding to overfishing definition	=	Unknown

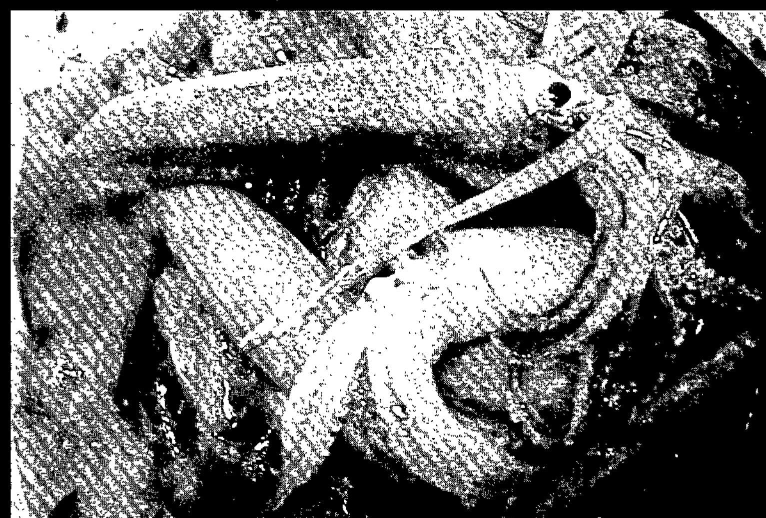
$M \geq 1.0$ $F_{0.1}$ = Unknown F_{max} = Unknown F_{1993} = Unknown

Long-finned Squid



by J. Brodziak

The long-finned squid (*Loligo pealei*) is a pelagic schooling loliginid distributed in continental shelf and slope waters from Newfoundland, Canada to the Gulf of Venezuela. Within its range of commercial exploitation (Southern Georges Bank to Cape Hatteras) the long-finned squid population is considered to be a unit stock. North of Cape Hatteras, long-finned squid undergo seasonal migrations; they move offshore during late autumn to overwinter in warmer waters along the edge of the continental shelf and return inshore during the spring and early summer to feed and spawn. Recent research indicates that long-finned squid live for less than one year, grow rapidly, and have the capacity to spawn year-round. The long-finned squid is sexually dimorphic with males growing more rapidly and attaining larger sizes than females. Some male long-finned squid attain lengths of more than 40 cm (16 in.) in dorsal-mantle length, although most squid harvested in the commercial fishery are less than 30 cm (12 in.).



Long-finned squid
NMFS/NEFSC photos by Brenda Figuerido

The Northwest Atlantic long-finned squid fishery began in the late 1800s, and from 1928 to 1966, annual squid landings from Maine to North Carolina (including *Illex illecebrosus* landings) averaged roughly 2,000 mt. A directed foreign fishery for long-finned squid developed in 1967, and foreign fishing fleets exploited long-finned squid throughout the 1970s and early 1980s. Annual landings averaged 19,900 mt from 1967 to 1986 with a peak of 37,600 mt in 1973. In 1987, foreign fishing effort effectively ceased. U.S. landings averaged 17,800 mt annually during 1987 to 1992.

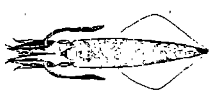
The long-finned squid stock is managed by the Mid-Atlantic Fishery Management Council under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. For 1993 and 1994, the maximum optimum yield, allowable biological catch, and domestic allowable harvest were set at 44,000 mt. Management targets for the long-finned squid stock are being re-evaluated to reflect recent research on its life history.

Long-finned squid landings totaled 22,300 mt in 1993, an increase of 23% over 1992 levels. The spatial pattern of the long-finned squid fishery in 1993 was similar to that of recent years. Most landings were taken from Southern New England, New York Bight, and Mid-Atlantic Bight waters.

The NEFSC autumn bottom trawl survey indices suggest reductions in abundance and biomass below their long-term averages in autumn of 1993. The mean catch in weight per tow of long-finned squid was 5.3 kg (34% below average), while the mean number of squid per tow was 199 (40% below average). In contrast, stock size was well above average during the autumn of 1992 when the prerecruit (≤ 8 cm dorsal-mantle) index was the highest on record.

Overall, total long-finned squid landings increased to 22,300 mt in 1993, primarily as a result of above-average landings from January to April when 13,500 mt (60% of the annual total) were landed (the corresponding average percentage during 1982-1992 was 25%). Effort and landings per unit of effort (LPUE) in the large-vessel fishery for long-finned squid increased to near record levels in 1993; LPUE in the small-vessel, inshore fishery for long-finned squid decreased by 6% to a record low level,

"Management targets for the long-finned squid stock are being re-evaluated to reflect recent research on its life history."



although effort increased by 92% and was also above average for 1982-1992.

The short lifespan of long-finned squid combined with their rapid growth and capacity to spawn year-round leads to a seasonally dynamic resource. The potential for recruitment overfishing of the long-finned squid stock is substantial because of recruitment to the fishery and the spawning stock within the same year. At present, the stock is considered to be fully exploited. In 1994, preliminary landings of long-finned squid during January to March were 60% below 1993 levels. As a result, it is unlikely that 1994 landings will exceed 1993 landings unless a strong cohort is produced during the first half of 1994.

For further information

Brodziak, J.K.T. and W.K. Macy, III. 1994. Revised estimates of growth of long-finned squid, *Loligo pealei*, in the Northwest Atlantic based on statolith ageing: Implications for stock assessment and fishery management. *ICES* [International Council for the Exploration of the Sea] *C.M.* 1994/K:13.

Mid-Atlantic Fishery Management Council. 1992. 1993-1994 allowable biological catch, optimum yield, domestic annual harvest, domestic annual processing, joint venture processing, and total allowable level of foreign fishing recommendations for Atlantic Mackerel, *Loligo*, *Illex*, and Butterfish. Dover, DE:MAFMC.

NEFSC [Northeast Fisheries Science Center]. 1994. Report of the 17th Northeast Regional Stock Assessment Workshop (17th SAW). Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-06.

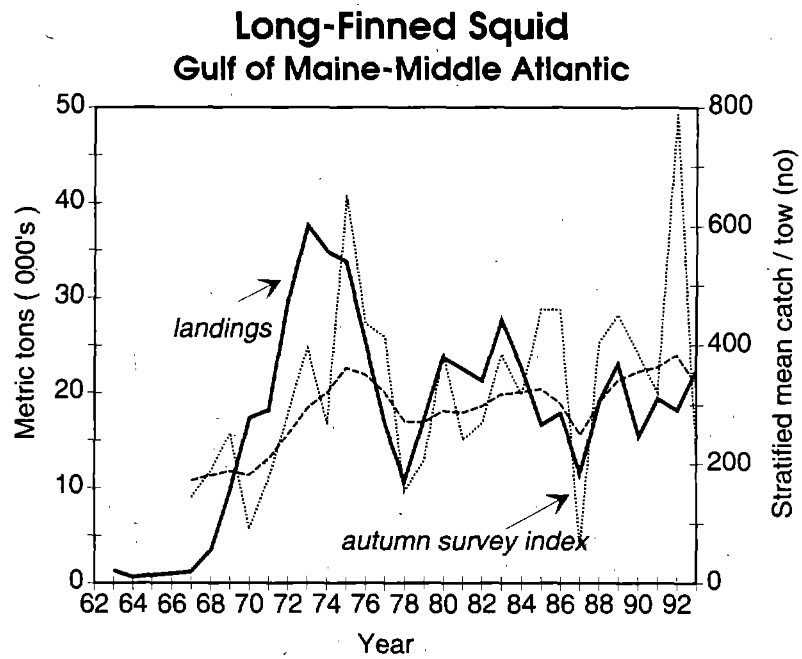


Table 28.1 Recreational and commercial catches (thousand metric tons)

Category	Year 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	4.2	11.6	10.2	13.3	11.5	19.1	23.0	15.5	19.4	18.2	22.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	19.2	11.0	6.5	4.6	<0.1	<0.1	<0.1	0.0	0.0	-	-
Total catch	23.4	22.6	16.7	17.9	11.5	19.1	23.0	15.5	19.4	18.2	22.3
Allowable biological catch	-	44.0	33.0	37.0	37.0	37.0	37.0	37.0	37.0	44.0	44.0

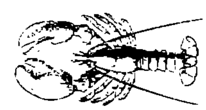
Gulf of Maine-Middle Atlantic Long-Finned Squid

Long-term potential catch	=	36,000[1] mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Mackerel, Squid and Butterfish FMP
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	<1 year
Size at 50% maturity	=	16 cm dorsal-mantle length
Assessment level	=	Index
Overfishing definition	=	3-year moving average of autumn prerecruit index falls within lowest quartile of this time series

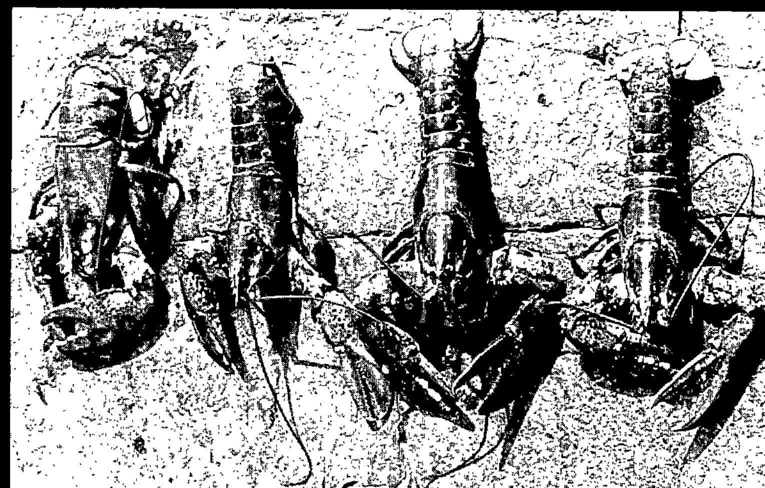
$M^m = .34$[2] **$F_{0.1} = 0.16$[2]** **$F_{max} = 0.26$[2]** **F_{1993} = Unknown**

[1]Provisional estimate
[2]Provisional <u>monthly</u> natural mortality rate

American Lobster



by J. Idoine



Lobsters *NMFS/NEFSC Photo*

The American lobster, *Homarus americanus*, is distributed in the Northwest Atlantic from Labrador to Cape Hatteras, from coastal regions out to depths of 700 m (400 fathoms). Lobsters are locally abundant in coastal regions within the Gulf of Maine and off southern New England. Coastal lobsters are concentrated in rocky areas where shelter is readily available, although occasional high densities occur in mud substrates suitable for burrowing. Offshore populations are most abundant in the vicinity of submarine canyons along the continental shelf edge. Tagging experiments in coastal waters suggest that small lobsters undertake rather limited movement, although larger individuals may travel extensively. In contrast, offshore lobsters show well-defined shoalward migrations during the spring, traveling as much as 300 km (186 mi), regularly 80 km (50 mi). Lateral movements along the shelf edge have been demonstrated as well.

Lobsters exhibit a complex life cycle in which mating occurs following molting of the female. Eggs (7,000 to 80,000) are carried under the females abdomen during a 9 to 11 month incubation period. The eggs hatch during late spring or early summer and the pelagic larvae undergo four molts before attaining adult characteristics and settling to the bottom. Lobsters molt approximately 20 times (in 5 to 8 years) before reaching minimum legal size. A significant proportion of the female lobsters caught in inshore areas are not sexually mature.

The principal fishing gear used to catch lobsters is the trap. Lobsters are also taken as a bycatch with otter trawls. Recreational fishing occurs, especially in coastal waters, but estimates of the catch are not available. Foreign fishing is insignificant. The fishery is managed under the New England Fishery Management Council's Lobster Fishery Manage-

American Lobster

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Minor
Management	=	FMP/NEFMC
Status of exploitation	=	Overexploited
Size at 50% maturity	=	9-10 cm (3.5 - 3.9 in.) carapace length
Assessment level	=	Age structured (DeLury)
Overfishing definition	=	10% egg production per recruit
Fishing mortality rate corresponding to overfishing definition	=	0.52[1] 0.44[2] 0.68[3]

M = 0.10	F_{max} (females)	= 0.29[1]	$F_{1989-1991}$	= 0.65[1]
		= 0.15[2]	$F_{1988-1990}$	= 0.24 - 0.51[2]
		= 0.38[3]	$F_{1989-1991}$	= 1.47[3]

[1]Gulf of Maine
[2]Georges Bank and South
[3]Southern Cape Cod - Long Island Sound

ment Plan, and within 3 mi of shore under various state regulations. The primary regulatory measure is carapace length (CL). Total landings increased 15% from 1989 to 1991 (from 24,000 to 28,700 mt). In 1993, total U.S. landings were around 25,600, a slight rise from the previous year but about a 12% drop from 1991. Similar trends in landings were seen in Canada's Scotia-Fundy region.

Inshore Fishery

Nominal landings in the U.S. inshore fishery were relatively stable from 1965 to 1975, ranging from 10,300 to 12,200 mt, averaging 11,100 mt. Landings then rose steadily from 12,900 mt in 1978 to a record 24,000 mt in 1991, an increase of about 86%. This increase can be attributed both to increased abundance and a continuing increase in effort, especially in the number of pots and areas fished. Some of this effort increase may be in response to recent increases in minimum size limits and other proposed management measures. Fishermen, trying to cover short-term losses, appear to be fishing more pots in the inshore areas, as well as expanding the areas and seasons fished. However, in 1992, inshore landings decreased to 20,971 mt (-13%). This decrease was seen throughout the U.S. fishery. In 1993, a 6% increase in inshore landings (22,129 mt) resulted in total U.S. landings (25,634 mt) only slightly higher than the 1992 value of 25,300 mt. This rise was entirely due to increases from Maine, since other areas reported no change or declines. However, the mean size of lobsters landed is still within one or two molts of the minimum size, representative of a continuing dependency on newly recruited animals (*i.e.*, those lobsters that have just grown into legal size). In addition, data from Massachusetts and Maine indicate the majority of egg production is coming from small females. In Canada, the Scotia-Fundy region has experienced similar trends in landings over the past decade.

"...the mean size of lobsters landed is still within one or two molts of the minimum size, representative of a continuing dependency on newly recruited animals..."

American Lobster
Gulf of Maine-Middle Atlantic

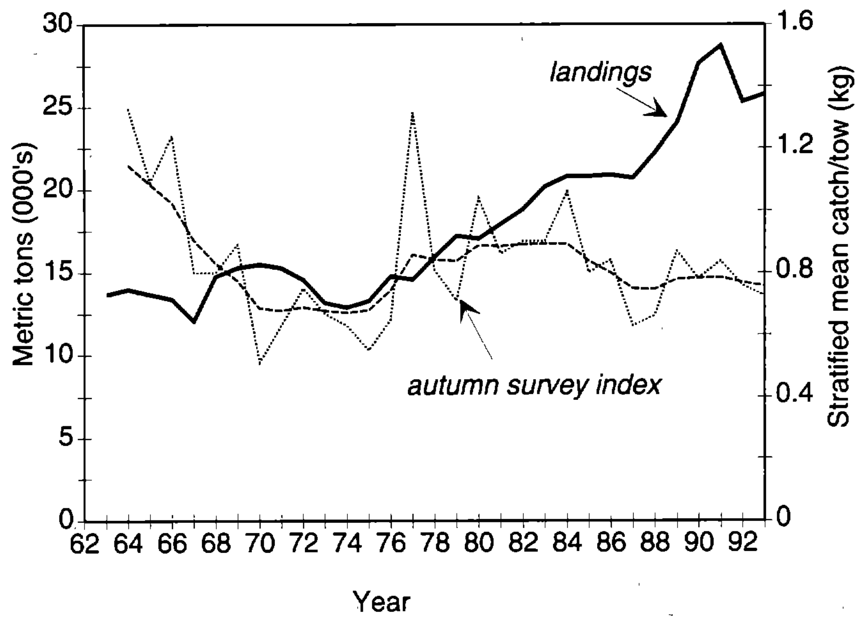


Table 29.1 Commercial and recreational landings (thousand metric tons), live weight). Landings statistics havebeen revised to reflect unreported catches.

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational[1]	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States											
Offshore[2]	2.7	4.2	2.6	3.4	3.3	3.0	3.3	5.0	4.7	4.4	3.5
Inshore[3]	13.3	16.4	18.0	17.8	17.3	19.2	20.7	22.6	24.0	20.9	22.1
Canada											
Georges Bank	0.2	0.2	0.2	<0.1	<0.1	<0.1	<0.1	0.1	0.2	0.2	0.2
Total nominal catch	16.2	20.8	20.8	20.9	20.7	22.2	24.0	27.7	28.9	25.5	25.8

[1]Recreational catches unknown
[2]Includes trawl and offshore trap catches
[3]Inshore trap catches

Offshore Fishery

Prior to 1950, lobsters were primarily taken offshore as incidental trawl catches in demersal fisheries. Reported offshore lobster landings increased dramatically from about 400 mt during the 1950s to an average of more than 2,000 mt in the 1960s. In 1969, technological

"If consistent recruitment in coastal areas depends on egg production from offshore, heavy exploitation of offshore populations could impact all fisheries."

advances permitted the introduction of trap fishing to the deeper offshore areas. Landings from offshore traps rose from 50 mt in 1969 to 2,900 mt in 1972 and remained relatively stable at around 2,000 mt from 1975 to 1983.

From 1985 through 1989 trap landings averaged around 2,800 mt. This increase in offshore trap landings has been accompanied by a decrease in trawl landings from a peak of 3,200 mt in 1971 to 500 mt in 1984. In subsequent years the trawl component of the fishery has averaged a little over 300 mt. Total offshore landings rose to an average of around 3,200 mt in the late 1980s, peaked at 5,000 mt in 1990 and have steadily declined since to 3,500 mt in 1993, 14% of the U.S. total. Offshore landings have never constituted more than 20% of the U.S. total.

Survey Indices

The NEFSC autumn survey biomass index declined steadily from 1.2 kg/tow in 1964 to an average of 0.7 kg/tow from 1971 - 1976. The index then increased to an average of 0.9 kg/tow from 1977 - 1984. Since the, the index has declined somewhat and in recent years has fluctuated at an average of about 0.8 kg/tow. These trends in biomass indices and offshore landings are consistent in indicating a reduction in stock biomass following the development of the offshore fishery, with stabilization of the stock at reduced levels.

Recent Assessments

During the past decade, increases in areal expansion of the lobster fishery, landings from both inshore and offshore and the continued intense inshore fishery have called into question the relationship between animals in these areas. If consistent recruitment in coastal areas depends on egg production from offshore, heavy exploitation of offshore populations could impact all fisheries. It would be prudent to view lobsters from both areas as a unit resource.

Bureau of Commercial Fisheries scientist Joe Uzmann wth lobsters
Booth Bay Harbor Lab, Maine, circa 1965
NMFS/NEFSC photo by Gareth Coffin

The NEFSC-sponsored Stock Assessment Review Committee (SARC) Invertebrate Subcommittee has worked to address this issue. In the most recent assessment, based on biological data and exploitation patterns, the resource was divided into three regions: 1) Gulf of Maine (inshore and offshore combined); 2) Georges Bank and South offshore and the 3) Southern Cape Cod to Long Island Sound inshore area.

The fishery is dominated by inshore pots and is managed based on a minimum size of 3.25 in. (82.6 mm) CL throughout, protection of berried (egg-bearing) females. In addition, the state of Maine enforces a maximum size of 5 in. (127 mm CL) and some level of v-notching protection for females. The Gulf of Maine provides approximately 71% of the landings.

The overfishing definition adopted by the New England Fishery Management Council refers only to females (it is based on egg production). Assessment results indicate that the Gulf of Maine and Southern Cape Cod to Long Island Sound Inshore regions are overfished, while the Georges Bank and South Offshore area is at least fully exploited. Overall, the American lobster resource is considered overexploited.

For further information

Fogarty, M.J., R.A. Cooper, J.R. Uzmann, and T.S. Burns. 1982. Assessment of the USA offshore American lobster, *Homarus americanus*, fishery. *ICES* [International Council for Exploration of the Sea] *C.M.* 1982/K:13.

NEFSC [Northeast Fisheries Science Center]. 1993. Report of the Sixteenth Northeast Regional Stock Assessment Workshop (16th SAW), Stock Assessment Review Committee (SARC), consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-18.

Northern Shrimp

by R.A. Richards

The northern shrimp, *Pandalus borealis*, supports important commercial fisheries in the North Atlantic and the North Pacific; the Gulf of Maine marks the southernmost extent of its Atlantic range. Distribution within the Gulf appears to be governed in large measure by temperature conditions; highest concentrations occur in the southwestern Gulf of Maine where temperatures are coolest, and seasonal changes in distribution appear to correlate well with localized temperature trends. This stock collapsed during the mid-1970s, but abundance has since increased considerably.

Northern shrimp are sequential hermaphrodites, maturing first as males. After spawning as males in late summer at about 2.5 years of age, individual shrimp pass through a series of transitional stages the following winter and spring, and then spawn as females (age 3.5 years) the following summer. Eggs are extruded onto the abdomen and fertilized within a month of spawning. During autumn and winter, egg-bearing females migrate inshore, where the eggs hatch during late winter. Females may survive to spawn in subsequent years, although natural mortality appears to increase sharply following first reproduction.

Shrimp are taken primarily by otter trawling, although pots have also been used successfully along the central Maine coast. There is no recreational or foreign fishery. Management is by the participating states (Maine, New Hampshire, and Massachusetts) under the auspices of the Atlantic States Marine Fisheries Commission. The fishery has been managed primarily by mesh size regulations and seasonal closures. Current management allows for fishing seasons of varying length within a window of 183 days (December 1 to May 31), depending on resource conditions. The 1994 fishing season extended from Dec. 15, 1993 to April 15, 1994.

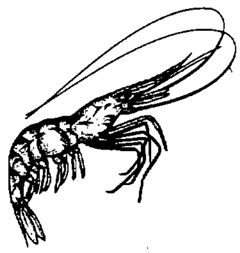
Northern shrimp
NMFS/NEFSC photos by Brenda Figuerido

Fishing effort has been directed primarily toward mature females in inshore areas during winter; effort tends to shift further offshore in spring, reflecting both post-hatch movement and improving weather conditions. Nominal effort on this stock (number of trips) rose steadily during the 1980s, from 1,100 trips in 1980 to a peak of 12,300 trips in 1987. Nominal effort has declined somewhat since then, to 6,000 trips in the 1994 season.

Commercial landings have fluctuated widely during the past 25 years. From 1969-1972, landings averaged 11,400 mt, but by 1977 had declined to only 400 mt. The fishery was closed in 1978. Landings began to increase in 1981, and reached 5,000 mt in 1987. Since then, landings have fluctuated around an average of 3,400 mt. Landings during the 1993 and 1994 seasons were below the 1988-1994 seasonal average.

Since 1983, the primary source of assessment information for this stock has been the cooperative state-federal survey conducted each August by the Northern Shrimp Technical Committee aboard the Northeast Fisheries Science Center's research vessel *Gloria Michelle*.

"Three strong year classes have been detected in recent years, occurring in 1982, 1987 and 1992."



Abundance indices from this survey have paralleled the NEFSC autumn survey index; both have been closely tracked by commercial landings. Three strong year classes have been detected in recent years, occurring in 1982, 1987 and 1992. Landings in 1990-1992 were supported primarily by the 1987 year-class. That year-class then passed out of the fishery and landings declined in 1993. In 1994 landings increased slightly as small male shrimp of the 1992 year class began to appear in the landings. Preliminary data from the 1994 summer shrimp survey suggest stock biomass and landings will increase during 1995.

For further information

McInnes, D. 1986. Interstate fishery management plan for the northern shrimp (*Pandalus borealis* Kroyer) fishery in the western Gulf of Maine. Washington, D.C.: *ASMFC. Atl. States Mar. Fisher. Commis. Fish. Mgt. Rept.* No. 9.

Northern Shrimp Technical Committee. 1994. Assessment report for Gulf of Maine northern shrimp, 1994. Report to the Northern Shrimp Section of the Atlantic States Marine Fisheries Commission, October 1994. Washington, D.C.: Atlantic States Marine Fisheries Commission.

Northern Shrimp Technical Committee. Unpublished. Cruise results: Gulf of Maine northern shrimp survey, August 2-11, 1994. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Resource Surveys Investigation, Woods Hole, MA 02543.

Northern Shrimp
Gulf of Maine

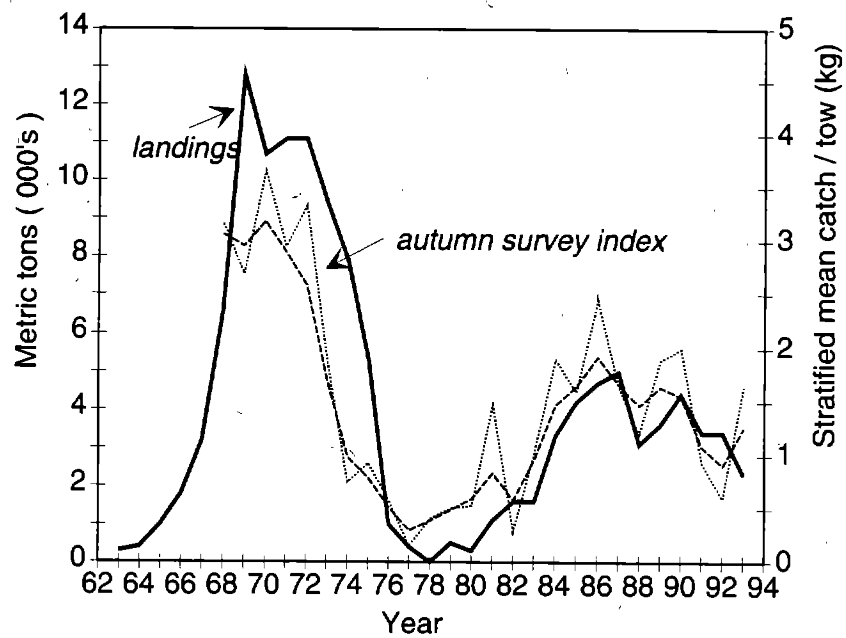


Table 30.1 Recreational catches and commercial landings (thousand metric tons)

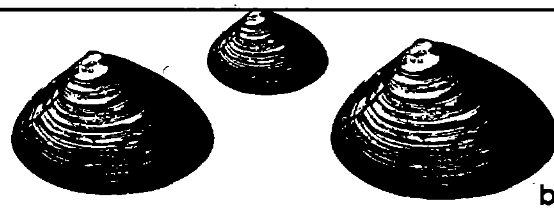
Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	2.0	3.3	4.2	4.7	5.0	3.1	3.6	4.4	3.4	3.4	2.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	2.0	3.3	4.2	4.7	5.0	3.1	3.6	4.4	3.4	3.4	2.3

Gulf of Maine
Northern Shrimp

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	N/A
Importance of recreational fishery	=	Insignificant
Management	=	Interstate Shrimp FMP
Status of exploitation	=	Fully exploited
Age at 50% maturity (females)	=	3.5 years
Size at 50% maturity (females)	=	26mm carapace length (1.0 in.)
Assessment level	=	Index
Overfishing definition	=	None
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.5$ $F_{0.1} = 0.5$ F_{max} = Undefined $F_{1993} = 0.4$

Surfclam



by J. Weinberg

Surfclams, *Spisula solidissima*, are distributed in western North Atlantic waters from the southern Gulf of St. Lawrence to Cape Hatteras. Commercial concentrations are found primarily off New Jersey and the Delmarva Peninsula, although some fishable quantities exist in Southern New England waters, on Georges Bank, and off the Virginia Capes. In the Mid-Atlantic region, surfclams are found from the beach zone to a depth of about 60 m; beyond 40 m, however, abundance is low. Growth rates are relatively rapid, with clams reaching harvestable size in about six to seven years. Maximum size is about 22.5 cm (8-7/8 in.), but clams larger than 20 cm (7-7/8 in.) are rare. Surfclams are capable of reproduction at the end of their first year of life, although most do not spawn until the end of their second year. Eggs and sperm are shed directly into the water column; recruitment to the bottom occurs after a planktonic larval period of about three weeks (at 22°C).

The principal fishing gear for surfclam is the hydraulic clam dredge. Recreational and foreign fishing are insignificant. The EEZ fishery is managed under the Surfclam-Ocean Quahog Fishery Management Plan (FMP) of the Mid-Atlantic Fishery Management Council, primarily by a total allowable catch (TAC) limit. From 1992 to 1993, landings from EEZ and state waters increased 3% (from 32,700 to 33,600 mt).

Total landings of surfclams averaged roughly 20,000 mt in the early 1960s, increased to over 46,000 mt by 1974, and then decreased by 1979 to well below the earlier average of 20,000 mt. Landings have subsequently increased under management restrictions, especially in EEZ waters.

The principal management objective for the fishery under Amendments 1 through 7 of the Surfclam-Ocean Quahog FMP was to rebuild depleted stocks. Under Amendment 8, an ITQ (individual transferable quota) system was established in 1990, whereby the annual landing quota was allocated disproportionately among participating vessels, based on performance history and vessel size. This system is intended to address economic inefficiencies that resulted from the intensive regulatory scheme used to promote rebuilding. With the adoption of the ITQs , restrictions on hours and days of the week fished and a moratorium on vessel construction were dropped. Instead, trading of vessel allocations is permitted, which is intended to reduce vessel overcapitalization and result in more efficient use of harvest sector capital. In 1990, 128 vessels participated in the Mid-Atlantic EEZ fishery. With the adoption of Amendment #8 to the FMP, the number of vessels in the fishery declined to 75 in 1991 (-41 percent), to 59 in 1992 (-21 percent)and to 53 in 1993 (-10 percent). Two management areas, New England and Mid-Atlantic, were formerly identified in the FMP, but were combined in Amendment #8 of the FMP. A single annual quota (22,000 mt of meats in 1993) applies to all management areas. Currently, the Georges Bank region is closed to the harvesting of surfclams, due to the presence of paralytic shellfish poisoning toxins.

Intensive fishing for surfclams was initiated during the post-World War II era in response to increasing demands and dwindling supplies of traditional clam species. Almost all of these early landings were derived off Long Island and northern New Jersey. Extensive offshore beds were discovered and developed off Pt. Pleasant, N.J. during the 1950s; combined with inshore beds near Cape May-Wildwood, the New Jersey resources supported the fishery until the early 1970s. Declining productivity off New Jersey prompted a shift of effort to the south during the early 1970s. New beds off southern Virginia and North Carolina contributed to a tremendous increase in total landings; the 1973-75 average of 40,100 mt (meats) was 50% greater than the 1965-1977 average (27,000 mt). The southern Virginia-North Carolina fishery collapsed during 1976, and most participating vessels returned to more northern ports. Total EEZ landings in 1993 were 22,000 mt, representing a 1% increase from the previous year's total of 21,700 mt.

Biomass indices from research vessel surveys generally parallel trends in landings. Stock biomass and landings of surfclams declined steadily off the northern New Jersey coast from the mid-1960s to 1977. A mass mortality of surfclams in the northern New Jersey area during the summer of 1976 reduced the abundance of commercial-sized clams to extremely low levels. Surveys from 1978 onward indicated a substantial 1976 year class in the area subjected to the clam kill. Growth of this year class resulted in an increasing proportion of total Mid-Atlantic landings from off northern New Jersey. Almost all of the 1976 year class is now larger than 12 cm. This was the minimum legal size until 1991. The limit was suspended for the 1991 fishing season due to relatively low abundance of prerecruit-sized clams and the likely incentive under Amendment 8 to target beds of larger surfclams.

Biomass off the Delmarva Peninsula remained at relatively high levels until the fleet returned from southern Virginia-North Carolina during 1976. Concentration of the offshore fishery in Delmarva waters between 1976 and 1980 resulted in a decline in harvestable biomass. Recent surveys indicate that the abundance of the 1977 year class has remained high but is declining. These clams have grown at substantially slower rates than the 1976 year class off New Jersey, perhaps in response to high density.

Research vessel survey data collected through 1992 indicate adequate surfclam resources to support the Middle Atlantic EEZ fishery at or near the current levels (18,000 to 23,000 mt of meats) for the next few years. Likewise, landings of 3,000 to 4,000 mt of meats can be sustained from New England waters (southern New England and Georges Bank) for the next decade. With the closure of the Georges Bank fishery, biomass will likely accumulate due to the low natural mortality rate of surfclams.

Landings from inshore (state) waters increased between 1987 and 1993, i.e., from 5,400 mt to 11,600 mt. This increase in nearshore landings is due primarily to greater landings from inshore New York waters, and to a lesser extent, from off New Jersey.

EEZ landings continue to be relatively stable due to the large standing stock relative to the annual quota. In the last several years, concentrated fishing off Atlantic City, New Jersey has reduced biomass in that area. Nevertheless, resources there, and especially off the Delmarva Peninsula, are sufficient to sustain the fishery during the next several years. Catch per unit effort (bushels per hour fished) has peaked for the Mid-Atlantic fishery and will continue to decline gradually given the absence of strong year classes since 1977.

For further information

Murawski, S.A., and J.S. Idoine. 1990. Yield sustainability under constant catch policy and stochastic recruitment. *Trans. Amer. Fish. Soc.* 118(4):349-367.

Northeast Fisheries Center. 1989. Report of 9th NEFC Stock Assessment Workshop (9th SAW). Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 89-08.

NEFSC [Northeast Fisheries Science Center]. 1993. Report of the 15th Northeast Regional Stock Assessment Workshop (15th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-06.

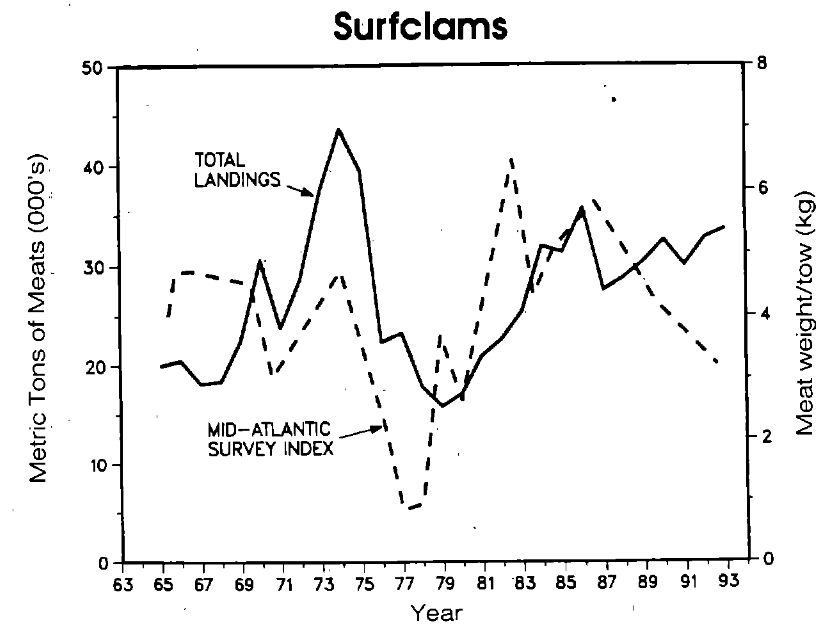


Table 31.1 Recreational catches and commercial landings (thousand metric tons, meats)

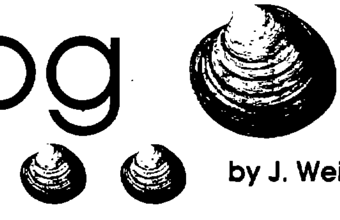
Category	Year 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States											
EEZ	19.0	24.8	23.7	24.9	22.1	23.9	22.3	24.0	20.6	21.7	22.0
State waters	5.8	7.2	9.2	10.8	5.4	4.9	8.1	8.5	9.4	11.0	11.6
Canada	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	24.7	32.0	32.9	35.7	27.5	28.8	30.4	32.5	30.0	32.7	33.6
Total allowable EEZ catch	-	24.3	24.3	24.3	24.3	24.3	25.2	24.3	22.0	22.0	22.0

New England-Middle Atlantic Surfclams

Long-term potential catch	=	22,000 mt
SSB for Long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Surfclam and Ocean Quahog FMP
Status of exploitation	=	Fully exploited in some areas
Age at 50% maturity	=	2 years
Size at 50% maturity	=	5 cm (2.0 in.) shell length
Assessment level	=	Size structured (DeLury)
Overfishing definition	=	Annual quota
Fishing mortality rate corresponding to overfishing definition	=	$F > F_{quota}$

$M = 0.02\text{-}0.08$ $F_{0.1} = 0.07$ $F_{max} = 0.21$ $F_{1993} = 0.2$

Ocean Quahog



by J. Weinberg

The ocean quahog, *Arctica islandica*, is a bivalve mollusk found in temperate and boreal waters on both sides of the North Atlantic. Distribution in the western Atlantic ranges from Newfoundland to Cape Hatteras in depths from 8 to 256 m. Quahogs are rarely found where bottom water temperatures exceed 16°C, and occur progressively further offshore between Cape Cod and Cape Hatteras. In the Gulf of Maine region, ocean quahogs are distributed in relatively nearshore waters, with fishable concentrations 3 to 7 mi from shore.

In the Middle Atlantic region, ocean quahog populations are composed primarily of relatively large (>70 mm shell length), old individuals, and there is little evidence of recent recruitment to these populations. In contrast, Gulf of Maine populations (primarily off eastern Maine) are composed of smaller (about 50 mm shell length) individuals, with more dynamic recruitment in recent years. Growth rates of ocean quahog are lower in the Gulf of Maine than in Middle Atlantic areas. Results of mark-recapture, shell banding, and length frequency studies indicate that the ocean quahog has a longevity of more than 100 years, and that after age 20 the growth rate is exceedingly slow. Spawning apparently occurs over a protracted interval from summer through autumn, free-floating larvae develop slowly (more than 90 days until setting), and thus may drift far from their parents.

The principal gear used is the hydraulic clam dredge, and most ocean quahogs are caught off southern New Jersey and the Delmarva peninsula. Recreational and foreign fishing in the EEZ are insignificant. The Mid-Atlantic EEZ fishery is managed under the Surf Clam-Ocean Quahog Fishery Management Plan (FMP) of the Mid-Atlantic Fishery Management Council. Provisions of Amendment 8 of the Surf Clam-Ocean Quahog FMP institute for the first time an individual transferable quota (ITQ) system for both surfclams and ocean quahogs, allocating percentages of the annual quota, based on vessel performance history and vessel size. For ocean quahog, management measures in effect include an annual quota (25,000 mt of shucked meats), vessel allocations, and reporting requirements for both processors and fishing vessels.

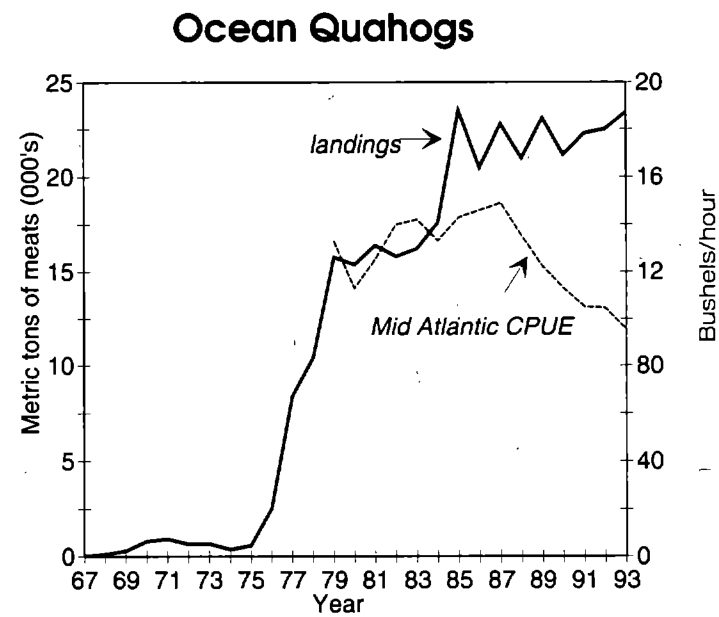
Ocean quahogs were first harvested commercially during World War II off Rhode Island. Total landings, however, never exceeded 2,000 mt of shucked meats until 1976 when offshore exploitation began off New Jersey and Maryland. Steady declines in offshore Mid-Atlantic surfclam stocks combined with the massive kill of surfclams off New Jersey in 1976 stimulated fishing for the deeper-dwelling ocean quahog. Total ocean quahog landings increased dramatically between 1976 and 1979, from 2,500 to 15,800 mt of meats per year. Landings in 1993 (23,400 mt) were near the record high level observed in 1985. Most of the landings are currently derived from EEZ waters off Long Island and northern New Jersey. Quahogs are also taken in the EEZ off Maine, and inshore (state waters) off Rhode Island. The Gulf of Maine fishery has been designated as an experimental one to provide information on abundance, distribution, and biological characteristics of the resource and is not subject to ITQ regulations. Landings from the Gulf of Maine fishery are primarily for small (about 50 mm shell length) quahogs, which are sold as a fresh, in-shell product. Landings of larger quahogs in Middle Atlantic waters are used in processed clam products (for example, chowders, minced clams, juices, *etc.*)

Resource surveys for ocean quahog in the Georges Bank-Cape Hatteras region have been conducted by the NEFSC since 1965. Biomass indices from swept-area calculations indicate a biomass (meat weight) of about 1.0 million mt. These calculations are considered a minimum estimate of standing stock to the extent that the survey dredge is not 100 percent efficient in catching animals encountered in the dredge path. Of this total biomass, 6 percent is found off Delmarva, 13 percent off New Jersey, 22 percent off Long Island, 31 percent off Southern New England, and 28 percent on Georges Bank.

Quahogs
NMFS/NEFSC photo by Brenda Figuerido

Trends in fishery performance from 1979 to 1993 have been documented using catch and effort data from mandatory logbook submissions. These data indicate a significant downward trend since 1987 (after an initial fishery development period). In the absence of new recruitment (as indicated from NEFSC surveys), catch per unit of effort (CPUE) in all Middle Atlantic assessment regions will continue to decline. The fishery has expanded spatially as catch rates have declined in heavily fished areas off Delmarva and southern New Jersey. Continued northward expansion of the Mid-Atlantic fishery is anticipated. In 1991 and 1992, the fishery expanded to the Long Island area, a region heretofore unexploited. Fishery-wide CPUE has continued to decline.

Although annual landings are less that 2 percent of the total estimated stock in the Middle Atlantic, and on Georges Bank, landings considerably greater than current levels are not warranted due to extremely slow growth rates and low annual recruitment. If current harvest rates and patterns are maintained, the ocean quahog fishery off New Jersey and Delmarva should continue to exhibit declining CPUE and a northward shift of the fishery. A large ocean quahog resource currently exists on Georges Bank, but it has been subject to fishery closure because of the presence of paralytic shellfish poisoning toxins.



For further information

Murawski, S.A., F.M. Serchuk, J.S. Idoine, and J.W. Ropes. 1990. Population and fishery dynamics of ocean quahog, *Arctica islandica*, in the Middle Atlantic Bight. *In* Report of the 10th NEFC Stock Assessment Workshop (SAW 10). Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 90-07, Working Paper #10.

Murawski, S.A., J.W. Ropes, and F.M. Serchuk. 1982. Growth of the ocean quahog, *Arctica islandica*, in the Middle Atlantic Bight. *Fish. Bull. [U.S.]* 80(1):21-34.

NEFSC [Northeast Fisheries Science Center]. 1990. Report of the Spring 1990 NEFC Stock Assessment Workshop (Tenth SAW). Woods Hole, MA: NOAA/NMFS/NEFC. *NEFSC Ref. Doc.* No 90-07.

NEFSC [Northeast Fisheries Science Center]. 1993. Report of the 15th Northeast Regional Stock Assessment Workshop (15th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-06.

Ropes, J.W., D.S. Jones, S.A. Murawski, F.M. Serchuk, and A. Jearld, Jr. 1984. Documentation of annual growth lines in ocean quahogs, *Arctica islandica* Linne. *Fish. Bull. [U.S.]* 82(1):1-19.

Table 32.1 Recreational catches and commercial landings (thousand metric tons, meats)

Category	Year: 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States											
EEZ	11.7	16.4	23.6	19.8	22.2	20.6	22.9	21.1	22.2	22.5	22.1
State	0.8	1.2	<0.1	0.8	0.6	0.4	0.2	0.1	0.1	<0.1	1.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	10.2	17.6	23.6	20.6	22.8	21.0	23.1	21.2	22.3	22.5	23.4
Total allowable FCZ	-	18.1	27.2	27.2	27.2	27.2	23.6	24.0	24.0	24.0	25.0

Note: 1976 was the beginning of the FCZ fishery

New England-Middle Atlantic Ocean Quahogs

Long-term potential catch	=	25,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Surf Clam and Ocean Quahog FMP
Status of exploitation	=	Fully exploited in some areas
Age at 50% Maturity	=	8 years, males 11 years, females
Size at 50% maturity	=	50 mm (2.0 in.) shell length
Assessment level	=	DeLury Depletion
Overfishing definition	=	Annual quota
Fishing mortality rate corresponding to overfishing definition	=	$F > F_{quota}$

M = 0.01-0.03 **$F_{0.1}$ = 0.03** **F_{max} = 0.065** **F_{1993} = <0.1**

Sea Scallop

by S. Murawski
S. Wigley

Sea scallops, *Placopecten magellanicus*, are found in western North Atlantic continental shelf waters from Newfoundland to North Carolina. North of Cape Cod, concentrations are generally scattered in shallow water less than 20 m (11 fathoms) deep. South of Cape Cod, sea scallops normally are found at depths between 40 and 200 m (22 to 110 fathoms). Commercial concentrations generally exist between 40 and 100 m (22 to 55 fathoms) in waters cooler than 20°C (68°F). Principal U.S. commercial fisheries are conducted in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic offshore region. Recreational fishing is insignificant, occurring primarily in Maine where shallow-water scallop beds most commonly occur.

Scallops grow rapidly during the first several years of life. Between ages 3 and 5, scallops commonly increase 50 to 80% in shell height and quadruple in meat weight. During this time span, the number of meats per pound is reduced from greater than 100 to about 23. Maximum size is about 23 cm (9.0 in.), but scallops larger than 17 cm (6.7 in.) are rare. Sexual maturity commences at age 2, but scallops younger than age 4 probably contribute little to total egg production. Spawning generally occurs in late summer and early autumn. In the Mid-Atlantic region, spring spawning may also occur. Eggs are buoyant, and larvae remain in the water column for four to six weeks before settling to the bottom.

The commercial fishery for scallops is conducted year round, with dredges and otter trawls as the primary gears. The U.S. fishery is managed under Amendment #4 of the New England Fishery Management Council's Fishery Management Plan for the Atlantic Sea Scallop Fishery. Total U.S. sea scallop landings in 1993 were 7,300 mt, a 48% decrease over 1992.

Scallop resource survey, circa 1940
O.E. Sette Collection, NMFS/NEFSC Photo Archive

Gulf of Maine

Nominal landings in 1993 from the Gulf of Maine were 800 mt, 10% higher than in 1991. More than 80% of the catch was from state territorial waters (less than 3 nmi from shore) indicating continued dependence of the fishery on inshore scallop beds.

Georges Bank

Total (United States and Canada) nominal landings from Georges Bank declined to 9,900 mt in 1993, 32% below the 1992 total of 14,600 mt. Of the 1993 total, U.S. landings accounted for 37% (3,700 mt) while Canadian landings accounted for 63% (6,200 mt). While U.S. landings on Georges Bank declined by 56% in 1993, Canadian landings increased by 2%.

The U.S. sea scallop research vessel survey indices (for the U.S. portion of Georges Bank) for 1993 and 1994 were the lowest observed since 1985. In the South Channel region of the Bank, all indices of abundance and biomass decreased sharply after 1992, and are one-tenth the maximum level observed in

1991. In the southeastern part, abundance of prerecruits (scallops smaller than 72 mm shell height) declined fivefold, while recruits declined by half. In 1994, the prerecruit survey index increased to levels last seen in 1991, whereas the recruit index was the second lowest observed in the 1975-1994 time series. Biomass indices for the U.S. northern edge and peak regions, are also the lowest levels observed, in this case from 1985-1994.

Low prerecruit abundance in most U.S. areas of the Bank in 1993 and 1994 indicate that landings will continue to decline in the near future. Declining recruitment has resulted in lower average meat counts per pound in U.S. research vessel surveys. In 1993 and 1994 surveys average meat counts were 47.7 and 50.6, respectively, whereas the 1990-1992 average was 90.4.

For the entire bank, fishing mortality is much higher than F_{max} (F=0.23), and about double the overfishing level as provisionally defined by the New England Fishery Management Council. At this high fishing mortality rate, the fishery is quite dependent on incoming recruitment, and the scallop resource composed of only a few age groups. As such, any increases in stock abundance due to good recruitment will be short-lived, and annual yield will fluctuate widely. If the fishery continues to focus heavily on incoming recruitment, as it has in the past, resource conditions are expected to deteriorate further.

Middle Atlantic

Total nominal catch in 1993 was 2,800 mt, 60% below the 1991 total of 7,000 mt. Landings in 1992 totaled 5,000 mt. U.S. survey index values declined dramatically in 1991 and 1992 but have since recovered somewhat.

Low abundance of scallops on Georges Bank, and improving conditions in the Mid-Atlantic, resulted in a shift in effort from Georges Bank to the Middle-Atlantic in 1994. Fishing mortality in this region appears to have increased.

Amendment #4 to the Sea Scallop FMP specifies reductions in days at sea to reduce overall harvest rates and dependence on new recruits. In recent years, landings have fluctuated greatly both annually and spatially, with virtually all small scallops harvested once available to the gear. The removal of maximum meat count regulations has resulted in even more effort on scallops on the 50-70 count range. Eventually, it is hoped that reduced effort will result in lower average meat counts, more stable landings patterns, and increased economic returns, since larger scallop meats command much higher prices than do smaller meats. The Canadian experience with ITQ (indi-

Table 33.1 Recreational and commercial landings (thousand metric tons, meat weight)

Category	Year 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U. S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
Gulf of Maine											
United States	0.7	0.7	0.4	0.3	0.4	0.5	0.6	0.6	0.6	0.7	0.8
Canada	<0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	0.0	<0.1	<0.1	<0.1
Total	0.7	0.8	0.5	0.3	0.4	0.5	0.7	0.6	0.6	0.7	0.8
Georges Bank											
United States[1]	4.6	3.2	3.0	4.6	4.9	6.1	5.8	10.1	9.4	8.5	3.7
Canada	7.3	2.0	3.8	4.7	6.8	4.4	4.7	5.2	5.8	6.1	6.2
Total	11.9	5.2	6.8	9.3	11.7	10.5	10.5	15.3	15.2	14.6	9.9
Mid-Atlantic	4.3	3.8	3.3	3.8	7.9	6.5	8.3	6.6	7.0	5.0	2.8
Total nominal catch	16.9	9.8	10.6	13.4	20.0	17.5	19.5	22.5	22.8	20.3	13.5

[1]For United States, Georges Bank landings include Southern New England

Gulf of Maine, Georges Bank, and Middle Atlantic Scallops

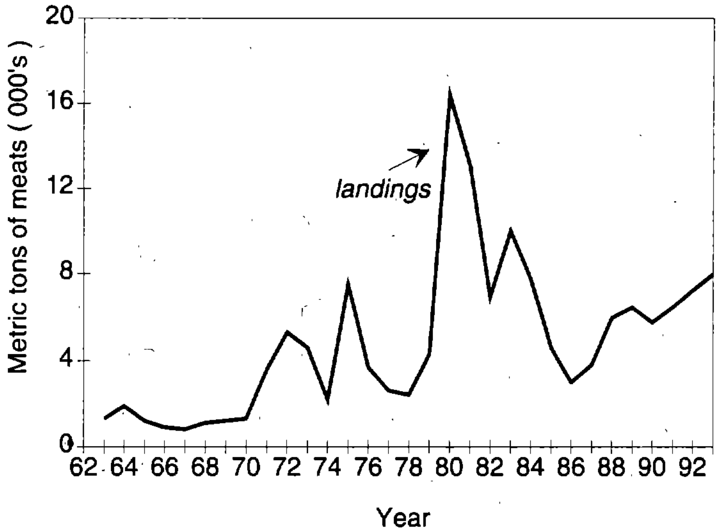
Long-term potential catch		
Gulf of Maine	=	300 mt (territorial waters)
Georges Bank	=	10,000 mt
Mid-Atlantic	=	3,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	NEFMC Sea Scallop FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 to 4 yrs (GB and MA)
Size at 50% maturity	=	60 mm (2.4 in.) to 90 mm (3.5 in.) shell height (GB and MA)
Assessment level	=	Age Structured (DeLury)
Overfishing definition	=	5% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.71

M = 0.10 **$F_{0.1}$ = 0.12** **F_{max} = 0.23** **F_{1993} = 1.1 to 1.3**

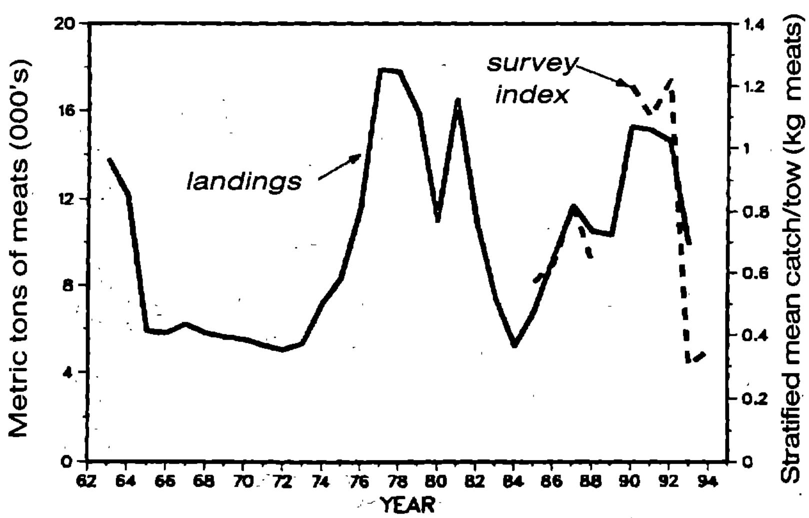
$F_{5\%}$ = 0.71

Sea Scallops

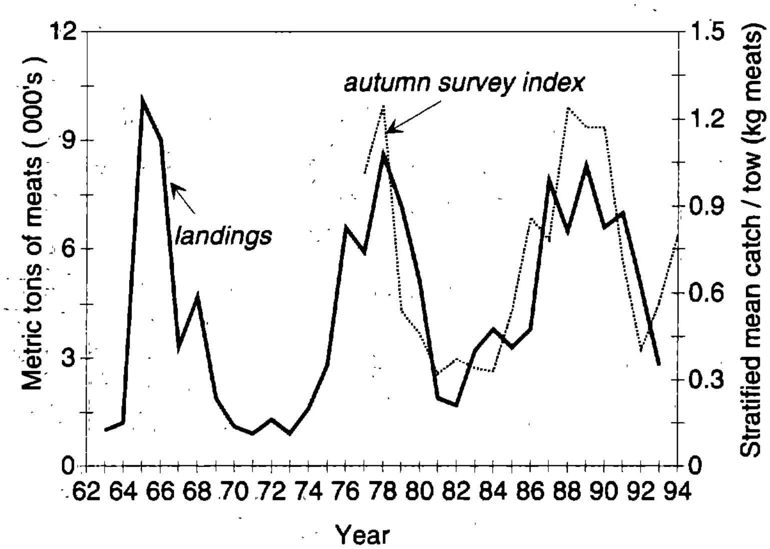
Gulf of Maine



Georges Bank



Middle Atlantic



"In recent years, landings have fluctuated greatly, both annually and spatially, with virtually all small scallops harvested once available to the gear."

vidual transferable quota) management in the post-Hague Line era on Georges Bank is noteworthy. Canadian landings of scallops have increased steadily, and now exceed those of the U.S. The large scallops landed by the Canadian fleet are generally exported to the United States, where they face little market competition. The fleet size was reduced significantly after the ITQ plan was initiated, resulting in high exvessel revenues and profits. Fishing mortality rates of scallops on the Canadian side of Georges Bank are substantially lower than in the U.S. sector.

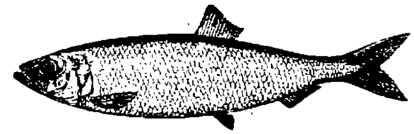
For further information

NEFSC [Northeast Fisheries Science Center]. 1995, in press. Report of the 20th Northeast Regional Stock Assessment Workshop (20th SAW). Woods Hole, MA: NOAA/NMFS/NEFSC.

Serchuk, F.M. and S.E. Wigley. 1992. Status of the sea scallop fisheries off the Northeastern United States, 1991.

NEFSC [Northeast Fisheries Science Center]. 1992. Report of the Thirteenth Regional Stock Assessment Workshop (13th SAW), Fall 1992. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 92-02.

River Herring



by G. Shepherd

River herring is a term applied collectively to alewife, *Alosa pseudoharengus*, and blueback herring, *Alosa aestivalis*. The coastal range of the blueback herring is from Nova Scotia to Florida; the coastal range of the alewife extends from Labrador to South Carolina. In coastal rivers where ranges overlap, fisheries for these species are mixed. Both species are anadromous and undertake upriver spawning migrations during spring. Alewives may live as long as 10 years and reach a length of 36 cm (14 in.). Blueback herring live for about 7 or 8 years and reach a maximum length of about 32 cm (13 in.).

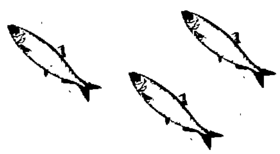
Alewives spawn in the spring when water temperatures are between 16°C and 19°C; blueback herring spawn later in the spring, when water temperatures are about 5°C warmer. Fecundity and age at maturity for both species are similar. Between 60,000 and 300,000 eggs are produced per female; and maturity is reached at ages 3 to 5, primarily at age 4.

The river herring fishery is one of the oldest in North America and was exclusively a U.S. inshore fishery until the late 1960s, when distant-water fleets began fishing for river herring off the Mid-Atlantic coast. The principal fishing gears used to catch river herring are fish weirs, pound nets, and gill nets. Recreational fishing does not contribute significantly to total landings. The U.S. nominal catch averaged 24,800 mt annually between 1963 and 1969. Landings subsequently declined to an averaged of 4,000 to 5,000 mt until the late 1980s, and have since declined further to a record low of 347 mt in 1993. North Carolina, Virginia, and Maine have accounted for approximately 90 percent of total landings.

In response to the observed decline in nominal catch and the apparent lack of a coastwide increase in stock biomass, the Atlantic States Marine Fisheries Commission prepared a comprehensive coastwide

Alewife
NMFS/NEFSC photo by Brenda Figuerido

"Although fishing pressure on the resource has eased considerably in recent years and the condition of spawning habitats has improved, recovery of the biomass has not been consistent."



management plan for shad and river herring with the participation of all coastal states between Maine and Florida. Although fishing pressure on the resource has eased considerably in recent years and the condition of spawning habitats has improved, recovery of the biomass has not been consistent. Several river herring populations along the East Coast are still being exploited at more than optimal levels and some potential spawning habitats remain unavailable. The dramatic decline in landings since the mid-1960s reflects substantial declines in resource abundance since that time.

For further information

Crecco, V.A. and M. Gibson. 1990. Stock assessment of river herring from selected Atlantic coast rivers. *ASMFC* [Atlantic States Marine Fisheries Commission] *Special Report* #19. Washington, D.C.: ASMFC.

Harris, P.J. and R.A. Rulifson. 1989. Investigations of ocean landings for American shad and river herring from United States East Coast waters. *ASMFC* [Atlantic States Marine Fisheries Commission] *Special Report* #18. Washington, D.C.: ASMFC.

Richkus, W. A. and G. DiNardo. 1984. Current status and biological characteristics of the anadromous alosid stocks of eastern United States: American shad, hickory shad, alewife, and blueback herring. Columbia, MD: Martin Marietta Environmental Center.

River Herring
Gulf of Maine-Middle Atlantic

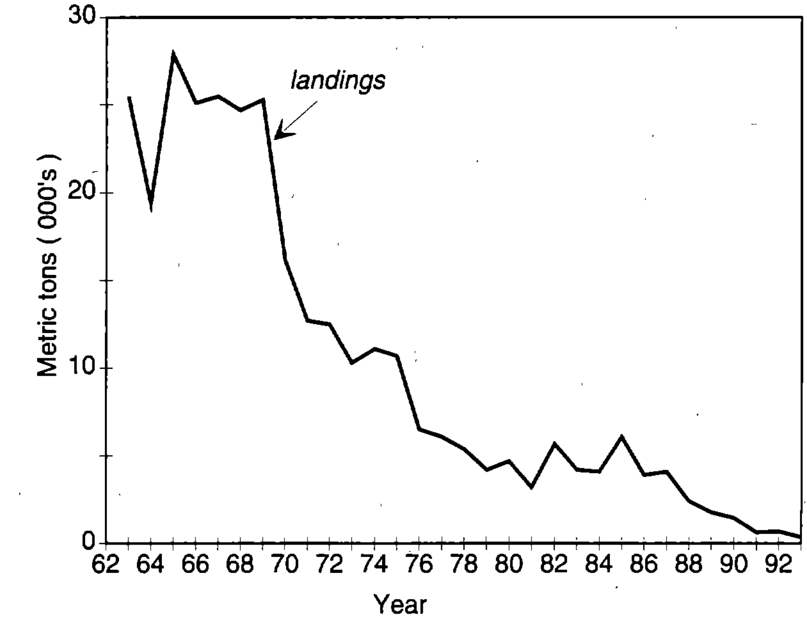


Table 34.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	6.2	4.1	6.1	3.9	4.1	2.4	1.8	1.4	0.6	0.7	0.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	1.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total nominal catch	7.3	4.1	6.1	3.9	4.1	2.4	1.8	1.4	0.6	0.7	0.3

Maine - Middle Atlantic
River Herring

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Minor
Management	=	Shad and River Herring Interstate Plan; Mackerel, Squid, and Butterfish FMP
Status of exploitation	=	Varies by river
Age at 50% maturity	=	2 to 4 years (varies by latitude)
Size at 50% maturity	=	28 cm (11.0 in.)
Assessment level	=	Index
Overfishing definition	=	Unknown
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = Variable **$F_{0.1}$ = Variable** **F_{max} = Variable** **F_{1993} = Variable**

American Shad

by G. Shepherd

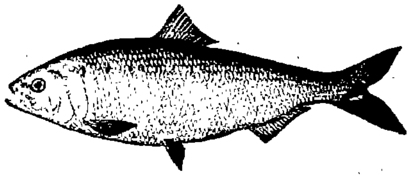
The American shad, *Alosa sapidissima*, is an anadromous member of the family Clupeidae (herrings). Along the Atlantic coast, its range extends from southern Labrador to northern Florida. American shad undergo extensive seasonal migrations along the Atlantic coast. Shad migrate into rivers for spawning beginning in April in southern rivers, and continuing until July in the northernmost portion of their range. After spawning, shad migrate north along the coast to Canada where they feed during the summer. A southward migration occurs later along the continental shelf where the fish winter prior to spring spawning migrations to their natal rivers.

American shad have a range of life history patterns depending on their river of origin. In southern rivers, shad return to spawn by age 4, and spawn 300,000 to 400,000 eggs; they usually spawn only once, however. With increasing latitude, the mean age at first spawning increases to 5, and the number of eggs per spawning decreases to 125,000 to 250,000 eggs; the number of spawnings per life time, however, increases.

Virtually every major coastal river along the Atlantic seaboard has, at one time, supported a distinct spawning population. American shad have historically been intensively exploited for their flesh and roe; Atlantic coast landings exceeded 22,000 mt in 1896. In contrast, commercial landings north of Cape Hatteras, N.C. during the 1980s averaged only 1,000 mt annually. Landings have since declined further, to only 700 mt in 1992 and 1993. The principal gear used is the gillnet. Recreational catches may be significant, but no estimates are available.

Excessive fishing has been blamed for declines in abundance in the Hudson and Connecticut Rivers, as well as in rivers in Maryland, North Carolina, and Florida. Dams along the Susquehanna

American shad, NMFS/NEFSC Resource Survey, circa 1962 (top, *Brigham Collection, NEFSC Photo Archive*), and 1992 (bottom, *NMFS/NEFSC phoo by Brenda Figuerido*)



River led to an almost complete disappearance of what was once a major fishery. Pollution in the lower Delaware has been cited as the primary cause for the decline in the fishery in that system. The Atlantic States Marine Fisheries Commission has implemented a coastwide management plan for American shad and river herring to facilitate cooperative management and restoration plans between states. Restoration efforts have involved habitat improvement, fish passageways, and stocking programs. Despite a brief period of improved returns to some major river systems such as the Susquehanna, Delaware and Connecticut Rivers, the number of American shad continues to decline.

An assessment of shad from 12 rivers along the Atlantic coast with established populations indicates that maximum sustainable yield ranges from 6 to 1,236 mt, depending on the drainage area of the river. Present catch levels are generally far below these levels, although recent increases in ocean intercept fisheries for American shad contribute an unknown degree of exploitation to certain river systems. Information is insufficient to confidently determine the status of individual populations.

For further information

Gibson, M.R., V.A. Crecco, and D.L. Stang. 1988. Stock assessment of American shad from selected Atlantic coast rivers. *ASMFC* [Atlantic States Marine Fisheries Commission] *Spec. Rpt. No.* 15. Washington, DC: ASMFC.

Richkus, W. A., and G. DiNardo. 1984. Current status and biological characteristics of the anadromous alosid stocks of eastern United States: American shad, hickory shad, alewife, and blueback herring. Columbia, MD: Martin Marietta Environmental Center.

American Shad
Gulf of Maine-Middle Atlantic

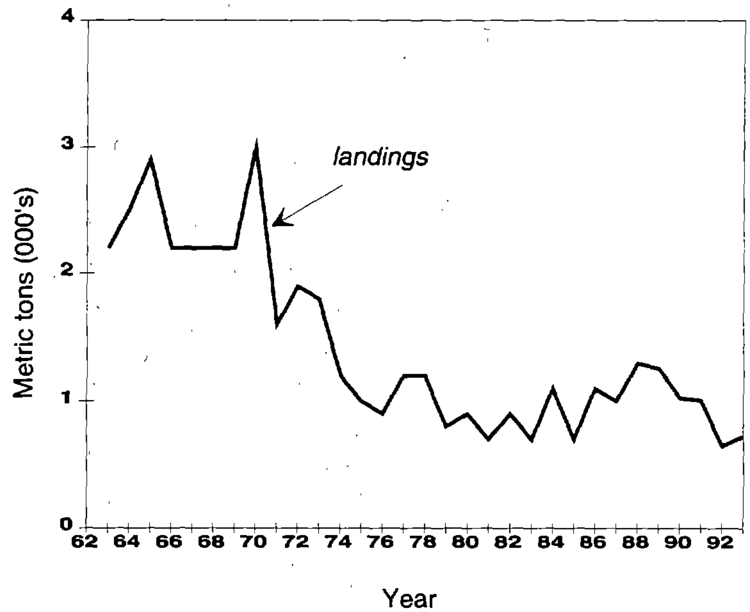


Table 35.1 Recreational catches and commercial landings (thousand metric tons)

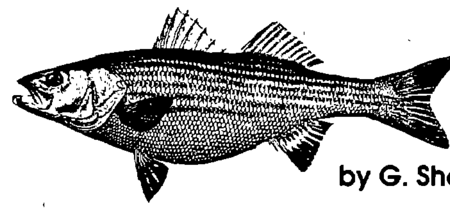
Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	0.9	1.1	0.7	1.1	0.9	1.3	1.3	1.0	1.0	0.7	0.7
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.9	1.1	0.7	1.1	0.9	1.3	1.3	1.0	1.0	0.7	0.7

Gulf of Maine-Middle Atlantic
American Shad

Long-term potential catch	=	6 to 1,236 mt, varying among river systems
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Shad and River Herring Interstate Plan
Status of exploitation	=	Varies
Age at 50% maturity	=	2 to 4 years (varies by latitude)
Size at 50% maturity	=	40 cm (15.8 in.)
Assessment level	=	Index
Overfishing definition	=	Unknown
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = varies by latitude **$F_{0.1}$ = Unknown** **F_{msy} = 0.35-1.25**
F_{1993} = Variable

Striped Bass

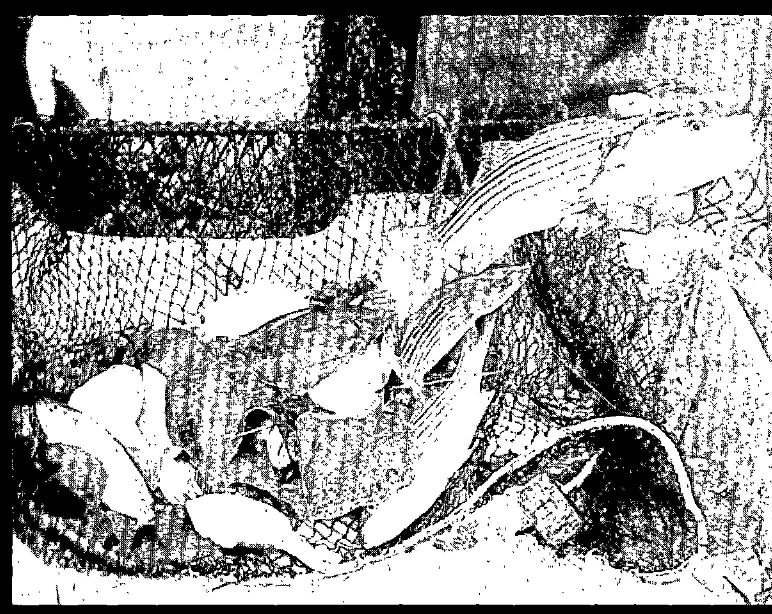


by G. Shepherd

The striped bass, *Morone saxatilis*, is an anadromous species distributed along the Atlantic coast from northern Florida to the St. Lawrence estuary, along the Pacific coast from Ensenada, Mexico to British Columbia, and in numerous inland lakes and reservoirs. Striped bass spawn from mid-February in Florida to late June or July in Canada, and from mid-March to late July in California. Spawning occurs at or near the surface in fresh or slightly brackish waters at temperatures ranging from 10° to 23°C; peak spawning activity is observed between 15° and 20°C. Larvae range from 2.0 to 3.7 mm in total length at hatching and initiate feeding after 4 to 10 days. At about 13 mm in length, larval striped bass form small schools and move inshore; juvenile striped bass move downriver into higher salinity waters during their first summer or autumn.

Most striped bass along the Atlantic coast are involved in two types of migrations: an upriver spawning migration from late winter to early spring, and coastal migrations that are apparently not associated with spawning activity. Coastal migrations may be quite extensive; striped bass tagged in Chesapeake Bay have been recaptured in the Bay of Fundy. Coastal migratory behavior appears to be limited to stocks north of Cape Hatteras and is related to sex and age.

Atlantic coastal fisheries for striped bass rely primarily on production from populations spawning in the Hudson River and in tributaries of Chesapeake Bay. Chesapeake Bay has historically produced most of the striped bass found along the coast. However, during most of the 1970s and 1980s, juvenile production in the Chesapeake Bay was extremely poor, causing a severe decline in commercial landings during the mid-1970s. Poor recruitment for Chesapeake Bay was probably due primarily to overfishing, however, poor water quality in spawning and nursery habitats likely also contributed.



Striped bass with silversides, NEFSC Resource Survey cruise, 1992 (top, *NMFS/NEFSC photo by Brenda Figuerido*), and mixed catch of young stripers and flounders from a Cape Cod fish weir, 1961 (bottom, *Brigham Collection, NEFSC Photo Archive*)

"...measures, aimed at protecting 1982 and subsequent year classes until females could spawn at least once, have been effective in increasing spawning stock abundance."

During the mid-1980s, stringent management measures were adopted by states from Virginia to Maine to attempt to rebuild the Chesapeake stocks. These measures, aimed at protecting 1982 and subsequent year classes until females could spawn at least once, have been effective in increasing spawning stock abundance. Signs of improved recruitment in Chesapeake Bay have appeared as well, although not in all areas and years. Since 1987, indices of juvenile production in Virginia's Chesapeake Bay tributaries have been at high levels in all but one year. In contrast, Maryland's index of juvenile abundance has remained very low except in two recent years. Maryland's 1989 index was the third highest on record, and exceeded management criteria for relaxing fishery regulations in 1990. The 1993 index was the highest on record with good production throughout the Chesapeake Bay estuary.

Recreational landings of striped bass often equal or exceed commercial landings. In 1993, the estimated recreational harvest (2,700 mt) was more than three times the commercial landings level, 767 mt. During 1993, an estimated 5.6 million striped bass were caught by recreational anglers; 90% of these were released alive.

For further information

Richards, R.A. and D.G. Deuel. 1987. Atlantic striped bass: Stock status and the recreational fishery. *Mar. Fish. Rev.* 49(2):58-66.

USDOI and USDOC. 1994. Striped bass research study. Report for 1992. Washington, DC: U.S. Department of the Interior, U.S. Department of Commerce.

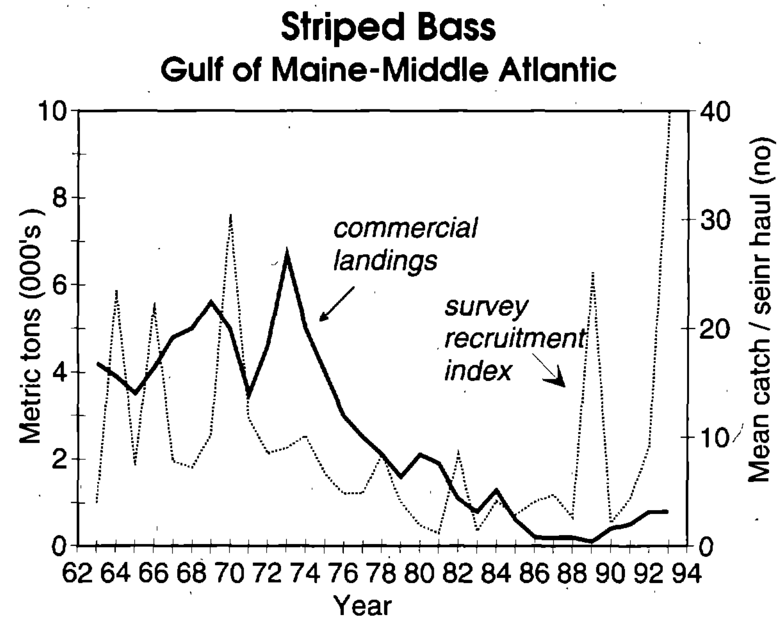


Table 36.1 Recreational harvest and commercial landings (thousand metric tons)

Category	Year: 1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	1.4[1]	0.5	0.8	0.4	0.4	0.6	0.3	1.2	1.6	2.2	2.7
Commercial											
United States	2.4	1.3	0.6	0.2	0.2	0.2	0.1	0.4	0.5	0.8	0.8
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.8	1.8	1.4	0.6	0.6	0.8	0.4	1.6	2.1	3.0	3.5

[1]1979-1983 (survey not conducted prior to 1979)

Gulf of Maine - Middle Atlantic
Striped Bass

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Striped Bass ISFMP
Status of exploitation	=	Under protection[1]
Age at 50% maturity	=	2 years, males 6 years, females
Size at 50% maturity	=	29.7 cm (11.7 in.) males 71.1 cm (28.0 in.) females
Assessment level	=	Population projection
Overfishing definition	=	Fishing mortality in excess of target rates
Fishing mortality rate corresponding to overfishing definition	=	0.25(during recovery phase) 0.5 (when stocks are fully recovered)

M = 0.15 **$F_{0.1}$ = not calculated** **F_{max} = 0.5** **F_{1993} = 0.25**

[1]Exploitation began in 1990

Atlantic Salmon

by K. Friedland

The Atlantic salmon, *Salmo salar*, is a highly desirable food fish and prized sport catch native to New England rivers. The historic North American range of Atlantic salmon extended from the rivers of Ungava Bay, Canada, to Long Island Sound. As a consequence of industrial and agricultural development, most of the runs native to New England have been extirpated. Self-supporting runs of Atlantic salmon in the United States can only be found in Maine. Restoration efforts, in the form of stocking and fish passage construction, are underway in the Connecticut, Pawcatuck, Merrimack and Penobscot rivers of New England.

Atlantic salmon life history is extremely complex owing to its use of both freshwater and marine habitats and long ocean migrations. Atlantic salmon spawn in fresh water during fall. Eggs remain in gravel substrates over winter until they hatch and emerge as fry during spring. Juvenile salmon, commonly called parr, remain in freshwater two to three years in New England Rivers depending on growth. When parr grow to sufficient size (>16 cm or 6.4 in.) they develop into smolts and migrate to the sea. As evidenced from tagging data for New England stocks, young salmon migrate as far north as the Labrador Sea during their first summer in the ocean.

Maine fisherman with Atlantic salmon, circa 1940
O.E. Sette Collection, NMFS/NEFSC photo archive

After their first winter at sea (the fish are now referred to as 1 sea-winter salmon) a small portion of the cohort becomes sexually mature and returns to their natal rivers. Those remaining at sea feed in the coastal waters of Canada and Greenland. Historically, it has been in these foraging areas, off Nova Scotia, Newfoundland, Labrador, and West Greenland, that commercial gillnet fisheries for salmon took place. After their second winter at sea, most U.S. salmon return home to spawn. Three sea-winter and repeat-spawning salmon life history patterns do occur in New England populations.

Home-water fisheries are limited to an angling fishery in Maine on sea-run fish and a fishery on surplus broodstock in the upper Merrimack River. Angler landings in Maine have averaged approximately 350 salmon in recent years, which resulted in an exploitation rate of approximately 10 percent of the run to Maine Rivers. In 1993, the first year the Merrimack River broodstock fishery was operated, a total catch of 994 was achieved on a release of 1500 fish. The fishery was very popular and was repeated in 1994. Management authority for Atlantic salmon in U.S. waters resides with the states and the New England Fishery Management Council.

The last two decades mark a period of decline in stock status for all salmon populations of the North Atlantic. As evidenced by both indices and complete measures of population abundance, marine natural survival appears to have plummeted as much as fivefold for some stocks. This has intensified concern over the additive effects of overfishing in both home-water and mixed stock fisheries.

Distant-water fisheries (the commercial gillnet fisheries in Canada and Greenland) have been evaluated by extensive tagging experiments with U.S. stocks. Harvest estimates based on Carlin tag returns put exploitation of the U.S. 1 sea-winter stock component at approximately 60% in recent years and at approximately 80% for the 2 sea-winter component. These results indicated that the stocks were overexploited. The commercial fisheries in Canada and Greenland are managed under the auspices of North Atlantic Salmon Conservation Organization (NASCO), of which the United

"As evidenced by both indices and complete measures of population abundance, marine natural survival appears to have plummeted as much as fivefold for some stocks. "

States is a member. The Greenland fishery is managed with a quota system that has been in place since 1976. In 1993, with concerns over stock status in mind, a multi-year quota agreement was obtained, which provides a framework for quota setting based on a forecast model of salmon abundance. The 1994 quota has been set at 159 mt and was designed to achieve 95% of the target spawning escapement to North America rivers. Subsequent to the governmental negotiated quota agreement, a private initiative was successful in purchasing the 1994 quota with the exception of a small fishery for local use.

The Canadian fishery has been managed by time-area closures and quotas. However, beginning in 1992 the largest component of the fishery, the fishery around the Island of Newfoundland, was closed for a moratorium period of five years and a fishing license buy-back program was initiated by the Canadian government. The remaining commercial fishery in Labrador was reduced in 1994 by an amount consistent with the reduction in licensed effort in that part of the Province.

For further information

Mills, D. 1989. Ecology and Management of Atlantic Salmon. New York: Chapman and Hall.

ICES NASWG. 1993. Report of the ICES North Atlantic Salmon Working Group. *ICES* [International Council for Exploration of the Sea] *C.M.* 1993/Assess:10.

Atlantic Salmon

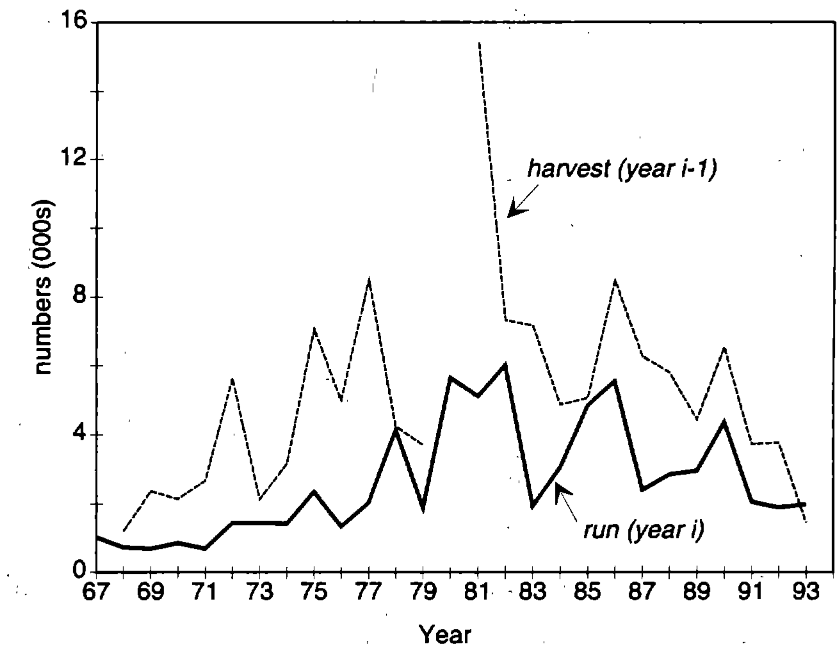


Table 37.1 Recreational catches and commercial landings (numbers)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	655	639	958	1091	424	400	1007	1414	477	600	659
Commercial[1]											
United States	-	-	-	-	-	-	-	-	-	-	-
Canada	3052	2657	4575	1104	1161	590	1722	780	1425	275	-
Greenland	2662	1697	2939	4070	4175	3463	3797	1525	1777	991	-
Total nominal catch	6369	4993	8472	6265	5760	4453	6526	3719	3679	1866	659

[1]Carlin tag harvest estimates

Atlantic Salmon

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	State regulation, FMP, NASCO Treaty
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	2 sea years
Size at 50% maturity	=	71.0 cm (28.0 in.)
Assessment level	=	Modified VPA
Overfishing definition	=	None defined, optimum yield is set at zero under FMP
Fishing mortality rate corresponding to overfishing definition	=	Not defined

$M = 0.12$ $F_{0.1}$ = Unknown F_{max} = Unknown $F_{1993} = 0.5$

Atlantic and Shortnose Sturgeon

by K. Friedland

The Atlantic, *Acipenser oxyrhynchus*, and shortnose, *Acipenser brevirostrum*, sturgeons have been utilized as high-quality food fish and as a source of caviar since colonial days. Both species are distributed as far south as Florida, but the Atlantic sturgeon is found as far north as Labrador, whereas the shortnose sturgeon ranges only to New Brunswick.

Sturgeon once supported a substantial commercial fishery, however, like other anadromous species, their populations were adversely affected by the industrial use of rivers beginning in the 1800s and by overfishing. Their decline has left only remanent populations of both species and has resulted in the enactment of state management measures to protect the Atlantic sturgeon and an endangered species listing of the shortnose sturgeon under the federal Endangered Species Act (ESA). Today, the lack of fish passage facilities at dams and poor habitat conditions continue to stand as impediments to the re-establishment of many sturgeon populations.

Sturgeon hauled aboard, circa 1935
O.E. Sette Collection, NMFS/NEFSC Photo Archive

The basic life history patterns for the two species are very similar, but there are important differences in the range and the timing of their migrations that serve to minimize habitat overlap. Sturgeons are relatively slow growing and mature late in life, making them vulnerable to overexploitation. Juveniles and adults are benthic (or bottom) feeders, consuming a variety of crustaceans, bivalves, and worms. As adults, shortnose sturgeon reach body lengths of approximately 100 cm (40 in.) whereas Atlantic sturgeon can attain more than twice that length. Both species begin spawning migrations to freshwater during late winter to early summer. The migrations occur later in the year at higher latitudes, and where

"The ASMFC plan seeks to restore the commercial fishery to levels of 10 percent of 1890 landings (7 million lb), while at the same time protecting stressed populations of Atlantic sturgeon."

the species co-occur, the shortnose sturgeon tends to begin its spawning migrations earlier than the Atlantic sturgeon. Though they mature late in life, both species are highly fecund, with total egg production proportional to their body size. Juvenile sturgeon will remain in freshwater for their first summer of life and then migrate to deeper more brackish water in winter. The juveniles will migrate to and from freshwater for a number of years before joining the adult migration pattern. Migrations out of freshwater are well known for the Atlantic sturgeon, but have only been recently documented for the rarer shortnose sturgeon. Tagging studies have demonstrated that Atlantic sturgeon can migrate extensively both north and south of their natal river systems.

A large commercial fishery for sturgeon once existed, but today only a limited directed fishery still occurs and a large proportion of the landings are bycatch. Around the turn of the century landings of sturgeon, believed to be a mix of the two species, were in excess of 3,000 mt (7 millon lb) a year. As these populations were overexploited, catches declined dramatically to only incidental landings during the period 1900 to 1950. Some fishing activity in the Carolinas began during the 1960s, which sustained landings of 100 tons through the 1980s. Most of these fisheries are now closed in compliance with the fishery management plan for Atlantic sturgeon. Recent increases in landings are due to increased catches in developing ocean fisheries in New York and New Jersey. There is no significant sport fishery for sturgeon.

Shortnose Sturgeon

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	ESA Recovery Plan
Status of exploitation	=	Protected
Age at 50% maturity	=	10 years
Size at 50% maturity	=	60.0 cm (24.0 in.)
Assessment level	=	Index
Overfishing definition	=	Not defined, fishing prohibited under the ESA
Fishing mortality rate corresponding to overfishing definition	=	None defined

M = 0.12 $F_{0.1}$ = Unknown F_{max} = Unknown F_{1993} = Unknown

Atlantic Sturgeon

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	ASMFC Plan
Status of exploitation	=	Overexploited
Age at 50% maturity	=	20 to 25 years
Size at 50% maturity	=	200.0 cm (79.0 in.)
Assessment level	=	Index
Overfishing definition	=	None defined
Fishing mortality rate corresponding to overfishing definition	=	None defined

M = 0.12 $F_{0.1}$ = Unknown F_{max} = Unknown F_{1993} = Unknown

"Shortnose sturgeon populations in some rivers, for example the Kennebec and Hudson, may be large enough to allow reclassification of their endangered status."

Sturgeon
East Coast

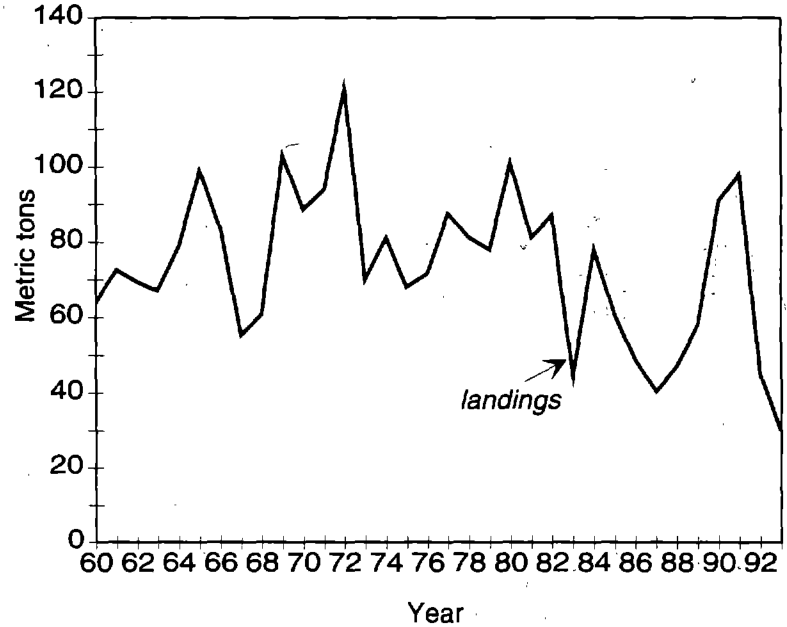
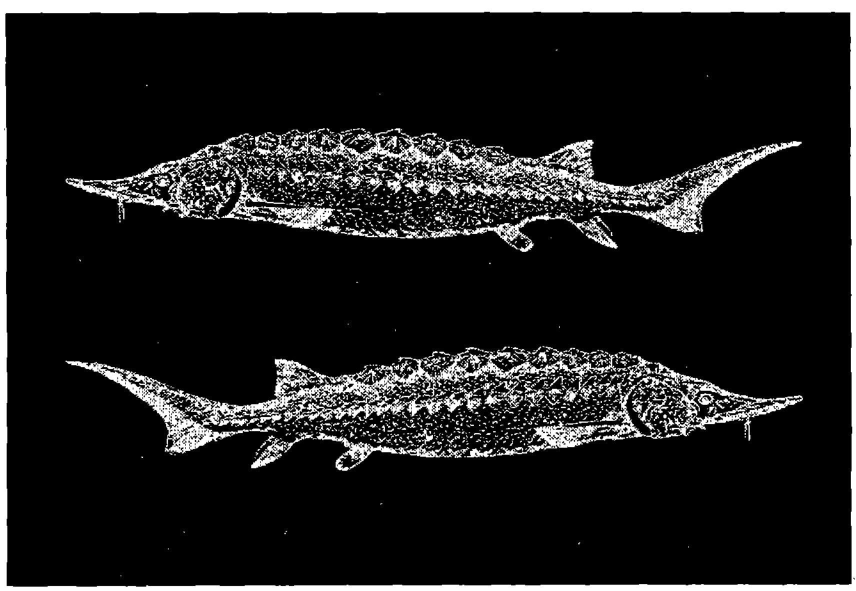


Table 38.1 Recreational catches and commercial landings (metric tons)

Category	1974-83 Average	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	78	78	61	49	41	47	58	91	97	58	30
Canada	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	78	78	61	49	41	47	58	91	97	58	30

The Atlantic sturgeon is managed under an Atlantic States Marine Fisheries Commission (ASMFC) plan; and a recovery plan is in effect under the Endangered Species Act for the shortnose sturgeon. The ASMFC plan seeks to restore the commercial fishery to levels of 10 percent of 1890 landings (700 thousand lb), while at the same time protecting stressed populations of Atlantic sturgeon. There are minimum size limits (7 ft), harvest restrictions, and closed seasons in some states. In some areas, state regulations followed by management measures consistent with the ASMFC plan resulted in decreased landings. The plan also provides for a research program to evaluate stock status of Atlantic sturgeon. The shortnose sturgeon ESA Recovery Plan is being revised. Shortnose sturgeon populations in some rivers, for example the Kennebec and Hudson, may be large enough to allow reclassification of their endangered status.



For further information

Dadswell, M.J., B.D. Taubert, T.S. Squires. D. Marchette, J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* LeSueur 1818. *NOAA/NMFS Tech. Rep.* 14.

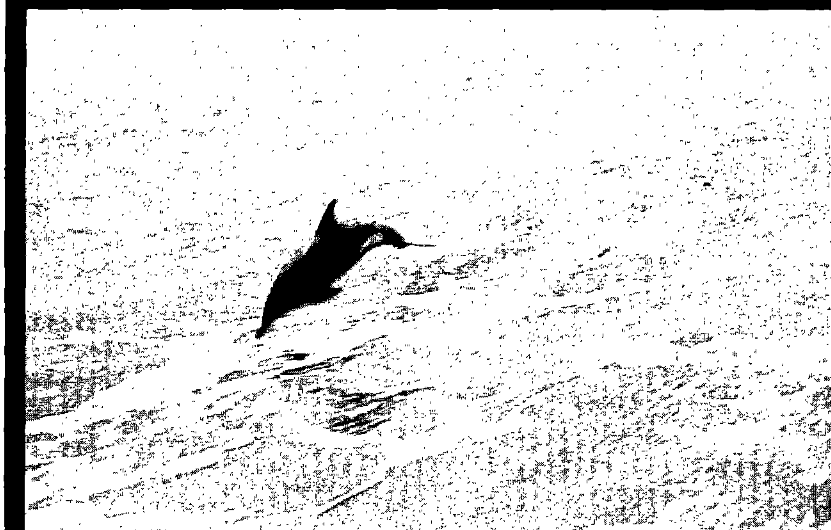
Gilbert, C.R. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Mid-Atlantic Bight)--Atlantic and shortnose sturgeons. *U.S. Fish and Wildlife Service Biological Report 82*(11.122) *U.S. Army Corps of Engineers TR EL*-82-4.

Harbor Porpoise

by J. Quintal

The harbor porpoise (*Phocoena phocoena)* is one of the smallest cetaceans, reaching lengths of about 150 cm (5 ft) and weights of about 64 kg (140 lb). Sexual maturity is reached at ages 4 to 6, and females most often bear a calf each year. Harbor porpoise births generally occur in May after 11 months of pregnancy, while ovulation and conception follow in late June and early July. This is one of the shortest-lived of all cetaceans, with a maximum longevity of 12-15 years.

Harbor porpoises are found in the northwestern Atlantic from North Carolina to Labrador. The geographical distribution and simultaneous timing of reproduction in widely separated geographical areas have suggested that there are four populations in the western North Atlantic Ocean; these being the western Greenland, Newfoundland-Labrador, Gulf of St. Lawrence, and Gulf of Maine populations. Research to date has not separated these putative populations.



Leaping harbor porpoise, Gulf of Maine survey cruise, circa 1935
O.E. Sette Collection, NMFS/NEFSC Photo Archive

Seasonal movements and the degree of mixing between putative populations is largely unknown. To determine abundance and seasonal distribution of harbor porpoise, the Marine Mammals Investigation of the NEFSC has conducted a series of aerial surveys in autumn, winter, and spring; and in summertime, shipboard line transect surveys. Large numbers of harbor porpoises are found in the Gulf of Maine - lower Bay of Fundy region in the summer months and nearly none in the same region in the winter. The winter distribution is largely unknown, although some harbor porpoises have been found stranded on beaches from New York to North Carolina in the winter and spring. There is little information concerning the distribution of harbor porpoises in non-summer months in Canadian waters.

Estimates of harbor porpoise abundance are available for the summer population in the Gulf of Maine and Bay of Fundy region. These are based on comprehensive shipboard line transect surveys conducted by NEFSC in the Gulf of Maine during the months of July and August in 1991, 1992, and 1993. These surveys have provided the best available estimates of population size: 37,500 (95% CI 26,700 to 86,400) animals for 1991 and 67,500 (95% CI 32,900 to 104,600) animals for 1992. Since these values are not significantly different, data have been combined to provide a pooled estimate of 47,200 (95% CI 39,500 to 70,600) animals.

Bycatch

Estimation of total mortality caused by commercial fisheries on the Gulf of Maine harbor porpoise population has been a difficult task. The largest measured incidental catches have been taken by the groundfish sink gill-net fisheries where harbor porpoises become entangled, presumably as they forage near the net. The NEFSC Sea Sampling Program has collected data on fishing activity and marine mammal interactions since June 1989 using trained observers aboard selected fishing vessels. The current level of observer coverage is approximately 8 to 10% of the total estimated U.S. fishing effort. Observed incidental catch rate data collected during this program have been combined with a measure of total fishing effort to estimate total incidental mortality. Estimation has been complicated by a number of factors, including the seasonal migration of harbor porpoises and seasonal changes in patterns of fishing effort. The NEFSC had prepared estimates of bycatch for harbor porpoises in the U.S. sink gill-net fishery in 1990 to 1992. During an international workshop held in Woods Hole in February 1994, these estimates were found to be biased downward in some cases due to underreporting. A new method of estimating bycatch was subsequently developed by the Marine Mammals Investigation and accepted by peer review. Current estimates of bycatch for 1990 to 1993 for the U.S. Gulf of Maine sink gillnet fishery based on application of the method are shown in Table 39.1.

Canadian biologists conducted a separate pilot study in the lower Bay of Fundy during the 1993 fishing season. The preliminary estimated bycatch was 200 to 400 animals. A more comprehensive study in 1994 estimated the 1994 bycatch to be between 80 and 120 animals.

Table 39.1. Revised U.S. harbor porpoise bycatch estimates, with measures of uncertainty. Numbers have been rounded to the nearest hundred.

Year	Estimate	95% Confidence Interval Bounds		CV
		Lower	Upper	
1990	2900	1500	5500	32
1991	2000	1000	3800	35
1992	1200	800	1700	21
1993	1400	1000	2000	18

Table 39.2. Estimated bycatch and ratio of bycatch to pooled weighted abundance with standard errors

Year	By-catch	SE	Ration (%)	SE
1990	2900	930	6.1	2.3
1991	2000	700	4.2	1.7
1992	1200	250	2.5	0.72
1993	1400	250	3.0	0.78

Biological Significance of the Bycatch

The ratio of estimates of bycatch from U.S. waters to estimates of abundance for the entire region has been used to estimate the biological significance of the bycatch. Using the four U.S. annual estimates of bycatch (Table 39.1) and the pooled estimate of abundance (47,200), these ratios appear to have declined from 1990 to 1992 before increasing slightly in 1993 (Table 39.2).

A complete understanding of the biological significance of the bycatch of this species in eastern North America will require additional information on (1) population structure and movements throughout the Northwest Atlantic (2) bycatch and abundance in other regions of the U.S and Canadian waters, (3) improved fishery sampling in the Gulf of Maine fishery, and (4) estimates of net productivity rates. Repetition of the abundance survey in the Gulf of Maine - Bay of Fundy in 1992 served to confirm the general results, and provided a relatively precise estimate of average summer abundance in the study area. However, lack of understanding of population structure and movements make it difficult to fully interpret the difference between the results of the two surveys. The resolution of such uncertainties is of high priority.

For further information

NEFSC [Northeast Fisheries Science Center]. 1992. Harbor porpoise in eastern North America: status and research needs. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 92-06

Bisack, K. 1993. Estimates of total bycatch in the Gulf of Maine sink gillnet fishery. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-11.

Bravington, M.V. and K.D. Bisack. *In review.* Estimates of harbor porpoise bycatch in the Gulf of Maine sink gillnet fishery, 1990-1993.

DFO [Department of Fisheries and Oceans-Canada]. 1995. Harbour porpoise bycatch in the Bay of Fundy gillnet fishery. *Project summary: Industry and Native Fisheries* No. 48.

Gaskin, D.E. 1984. The harbor porpoise *Phocoena phocoena* (L.): regional populations, status, and information on direct and indirect catches. *Rep. Int. Whal. Commn.* 34:569-586.

Haley, N.J. and A.J. Read. 1993. Summary of the workshop on harbor porpoise mortalities and human interaction. *NOAA Tech. Memo. NMFS-F/NER-5.*

NEFSC [Northeast Fisheries Science Center]. 1994. Estimating harbor porpoise bycatch in the Gulf of Maine sink gillnet fishery. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-24.

Palka, D.L. 1994. Abundance estimate of Gulf of Maine harbor porpoise. *Rep. int. Whal. Commn. Spec. Issue.*

Palka, D. (Ed.). 1994. Results of a scientific workshop to evaluate the status of harbor porpoises (*Phocoena phocoena*) in the western North Atlantic. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-09.

Polacheck, T., F.W. Wenzel, and G. Early. 1992. What do stranding data say about harbor porpoise (*Phocoena phocoena*)? *Rep. Int. Whal. Commn. Special Issue.*

Read, A.J. 1990. Reproductive seasonality in harbor porpoises,

Phocoena phocoena, from the Bay of Fundy. *Can. J. Zool.* 68:284-288.

Read, A.J., S.D. Kraus, K.D. Bisack, and D. Palka. 1993. Harbor porpoises and gill nets in the Gulf of Maine. *Cons. Biol.* 7:1:189-193.

Read, A.J. and D.E. Gaskin. 1988. Incidental catch of harborporpoises by gill nets. *Journal of Wildlife Management* 52:517-523.

Smith, T.D., D. Palka, and K. Bisack. 1993. Biological significance of bycatch of harbor porpoise in the Gulf of Maine demersal gillnet fishery. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-23.

Common Name Index

A

Alewife ... 126
American lobster ... 114
American plaice ... 71
American shad ... 128
Atlantic cod ... 44
Atlantic herring ... 98
Atlantic mackerel ... 100
Atlantic sturgeon ... 134
Atlantic wolffish ... 19
Angler ... 82

B

Bass
- Black sea ... 86
- Striped ... 130

Black sea bass ... 86
Blackback ... 74
Blueback herring ... 126
Bluefish ... 104
Butterfish ... 102

C

Catfish ... 94
Clam
- Surfclam ... 119
- Ocean quahog ... 121

Cod Atlantic ... 44
Cusk ... 92

D

Dab ... 71
Dogfish, spiny ... 106

F

Flounder
- Sand ... 79
- Summer ... 69
- Windowpane ... 79
- Winter ... 74
- Witch ... 73
- Yellowtail ... 64

Fluke ... 69

G

Goosefish ... 82
Gray sole ... 73

H

Haddock ... 48
Hake
- Red ... 58
- Silver ... 54
- White ... 90

Harbor porpoise ... 137
Herring ...
- Atlantic ... 98
- River ... 126
- Blueback ... 126

L

Lemon sole ... 74
Lobster ... 114
Long-finned squid ... 112

M

Mackerel ... 100
Monkfish ... 82

N

Northern lobster ... 114
Northern shrimp ... 117

O

Ocean perch ... 52
Ocean pout ... 88
Ocean quahog ... 121

P

Perch, ocean ... 52
Plaice, American ... 71
Pout, ocean ... 88
Pollock ... 61
Porgy ... 84
Porpoise, harbor ... 137

Q

Quahog, ocean ... 121

R

Red hake ... 58
Redfish ... 52
River herring ... 126

S

Salmon, Atlantic ... 132
Scallop, sea ... 123
Scup ... 84
Sea scallop ... 123
Shad, American ... 128
Short-finned squid ... 110
Shortnose sturgeon ... 134
Silver hake ... 54
Skates ... 108
Sole
- Gray ... 73
- Lemon ... 74

Spiny dogfish ... 106
Squid
- Long-finned ... 112
- Short-finned ... 110

Striped bass ... 130
Sturgeon
- Atlantic ... 134
- Shortnose ... 134

Summer flounder ... 69
Surfclam ... 119

T

Tilefish ... 96

W

White hake ... 90
Whiting ... 54
Winter flounder ... 74
Witch flounder ... 73

Y

Yellowtail flounder ... 64

Scientific Name Index

A

Acipenser brevirostrum 134
Acipenser oxyrhynchus 134
Alosa aestivalis 126
Alosa sapidissima 128
Alosa pseudoharengus 126
Anarchichas lupus 94
Arctica islandica 121

B

Brosme brosme 92

C

Centropristis striata 86
Clupea harengus 98

G

Gadus morhua 44
Glyptocephalus cynoglossus 73

H

Hippoglossoides platessoides 71
Homarus americanus 114

I

Illex illecebrosus 110

L

Loligo pealeii 112
Lophius americanus 82
Lopholatilus chamaeleonticeps 96

M

Macrozoarces americanus 88
Melanogrammus aeglefinus 48
Merluccius bilinearis 54
Morone saxatilis 130

P

Pandalus borealis 117
Paralichthys dentatus 69
Peprilus triacanthus 102
Phocoena phocoena 137
Placopecten magellanicus 123
Pleuronectes ferrugineus 64
Pleuronectes americanus 74
Pollachius virens 61
Pomatomus saltatrix 104

R

Raja eglanteria 108
Raja erinacea 108
Raja garmani 108
Raja laevis 108
Raja ocellata 108
Raja radiata 108
Raja senta 108

S

Salmo salar 132
Scomber scombrus 100
Scophthalmus aquosus 79
Sebastes fasciatus 52
Spisula solidissima 119
Squalus acanthias 106
Stenotomus chrysops 84

U

Urophycis chuss 58
Urophycis tenuis 90