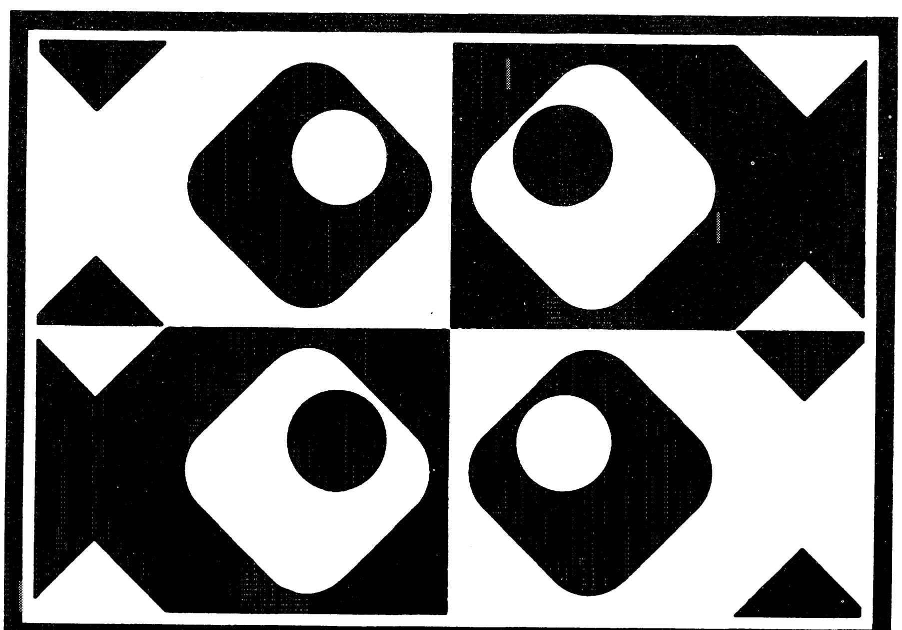
NOAA Technical Memorandum NMFS-F/NEC-101

Status of Fishery Resources off the Northeastern United States for 1993



October 1993

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Status of Fishery Resources off the Northeastern United States for 1993

Conservation and Utilization Division
Northeast Fisheries Science Center

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Computer plotting of the figures was by Frank Almeida and Katherine Sosebee. Lianne Armstrong drafted the figures for the ecosystems section. Steven Murawski and Elizabeth Holmes completed technical editing. Information Services staff provided copy editing, design, layout, photo management, printing, and distribution.

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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 1993.

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 ecosystem health and how it influences production of fishery resources. 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 harbor porpoise. There are several other species of commercial and recreational 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

NMFS scientist Roger Clifford displays haddock (left) and cod (right) captured during the annual NEFSC bottom trawl survey. Cod, haddock, and yellowtail flounder are the "traditional" groundfish species caught commercially off New England. While landings over all species in the region remained about the same as in 1991, landings of traditional groundfish were down 31 percent.

NMFS photo by Brenda Figuerido

(FCZ), while others are fisheries that have not been routinely assessed by the Northeast Fisheries Science Center.

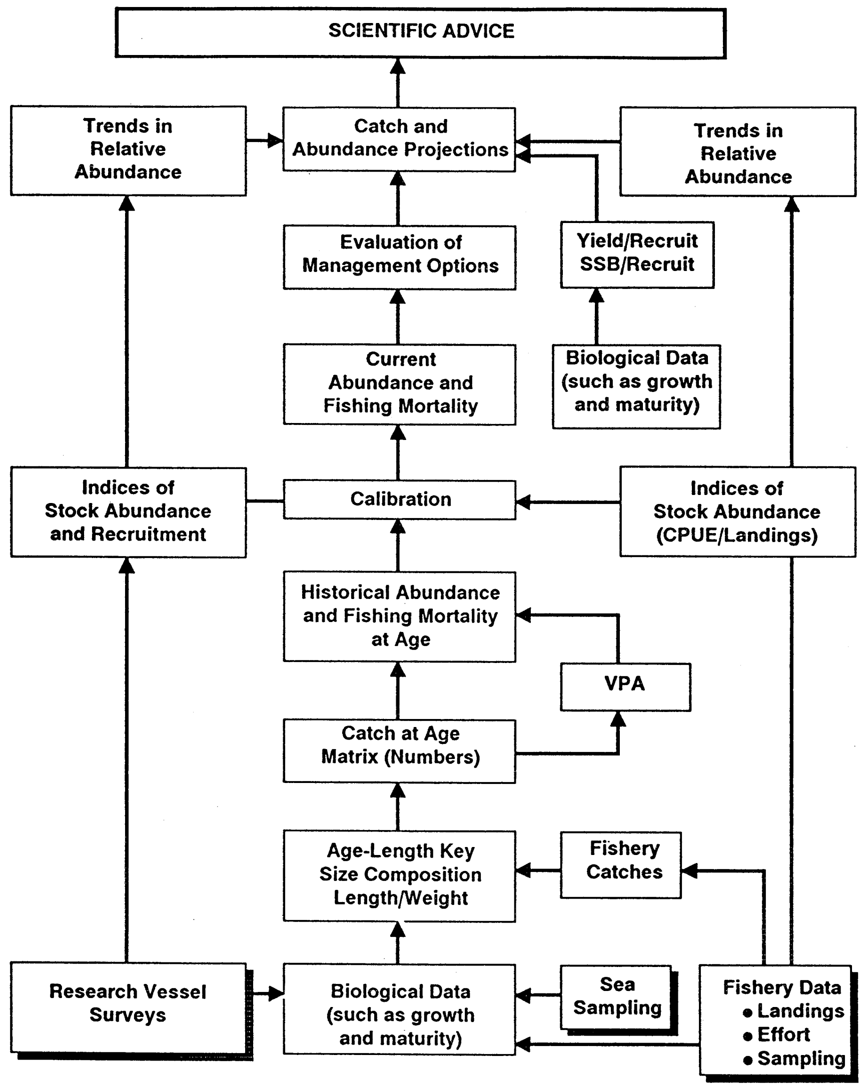


Figure 1. Diagram of alternative ways in which fishery-generated data and research vessel data (lower right and left boxes, respectively) are combined to provide scientific advice on the status of the stocks.

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 left and right 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 left side of Figure 1.

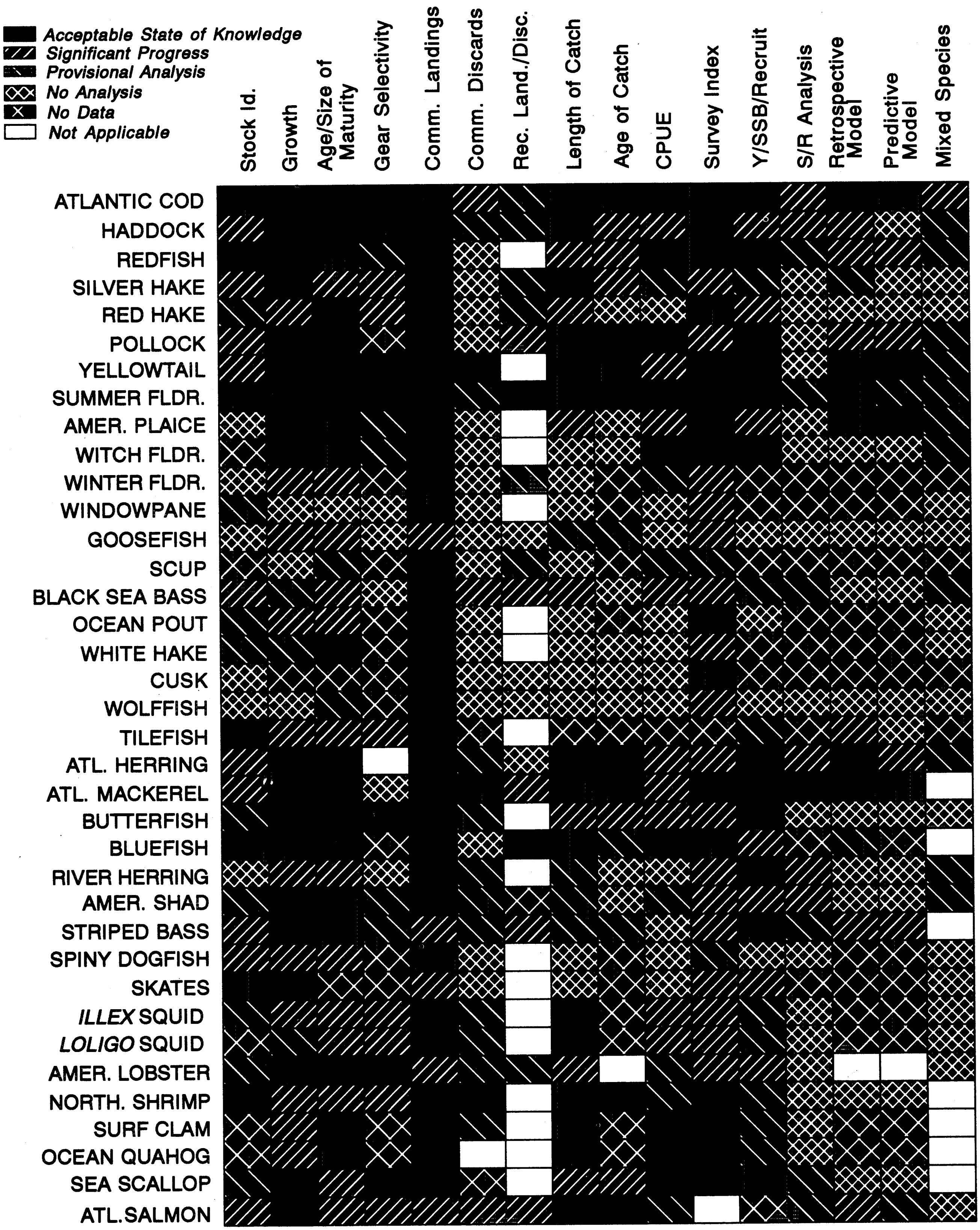
These approaches are frequently supplemented with knowledge of the animal's life history generated using biological data from sampling the commercial and survey catches. A third approach is to utilize the information about total stock size and population productivity generated under the first two approaches 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 that use 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 several 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 of the items are still not known. As fisheries become more intense, more of the categories will need to be filled to evaluate the effects of fishing on the resource. Much of the biological information (*e.g.*, growth and maturity rate) must be continually updated since these parameters are apt to change significantly with the level of exploitation and due to environmental variation.

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 2. Status of biological knowledge required for fishery management.

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



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 the 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 AGE AND GROWTH. 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.

Increasing the level of complexity of an assessment requires substantial 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 new 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 they had no interactions with each 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 has been dedicated to collecting information for 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 (Page 12). There, aggregate research trawl survey and commercial trawl data are presented illustrating major trends in abundance and catches. The information presented there, however, is rather simple, and does not address many of the complexities of these multispecies fisheries. Additional studies of the dynamics of the mixed-species trawl fishery, and of the mixed species complex that it catches, are needed to adequately address pressing management needs.

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, the Mid-Atlantic Fishery Management Council, and, in a few instances, under Preliminary Fishery Management Plans (PMPs) developed by the National Marine Fisheries Service. 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 currently in place is 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 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 section titled Overview of Assessment Approaches.

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 mi-

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	1991	4[1]
2.	Atlantic Sea Scallop	FMP	NEFMC	1982	1989	4[1]
3.	American Lobster	FMP	NEFMC	1983	1989	3[1]
4.	Surf Clam-Ocean Quahog	FMP	MAFMC	1977	1990	8[1]
5.	Squid-Mackerel-Butterfish	FMP	MAFMC	1978	1990	
6.	Summer Flounder	Cooperative	MAFMC/ASMFC	1988	1993	4[1]
7.	Bluefish	Cooperative	MAFMC/AFMFC	1989	-	-
8.	Atlantic Herring	Cooperative	NEFMC/ASMFC		Under development	
9.	Northern Shrimp	Interstate	ASMFC	1974	1986	-
10.	Striped Bass	Interstate	ASMFC	1981	1989	4
11.	Swordfish	FMP	NMFS		Under development	
12.	Pelagic Sharks	FMP	NMFS		Under development	
13.	Atlantic Billfish	FMP	NMFS		Under development	
14.	Tilefish	FMP	MAFMC		Under development	
15.	Atlantic Salmon	FMP	NEFMC	1987	-	-
16.	Winter Flounder	Interstate	ASMFC	1992	-	-

[1] Amendment revision in process

gration 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 $F_{0.1}$ 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 the 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 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. As young fish, death can occur from several causes: starvation, predation, or disease. As fish pass 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, the young life stages 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 the landings and spawning stock sizes, and, more importantly, the changes in populations that may be caused by regulations that those impose specific 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 fast 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 $1,000 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	1,000.00	50.00	1,050.00
2	1,050.00	52.50	1,102.50
3	1,102.50	55.13	1,157.63
4	1,157.63	57.88	1,215.51
5	1,215.51	60.78	1,276.29
6	1,276.29	63.81	1,340.10
7	1,340.10	67.01	1,407.11
8	1,407.11	70.36	1,477.47
9	1,477.47	73.87	1,551.34
10	1,551.34	77.57	1,628.91

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 your balance at the end of 10 years, you must make nine prior calculations to trace the interest and balance each year. Although this is a straightforward approach to a simple example, 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 that occur when rounding the account balances to whole cents, these add up over a large number of accounts, and (3) most importantly, the method is unrealistic since you cannot apply the annual rate directly to monthly or daily balances. In the real world, savings accounts constantly have 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 the three problems noted earlier. Computing the account balance at any point in time involves two formulas, and the use of logarithms:

r = ln (1+i) **(1)**

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 0.488. From this calculation, the bank can apply the following formula to compute account balances:

Balance = **(2)**

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;

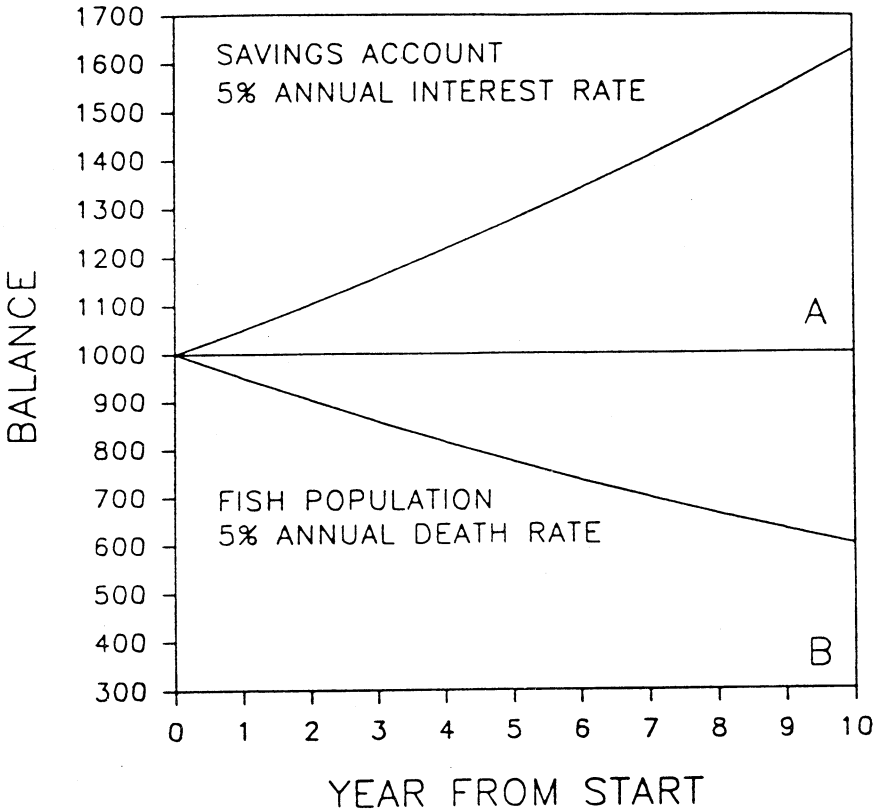
exp = the base of the natural logarithm system (= 2.71828);

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 are rounded to whole cents at each step in the calculation in the table. 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 fish mortality rates? The formulas used to illustrate bank interest rates

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 percent per year with annual compounding and no withdrawals. Panel B gives the expected population size over 10 years with an initial population size of 1,000 fish and an annual mortality rate of 5 percent.



are directly comparable to formulas used by fishery scientists to track the decline of stock. The one big difference is, of course, that the 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 various age groups 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 1,000 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:

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

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):

$$\text{Population Numbers} = \text{IPN X exp}(-zt) \qquad (4)$$

where,

Population Numbers= the population remaining at time, t;

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

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 exploited 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. If, at the beginning of the year there are 1,000 fish, the average population size during the year is calculated as: (1,000 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 the 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 a combination of direct and indirect control measures determines the overall fishing mortality rate, and ultimately the balance between births and deaths, resulting in an increasing, decreasing, or stable stock.

Nominal catch: The sum of catches that have been reported as live weight or equivalent of the landings. Nominal catches do not include unreported discards or unidentified young fish put into fish meal. Remember these are not catches but landings.

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

Recruitment: The amount of fish added to the fishery 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, both 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), such as the spawning stock biomass divided by the number of fish recruited to age 2. For a given exploitation pattern, rate of growth, and natural mortality, an equilibrium value of SSB/R is calculated for each level of F. This means that under constant conditions of growth, natural mortality, and exploitation patterns over the life span of the species, an expected average SSB/R would result from each constant rate of fishing. A useful reference point is the level of SSB/R that would be obtained if there were no fishing. This is a maximum value for SSB/R, and levels of SSB/R under different rates of fishing can be compared to it. For example, the maximum SSB/R for Georges Bank haddock is approximately 9 kg for a recruit at age.

Status of exploitation: An appraisal of exploitation is given for each stock of the species discussed in Species Synopsis section using the terms unknown, protected, not exploited, underexploited, moderately exploited, fully exploited, and overexploited. These terms describe the effect of current fishing effort on each stock, and represent the assessment scientists' educated opinion 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 stocks 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

Research survey crew sorting samples in a snowstorm at sea

NMFS photo by Brenda Figuerido

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 the instantaneous natural mortality rate was known in addition to the 10 fish caught per year in the fishery, then a virtual population analysis calculates the number that must have been alive each year to produce a catch of 10 fish each year in addition to 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 so that the population declines rapidly over time, then an approximate fishing mortality rate can be used in the last year (1979), and by calculating backward year by year for the year class, a precise estimate of the abundance can be determined for the previous three or four years (1976 or 1975). 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 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 and this group of fish is followed closely by assessment scientists since it can be pivotal in determining the stock abundance in later years.

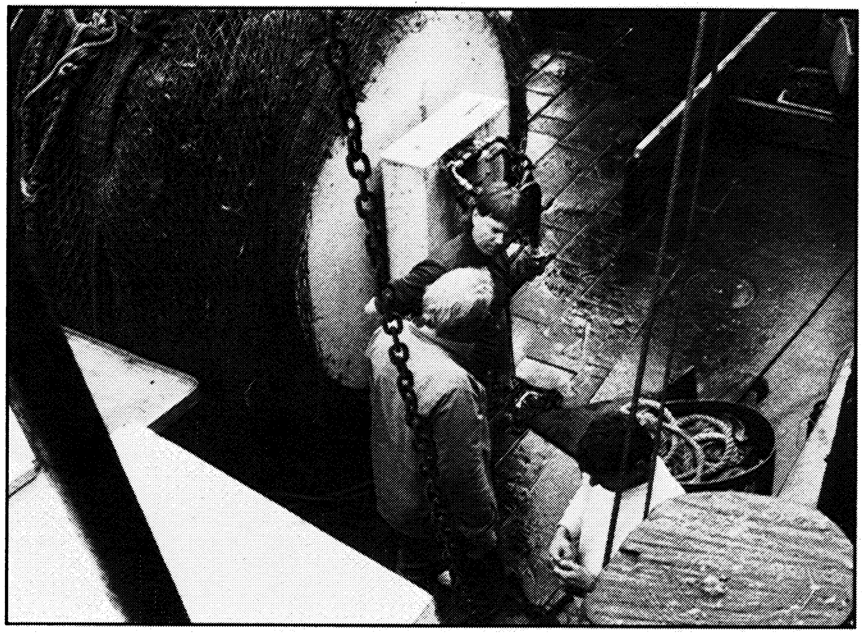
Yield-per-recruit: The expected lifetime yield-per-fish of a specific age (*e.g.*, per age 2 individual). For a given exploitation pattern, rate of growth, and natural mortality, and equilibrium value of Y/R is calculated for each level of F. This means that under constant conditions of growth, and natural mortality, an expected average Y/R would result from each constant rate of fishing.

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 1992 are estimated to be more than 4.3 million mt, of which approximately 18 percent were from the Northeast region. United States recreational landings are estimated to exceed 106,000 mt (excluding Alaska, Hawaii, and Pacific Coast salmon). Aggregate statistics for U.S. fisheries are detailed in *Fisheries of the United States, 1992*.

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 National Marine Fisheries Service. 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 the 38 species described in this document totaled 506,000 mt in 1992, a decrease of 6 percent from 1991 (Table 2). Of these landings, 23 percent were from foreign, 71 percent from domestic commercial, and 6 percent from domestic recreational fishing. Foreign commercial landings decreased 3 percent, while domestic commercial



NMFS port agents are assigned to major fishing communities in New England. Scott McNamara is assigned to Portland, Maine. Like other port agents, he collects landings figures, interviews skippers about their trips (top, Scott facing camera), and collects scientific samples from the catch (bottom, left) to help scientists and managers understand how, where, and what fish are caught by commercial and recreational fishermen.

NMFS photo by Bob Morrill

and recreational landings decreased 5 percent and 28 percent.

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

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 25 and 19 percent of the landings in 1991 and 1992. The invertebrates (short- and long-finned squid, American lobster, Northern shrimp, surfclams, ocean quahogs, sea scallops) accounted for 28 percent of the landings in 1992, up from 26 percent in 1991. Principal pelagic species (Atlantic herring, Atlantic mackerel) increased in percentage from 25 to 26 between 1991 and 1992.

The fourth highest landings were from the other groundfish (goosefish, scup, black sea bass, ocean pout, white hake, cusk, Atlantic wolffish, tilefish, spiny dogfish, skates), which accounted for 11 percent of the landings in 1991 and 13 percent in 1992.

Next in importance by weight are flounders, accounting for 7 percent of the total in 1992, and other pelagics, accounting for 6 percent.

Total 1992 foreign vessel landings of species and stocks occurring in U.S. waters was 117,000 mt, down 3 percent from 1991. 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 Georges Bank stocks, which occur on the Canadian portion of that fishing ground.

Table 2. Total landings of selected species and species groups off the northeastern United States by domestic and foreign commercial fisheries, and by recreational fisheries, 1991 and 1992 (1,000 mt)

Species	Commercial				Recreational		Total	
	Foreign		USA					
	1991	1992	1991	1992	1991	1992	1991	1992
Principal Groundfish								
Atlantic cod	13.4	11.7	42.0	27.7	3.8	1.3	59.2	40.7
Haddock	5.5	4.1	1.8	2.3	<0.1	<0.1	7.3	6.4
Redfish	<0.1	<0.1	0.5	0.8	0.0	0.0	0.5	0.8
Silver hake	0.0	0.0	16.6	15.6	<0.1	<0.1	16.6	15.6
Red hake	0.0	0.0	1.6	2.0	0.2	0.2	1.8	2.2
Pollock	41.2	35.2	7.9	7.2	0.1	<0.1	49.2	42.4
Subtotal	60.1	51.0	70.4	55.6	4.1	1.5	134.6	108.1
Flounders								
Yellowtail flounder	0.0	<0.1	7.5	5.4	0.0	0.0	7.5	5.4
Summer flounder	0.0	0.0	6.2	7.3	3.5	3.4	9.7	10.7
American plaice	<0.1	<0.1	4.3	6.6	0.0	0.0	4.3	6.6
Witch flounder	<0.1	<0.1	1.8	2.2	0.0	0.0	1.8	2.2
Winter flounder	<0.1	<0.1	7.5	6.0	1.1	0.5	8.7	6.5
Windowpane	0.0	0.0	3.7	2.1	0.0	0.0	3.7	2.1
Subtotal	<0.1	<0.1	31.0	29.6	4.7	3.9	35.7	33.5
Other Groundfish								
Goosefish	1.0	0.5	12.8	16.0	<0.1	<0.1	13.9	16.5
Scup	0.0	0.0	6.7	5.6	3.7	2.1	10.4	7.7
Black sea bass	0.0	0.0	1.1	1.3	2.1	1.3	3.2	2.6
Ocean pout	0.0	0.0	1.4	0.5	0.0	0.0	1.4	0.5
White hake	0.6	1.2	5.6	8.4	<0.1	<0.1	6.2	9.6
Cusk	0.6	0.8	1.5	1.6	<0.1	<0.1	2.1	2.4
Atlantic wolffish	<0.1	<0.1	0.5	0.5	<0.1	<0.1	0.5	0.5
Tilefish	0.0	0.0	1.2	1.6	<0.1	<0.1	1.2	1.6
Spiny dogfish	0.0	0.0	11.5	11.1	0.0	0.0	11.5	11.1
Skates	0.0	0.0	11.2	12.3	0.0	0.0	11.2	12.3
Subtotal	2.2	2.5	53.5	58.9	5.9	3.4	61.6	64.8
Principal Pelagics								
Atlantic herring	24.6	32.0	54.7	59.7	0.0	0.0	79.3	91.7
Atlantic mackerel	27.5	25.5	25.7	12.4	2.0	0.4	55.2	38.3
Subtotal	52.1	57.5	80.4	72.1	2.0	0.4	134.5	130.0
Other Pelagics								
Atlantic butterfish	0.0	0.0	2.2	2.7	0.0	0.0	2.2	2.7
Bluefish	0.0	0.0	6.2	4.8	21.1	17.0	27.3	21.8
River herring	<0.0	<0.1	0.6	0.7	0.0	0.0	0.6	0.7
American shad	0.0	0.0	1.0	0.7	0.0	0.0	1.0	0.7
Striped bass	0.0	0.0	0.5	0.8	1.6	2.2	2.1	3.0
Subtotal	<0.1	<0.1	10.5	9.7	22.7	19.2	33.2	28.9
Invertebrates								
Short-finned squid	0.0	0.0	11.9	17.8	0.0	0.0	11.9	17.8
Long-finned squid	0.0	0.0	19.4	18.2	0.0	0.0	19.4	18.2
American lobster	0.2	0.2	28.7	25.3	0.0	0.0	28.9	25.5
Northern shrimp	0.0	0.0	3.4	3.4	0.0	0.0	3.4	3.4
Surfclam	0.0	0.0	30.0	32.7	0.0	0.0	30.0	32.7
Ocean quahog	0.0	0.0	22.3	22.5	0.0	0.0	22.3	22.5
Sea scallop	5.8	6.1	17.0	14.2	0.0	0.0	22.8	20.3
Subtotal	6.0	6.3	132.7	134.1	0.0	0.0	138.7	140.4
Total	**120.4**	**117.3**	**378.5**	**360.0**	**39.2**	**28.4**	**538.2**	**505.7**

For more information

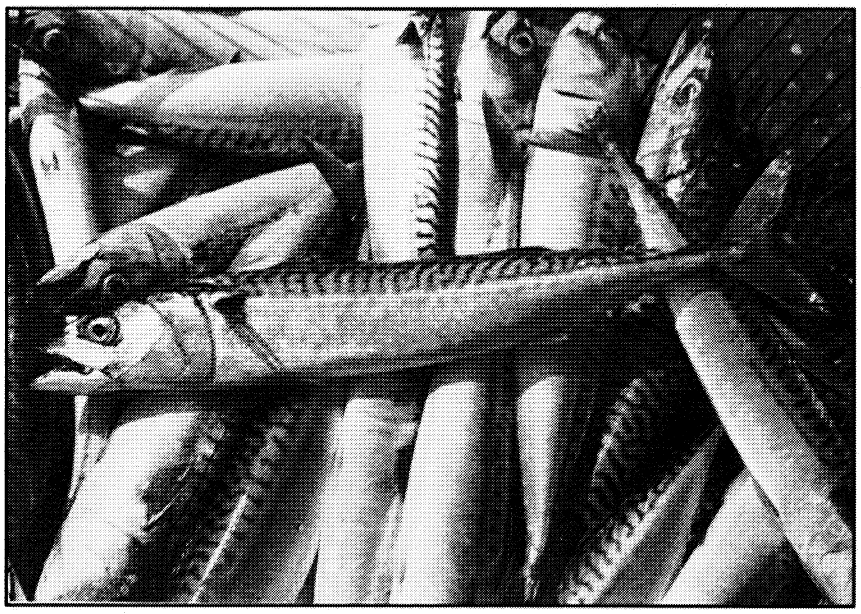
NMFS [National Marine Fisheries Service]. 1993. Fisheries of the United States, 1992. *Current Fishery Statistics* No. 9200. Available from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

AGGREGATE RESOURCE TRENDS

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 two 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 Multispecies FMP. Several pelagic fisheries in the southern portion of the region are managed in one plan, the Squid, Mackerel, and Butterfish FMP, and a new FMP is being developed to include summer flounder, black sea bass and scup.

While much of the stock assessment advice used to manage these fisheries requires knowledge of the dynamics of individual populations of each species, there is an increasing recognition of the need to consider fishery resource abundance information on a more aggregated level to fully understand the dynamics of the fisheries as a whole. In this section, trends are presented for several of the fishery resources in aggregate form to illustrate major changes in the fishery eco-



Mackerel

Atlantic herring

Mackerel and herring are the principal pelagic fish caught off New England. Overall, these fish are relatively abundant, reflecting recovery of the Gulf of Maine herring stock and the Northwest Atlantic mackerel stock, as well as some degree of recovery in the Georges Bank herring stock.

NMFS photos by Brenda Figuerido

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

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 25 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 supported historically important trawl fisheries.

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

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

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

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, kg) 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 of species an aggregate index of abundance has been computed as the sum of the individual 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, so the overall index in each case tends to reflect 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, so the aggregate indices derived from these data appear to provide a useful general index of overall resource trends, although they are weighted toward certain species.

SUMMARY OF TRENDS

Principal Groundfish and Flounders

This group includes important gadoid 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 percent 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, most silver and red hake stocks, and most 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 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 continually, and recruitment and abundance also increased for several flatfish stocks. The aggregate index peaked in 1978. Subsequently, the combined index again declined; 1987 and 1988 values were the lowest in the time series. The index increased somewhat during 1989-1990, reflecting improved recruitment (primarily for cod, redfish, silver and red hake, and American plaice). The index dropped sharply in 1991 and 1992 reflecting reduced survey catches for 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 have been small, although their combined contribution to U.S. commercial and recreational harvests has been significant.

The aggregate index for this group was relatively stable from 1963 to 1970 and then increased to peak levels from 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 demersal 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 declined more or less continually.

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 collected for principal groundfish and flounders, although the aggregate index is adequate to depict overall trends. This index declined to minimal levels in the mid-1970s, reflecting pronounced declines in abundance for both herring and mackerel (including the collapse of the Georges Bank herring stock). This was followed by a pronounced increase to high levels for 1987-1992, reflecting high levels of abundance for both species (Figure 4). This trend is corroborated by virtual population analysis or (VPA) of commercial catch-at-age data indicate recovery of both the coastwide herring stock and the Northwest Atlantic mackerel stock. There is also evidence for recovery of the Georges Bank herring stock. The 1992 index value was the highest in the time series.

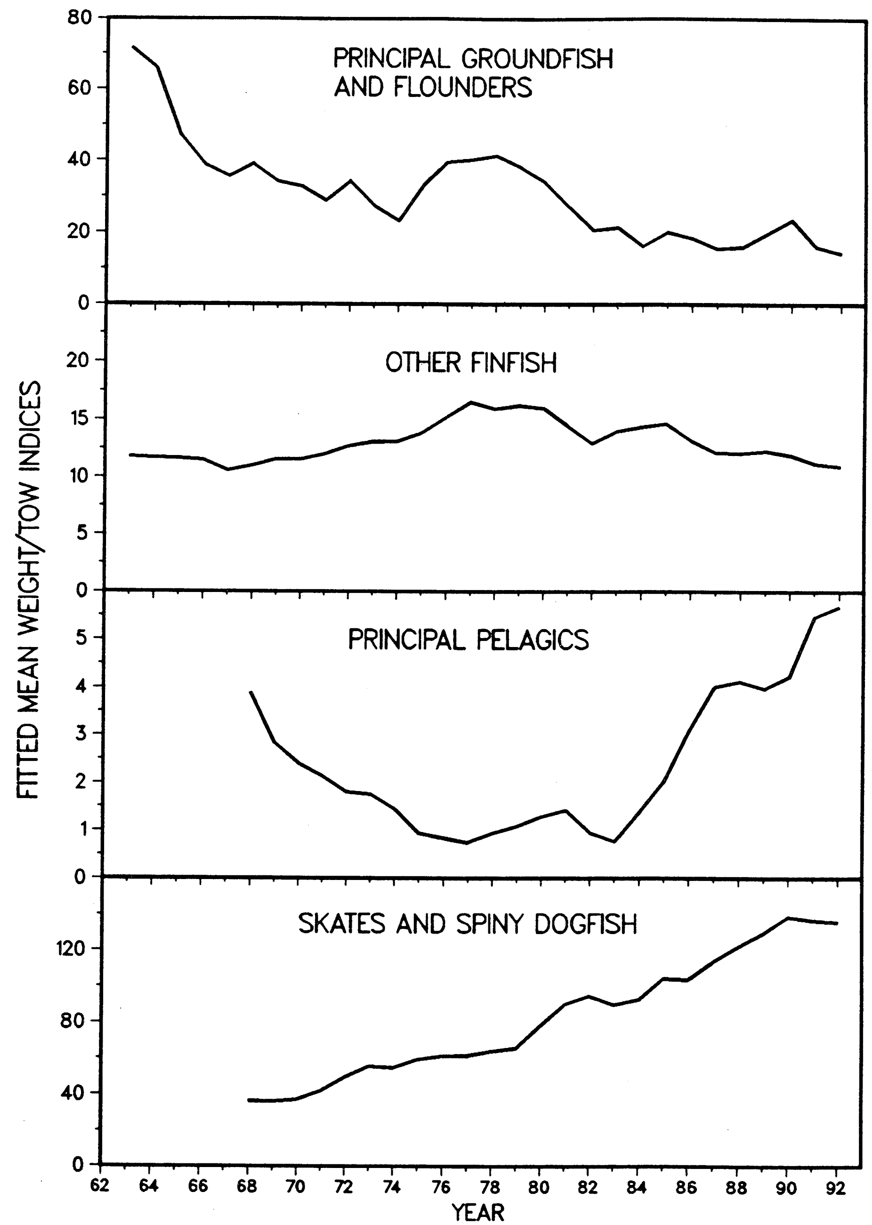


Figure 4. Trends in indices of aggregate abundance (catch in weight per survey trawl haul) for four species groups, reflecting the major changes in fishery resources, 1962-1992.

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-tailed, leopard, briar, and barndoor. The continued increase in this index since the late 1960s reflects major changes in relative abundance within the finfish species complex, with increasing abundance of species with low commercial value. These increases in dogfish and skate abundance, in conjunction with declining abundance of groundfish and flounders, have resulted in the proportion of dogfish and skates in Georges Bank survey catches increasing from roughly 25 percent by weight in 1963 to nearly 75 percent in recent years.

COMMERCIAL TRAWL CATCH AND EFFORT DATA

Commercial trawl landings and effort data have been consistently collected by NEFSC using dockside interviews and weigh-out reports since implementation of the MFCMA. Because of the mixed-species nature of this fishery throughout most of the region, there is a complex relationship between the amount of fishing effort and the landings of individual species or stocks. While simple indices based on total landings and effort will not directly reflect the abundance of any one species, such indices do provide useful measures of aggregate abundance that appear to reflect general overall trends, although increases in the efficiency of fishermen over time generally results in underestimates of the magnitude of change. 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 trawler fishing on Georges Bank. Appropriate weighing 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). These landings peaked in 1983 at 186,000 mt, and declined steadily to 112,000 mt in 1987 and 1988, a decrease of 40 percent. Otter trawl landings in 1992 decreased to 120,900 mt (5 percent lower than 1991) primarily due to decreased landings of yellowtail flounder, whiting, and pollock. Nominal fishing effort in terms of number of days fished (Figure 5) nearly doubled from roughly 25,000 standard days in the 1976-1978 period to roughly 48,000 in 1985. Subsequently, effort declined slightly, and has risen steadily since 1986. Total trawl effort increased 5 percent (to 48,800 days fished) from 1991 to 1992.

The total increase in the effect of fishing has been greater than indicated by these increases in days fished, however, because the fishing power of individual vessels has increased as vessels have become larger, with more powerful engines, larger nets, and more sophisticated electronic equipment.

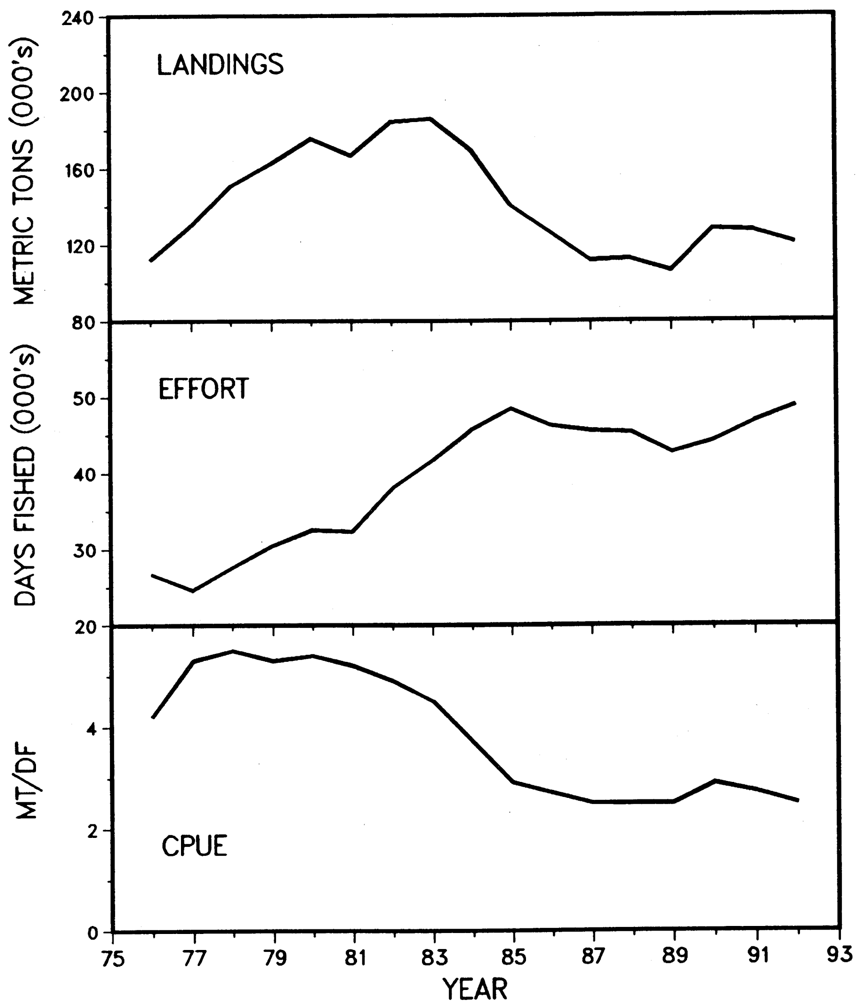


Figure 5. Total trawl catch (metric tons, all ages), standardized trawl fishing effort (DF, days fished), and catch divided by effort (CPUE,mt/DF) since the introduction of the MFCMA in 1977, reflecting major changes in trawl fishing activity and aggregate resource abundance.

The total landings (mt) divided by the total standardized effort (days fished, DF) for all three regions combined is 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 percent to 2.5 in 1987. The 1992 index decreased 7 percent (to 2.5 mt/df, reflecting decline of several groundfish stocks. The changes in this CPUE index are similar to those observed in the research trawl data for principal groundfish and flounders, with an initial rise and subsequently a major decline. The trend in this CPUE index is markedly different from the research trawl data for pelagic species and for other finfish, as might be expected given the nature of the trawl fishery. This CPUE index may, however, underestimate the 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 that have remained at relatively high stock sizes, such as butterfish and mackerel.

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, nominal effort increased 100 percent in the Gulf of Maine, 58 percent on Georges Bank, and 63 percent in the northern Mid-Atlantic. Total effort in the Gulf of Maine area increased from 13,300 days fished in 1991 to 14,500 days fished in 1992 (9 percent). Landings and CPUE declined 6 percent and 16 percent respectively. Georges Bank effort remained relatively stable since 1988 (decreasing 1 percent from 1991 to 1992). Landings and CPUE on Georges Bank decreased 10 and 10 percent, respectively in 1992, primarily because of lower landings of cod and yellowtail flounder. Landings and effort in the northern Mid-Atlantic increased from 1991 to 1992 (2 and 11 percent respectively), although CPUE decreased 9 percent.

During the period covered in these analyses, the species composition of landings changed dramatically for most vessel size classes and areas. In the Gulf of Maine, landings of pollock, redfish, and flounders have declined. Currently, cod, 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 cod, winter flounder, and windowpane flounder. In the northern Mid-Atlantic Bight, catches are generally highly mixed, but several trends are notable. Winter and summer flounder catches have declined relative to other species such as *Loligo* squid, butterfish, and silver hake. Yellowtail flounder catches decreased in the area in 1992 because of the reduced abundance of the 1987 year class.

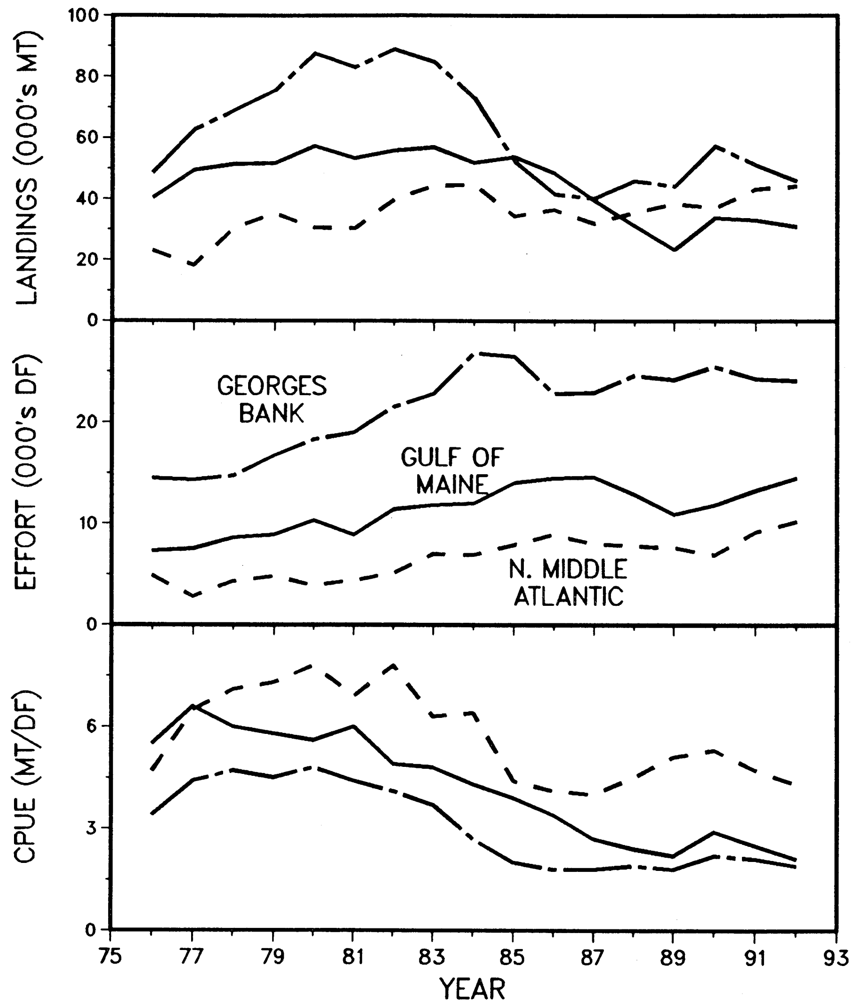


Figure 6. Total trawl catch (metric tons), standardized fishing effort (DF, days fished), and catch divided by effort (CPUE,mt/DF) since 1976 for three regions, reflecting changes in trawl fishing activity and aggregate resource abundance.

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 Northeast Atlantic, especially since the 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 increases in domestic fishing effort and landings. Abundance of groundfish and flounders started declining after 1978, and currently are at historically low levels. Abundance of other finfish has fluctuated widely, while that of the principal pelagics has increased steadily in recent years. More recently, the Georges Bank herring stock appears to be recovering. Trawl fishing effort increased steadily through 1985, and remains at near-record high levels. Total trawl catches increased until 1983, and have subsequently declined to levels comparable to those seen in 1976, despite the great increase in fishing effort. Trawl catches reached a time-series low in 1989, improved somewhat in 1990, and declined in 1991. These major changes in the fisheries have included extensive changes in the species composition of the catches, with shifts to previously less desirable species. At the same time, major increases in the abundance of nontarget species such as spiny dogfish and skates, has occurred.

It appears that most of the changes in resource abundance described above are directly related to changes in fishing mortality. For example, increases in abundance of groundfish and flounder occurred from 1975 to 1978 when fishing effort was being reduced by international and domestic management actions. Subsequently, decreases in abundance began in the early 1980s while fishing effort continued increasing. Fishing intensity appears to have been the principal cause of changes in resource abundance for these species. Decreases in fishing activity allowed more fish to survive and grow in the late 1970s, indicating the intensity of and significance of fishing on resource abundance. Record increases in fishing effort through the 1980s have reduced several new year classes before they were able to achieve full growth and reproduce. Continued high fishing effort sustains this pattern, with populations of several species being dominated by only one or two age groups.

Factors other than fishing effort may have played a role in these changes, as, for example, in years when exceptionally strong or weak recruitment occurred for some species. However, there is little evidence of long-term climatic changes that might have affected the recruitment of several species simultaneously as would be necessary to cause declines in abundance of the magnitude apparent in these data. Similarly, there is little suggestion that environmental contamination has played a significant role in these changes in resource abundance because comparable decreases have been seen in all three regions even though pollution levels vary greatly. Moreover, the effects of pollution are limited to nearshore regions, while fish abundance has declined in all areas.

Increased fishing effort in the three regions has resulted in elevated fishing mortality (exploitation) rates on the target species. Up to 70 percent of some harvestable stocks are removed by fishing each year. The high rates of population removal can result in two effects:

1. Catching young, fast growing fish, which may result in decreased aggregate yield-in-weight from a particular group of recruits; and

2. Reducing the total level of adult biomass to a point that too few young fish result from each year's spawning.

The elevated levels of fishing mortality clearly have resulted in the first problem. Total catch has been less than what is possible because exploitation rates for many species far exceed the levels that result in maximum yield per recruited fish. Recent analyses of the relationship between the production of young fish and adult spawning biomass suggest that the second problem is also occurring. Present fishing mortality rates do not allow sufficient young fish to be produced to maintain their populations at even their current low abundance levels.

While the causes of the changes in resource abundance shown by the indices of aggregate abundance described here are not completely understood, it appears that fishing is probably the major cause. Climatic or environmental changes of sufficient magnitude to cause simultaneous changes in all these stocks are not apparent. The amount of fishing has increased markedly, exceeding levels producing maximum catch-per-recruit, and for several species exceeding those levels that allow recruitment sufficient to maintain spawning stock size. While further research is needed, especially in terms of the possible effects of environmental or climatic changes, the changes that have occurred following a decline in fishing in the mid-1970s and a subsequent doubling in the amount of fishing, are consistent with similar changes that were clearly seen when fishing effort in the North Sea declined during and then increased after World Wars I and II. The message that was clear then is no less clear today: reducing fishing will result in increased abundance of fishery resources.

For further information

NEFC [Northeast Fisheries Science Center]. 1987. Status of mixed demersal finfish resources in New England and scientific basis for management. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Lab. Ref. Doc.* 87-09. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543-1097.

NEFMC[New England Fishery Management Council]. 1988. An assessment of the effectiveness of the Northeast Multispecies Management Plan with recommendations for plan and management system improvements. Saugus, MA: New England Fishery Management Council. Available from: NEFMC, Suntaug Office Park, 5 Broadway (Rte 1), Saugus, MA 01906.

NEFSC [Northeast Fisheries Science Center]. 1993. Report of the Fifteeth Northeast Regional Stock Assessment Workshop (15th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-06. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543-1097.

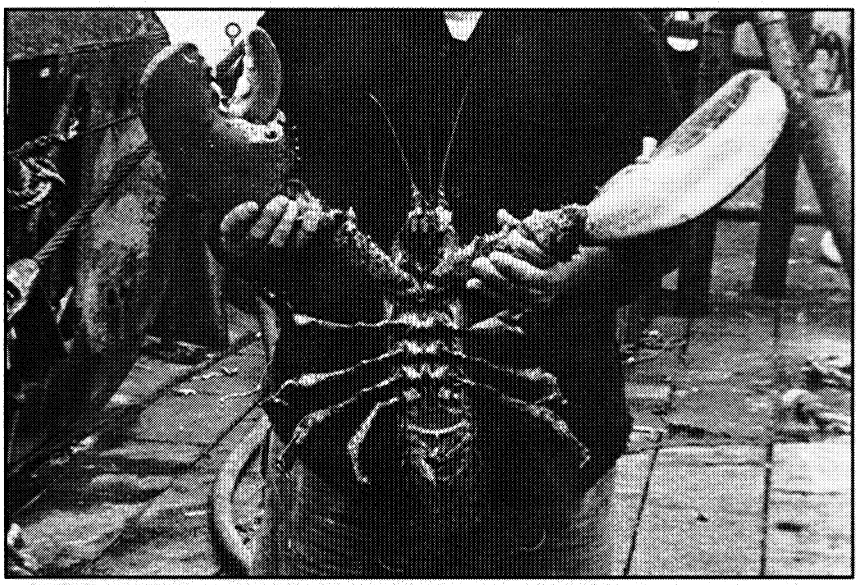
NEFSC[Northeast Fisheries Science Center]. 1993. Report of the Sixteenth Northeast Regional Stock Assessment Workshop (16th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc. 93-06.* Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543-1097.

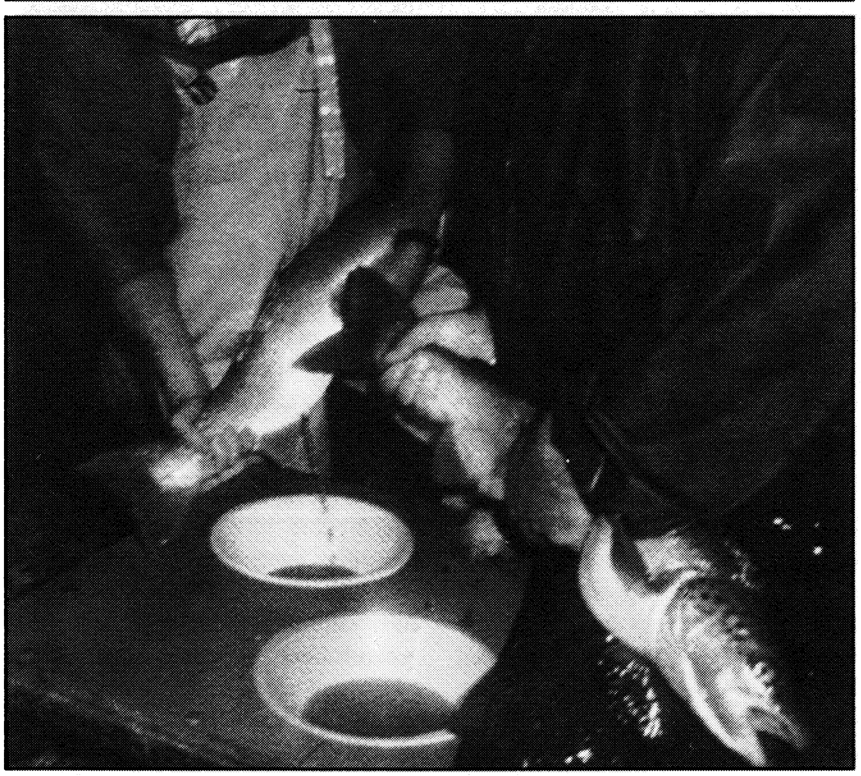
FISHERY ECONOMIC TRENDS

REGIONAL SUMMARY

The Northeast's commercial oceanic and estuarine fisheries produced domestic landings worth $886 million dockside in 1992 (preliminary figure), a decrease of $41 million, or 4 percent less than final 1991 figures. Total landings were down negligibly to 724,000 mt (preliminary). Finfish landings brought in $302 million, representing 34 percent of the revenue generated in the region. Shellfish landings were 199,000 mt, a decrease of 8 percent over 1991 levels. These figures are preliminary and subject to minor change as additional information is received from the ports. It is worth noting that preliminary revenue figures estimated in recent years have been three to four percent less than the final figures. Small differences between 1991 and 1992 figures should not be misinterpreted.

Important species of fish and shellfish landed or raised in the Northeast region are shown in Table 3 along with their prices, weight, and value for the last eight years. This table ranks the species by decreasing value and includes those covered by management plans. 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 ex-vessel value, are lobster, sea scallops, cod, Atlantic salmon, oysters, hard clams, surfclams, blue crab, and menhaden. Of the eight most important species in terms of value, six





Lobster (top) and scallop are still the most valuable species caught off New England. Fresh farmed Atlantic salmon (bottom) registered the largest revenue gain in 1992, moving into fourth place on the most valuable species list.

NMFS file photos

Table 3. Important species landed or raised in the Northeast, their landings (thousands of metric tons), values (millions of dollars), and prices (dollars per pound), 1985-1992 (preliminary data, 1992)

Year	Quantity	Value	Price	Quantity	Value	Price	Quantity	Value	Price	Quantity	Value	Price	Quantity	Value	Price
	Lobster			Sea scallops			Cod			Atlantic salmon			Oyster meat		
1985	21.3	117.0	2.49	6.8	72.0	4.82	37.4	35.0	0.42	0.0	0.0	0.0	6.7	30.0	2.04
1986	20.8	120.1	2.62	8.3	91.0	4.97	27.6	36.0	0.59	0.0	0.0	0.0	6.8	37.8	2.51
1987	20.8	142.1	3.10	13.2	123.4	4.23	26.8	44.2	0.75	0.0	0.0	0.0	4.3	29.5	3.11
1988	22.2	146.4	2.99	13.0	121.9	4.24	34.6	43.0	0.56	0.0	0.0	0.0	3.1	26.2	3.81
1989	24.0	148.9	2.82	14.4	126.6	3.98	35.6	47.8	0.61	0.0	0.0	0.0	2.4	22.3	4.16
1990	27.6	151.0	2.48	17.2	147.4	3.88	43.6	61.4	0.64	2.1	16.1	3.50	3.3	40.1	5.54
1991	29.1	166.1	2.59	17.2	153.5	4.05	42.2	74.3	0.80	4.7	30.0	2.89	4.0	40.8	4.67
1992	25.3	161.0	2.88	14.0	151.7	4.90	27.7	51.8	0.85	5.8	45.3	3.52	3.2	45.3	6.46
	Hard clam			Surfclam			Blue crab			Menhaden			Squid *Loligo*		
1985	5.7	45.8	3.64	32.1	37.8	0.53	48.0	36.0	0.34	314.6	31.0	0.04	9.0	6.2	0.31
1986	4.7	40.6	3.92	35.4	42.2	0.54	42.9	34.3	0.36	222.6	24.3	0.05	11.5	9.0	0.35
1987	5.0	50.3	4.59	27.4	27.9	0.46	38.9	37.6	0.44	300.0	32.5	0.05	10.5	9.3	0.40
1988	6.8	48.7	3.25	28.6	28.9	0.46	41.8	40.6	0.44	273.5	29.7	0.05	18.9	15.4	0.37
1989	4.2	50.6	5.48	30.4	30.7	0.46	45.6	42.0	0.42	287.8	31.3	0.05	23.0	21.8	0.43
1990	4.6	46.9	4.63	32.6	32.4	0.45	43.9	43.2	0.45	336.1	37.2	0.05	15.0	14.0	0.43
1991	4.4	44.8	4.61	30.0	29.2	0.44	49.5	40.4	0.37	294.8	33.2	0.05	19.4	22.7	0.53
1992	4.1	39.7	4.36	33.8	34.7	0.46	27.5	31.7	0.52	285.6	31.5	0.05	18.2	23.3	0.58
	Monkfish			Ocean quahog			Summer flounder			Soft clam			Winter flounder		
1985	7.2	4.5	0.28	22.5	15.7	0.32	10.8	23.4	0.99	3.3	20.0	2.73	11.0	20.6	0.85
1986	6.7	6.9	0.47	20.6	15.7	0.35	9.5	26.3	1.25	2.9	20.8	3.21	8.0	17.6	1.00
1987	6.9	9.8	0.64	22.8	16.6	0.33	9.9	32.0	1.46	3.4	19.2	2.58	9.0	24.1	1.21
1988	7.6	10.4	0.62	21.0	14.9	0.32	11.6	33.6	1.31	3.5	20.1	2.60	8.4	22.4	1.20
1989	11.3	12.6	0.51	23.1	16.4	0.34	6.2	22.2	1.63	2.9	19.4	2.98	6.6	19.6	1.34
1990	10.1	13.1	0.59	21.2	16.3	0.35	3.0	12.0	1.84	2.4	20.8	3.88	7.0	17.1	1.11
1991	12.1	21.8	0.81	22.3	19.0	0.39	4.6	14.8	1.45	1.9	14.8	3.51	7.6	19.1	1.14
1992	15.8	20.1	0.58	23.0	20.0	0.40	6.2	19.1	1.39	1.8	15.9	4.05	6.1	15.4	1.15
	Sea urchins			Bluefin tuna			American plaice			Yellowtail flounder			Swordfish		
1985	0.0	0.0	0.0	1.3	9.0	3.16	8.4	15.0	0.81	11.2	20.3	0.82	2.0	11.1	2.50
1986	0.0	0.0	0.0	0.9	15.2	7.92	6.1	12.4	0.92	10.4	21.0	0.92	2.0	13.1	3.01
1987	0.7	0.2	0.16	1.0	11.9	5.54	5.1	11.9	1.07	7.6	20.1	1.20	2.1	16.0	3.39
1988	2.8	1.8	0.28	0.8	11.3	6.61	4.7	10.5	1.01	5.0	13.2	1.19	2.7	18.1	2.99
1989	4.3	3.6	0.38	1.1	19.7	8.01	3.5	8.8	1.14	5.6	13.9	1.13	2.7	17.2	2.92
1990	6.1	6.1	0.45	1.0	21.2	9.26	2.5	5.6	1.03	14.4	28.1	0.89	2.3	15.1	2.92
1991	9.3	11.2	0.54	0.9	15.3	7.58	4.3	8.9	0.94	7.6	17.4	1.03	1.8	12.0	3.00
1992	12.0	15.2	0.57	0.9	14.5	7.23	6.6	13.9	0.95	5.6	13.8	1.12	1.7	10.8	2.90
	Whiting			Pollock			Squid *Illex*			White hake			Scup		
1985	20.2	8.3	0.19	19.8	7.0	0.16	2.4	0.8	0.15	7.4	3.3	0.21	6.5	8.1	0.57
1986	18.0	8.2	0.21	24.6	14.0	0.26	4.4	1.5	0.15	6.4	4.8	0.34	6.7	8.3	0.56
1987	15.7	11.6	0.33	20.7	17.9	0.39	7.0	3.1	0.20	5.8	5.2	0.41	6.0	8.7	0.66
1988	16.1	8.6	0.24	15.0	11.0	0.33	2.0	0.6	0.13	4.8	3.2	0.31	5.6	8.1	0.66
1989	17.8	9.4	0.24	10.5	9.9	0.43	6.8	3.2	0.22	5.1	4.4	0.39	3.5	6.1	0.78
1990	20.0	11.1	0.25	9.6	10.6	0.50	11.3	6.5	0.26	4.9	4.3	0.39	4.2	6.4	0.68
1991	16.1	11.1	0.31	7.9	9.9	0.57	11.9	6.9	0.26	5.6	5.4	0.44	6.8	7.8	0.52
1992	15.6	10.6	0.31	7.1	10.4	0.67	17.8	9.7	0.25	8.4	8.0	0.43	5.6	7.3	0.59
	Northern shrimp			Witch flounder			Atlantic herring			Haddock			Tilefish		
1985	4.2	4.1	0.44	6.4	12.9	0.91	25.9	3.0	0.05	6.5	13.5	0.94	2.0	4.9	1.13
1986	4.7	6.5	0.63	5.2	12.9	1.14	32.0	3.8	0.05	5.0	10.9	0.99	2.0	5.0	1.17
1987	5.0	12.2	1.10	3.8	12.2	1.45	39.4	4.5	0.05	3.0	8.5	1.28	3.2	7.9	1.11
1988	3.1	7.5	1.10	3.6	11.6	1.46	40.9	5.2	0.06	2.9	7.0	1.09	1.4	5.3	1.76
1989	3.6	7.8	0.98	2.4	9.0	1.73	40.7	5.0	0.06	1.7	4.5	1.19	0.5	2.0	1.81
1990	4.4	6.9	0.72	1.5	5.8	1.78	51.3	5.7	0.05	2.5	6.0	1.10	0.9	3.8	1.97
1991	3.4	6.8	0.91	1.8	6.1	1.57	48.5	6.3	0.06	1.8	4.6	1.13	1.2	4.2	1.61
1992	3.4	7.3	0.99	2.2	6.9	1.41	55.8	6.8	0.06	2.3	5.6	1.09	1.7	5.5	1.52
	Bigeye tuna			Yellowfin tuna			Atlantic mackerel			Butterfish			Windowpane flounder		
1985	0.4	2.0	2.39	0.4	0.4	0.53	2.9	1.0	0.15	4.6	3.5	0.34	4.2	4.9	0.53
1986	0.6	4.4	3.43	0.7	1.8	1.16	4.0	1.1	0.13	4.5	6.5	0.66	3.2	3.7	0.52
1987	0.6	4.7	3.56	0.9	2.6	1.25	4.3	1.0	0.11	4.6	6.4	0.63	2.3	3.1	0.61
1988	0.5	4.0	3.95	0.8	2.4	1.46	6.4	1.9	0.13	2.1	3.2	0.68	2.6	3.0	0.53
1989	0.4	2.7	3.18	0.5	1.6	1.33	8.1	3.2	0.18	3.0	3.9	0.60	2.6	3.1	0.55
1990	0.4	3.9	4.03	0.6	2.4	1.71	9.9	3.6	0.16	2.3	2.8	0.56	2.0	1.7	0.38
1991	0.7	6.2	3.93	2.0	3.5	0.80	16.5	5.4	0.15	2.1	2.7	0.59	3.7	4.4	0.54
1992	0.5	4.8	4.66	1.4	3.9	1.23	11.7	3.6	0.14	2.0	3.4	0.79	2.1	3.0	0.64
	Sea bass			Mussels			Weakfish			Bluefish			Striped bass		
1985	1.2	2.7	0.99	2.8	2.3	0.38	2.7	3.2	0.53	4.2	1.6	0.17	0.4	1.5	1.53
1986	1.6	3.5	0.99	2.9	2.5	0.39	2.7	2.7	0.45	4.6	1.8	0.18	0.1	0.2	1.06
1987	1.7	3.9	1.02	2.9	2.3	0.36	2.2	2.7	0.55	3.8	2.0	0.24	0.1	0.2	1.32
1988	1.3	3.2	1.08	3.9	2.9	0.33	2.2	2.3	0.48	4.3	1.8	0.19	0.1	0.4	1.39
1989	1.0	2.7	1.20	4.3	3.4	0.35	1.7	2.7	0.73	2.7	1.3	0.22	0.1	0.4	2.12
1990	1.3	3.0	1.06	3.9	2.9	0.34	1.4	2.2	0.69	3.6	2.1	0.26	0.3	1.0	1.48
1991	1.2	3.1	1.20	2.9	2.2	0.33	1.5	2.5	0.77	3.5	1.7	0.22	0.3	1.4	1.75
1992	1.3	2.8	1.00	3.5	2.5	0.33	1.1	1.9	0.79	3.3	1.7	0.24	0.5	1.7	1.53
	Red hake			Ocean perch			Ocean pout								
1985	1.8	0.5	0.13	4.4	3.2	0.33	1.5	0.3	0.09						
1986	2.1	0.7	0.14	3.0	3.2	0.48	0.8	0.2	0.11						
1987	2.0	0.9	0.20	1.9	2.7	0.64	2.2	0.5	0.10						
1988	1.7	0.6	0.16	1.1	1.5	0.62	1.8	0.4	0.10						
1989	1.6	0.6	0.17	0.6	0.9	0.66	1.3	0.3	0.10						
1990	1.6	0.6	0.17	0.6	0.7	0.53	1.3	0.3	0.10						
1991	1.6	0.8	0.22	0.5	0.5	0.46	1.4	0.3	0.10						
1992	2.0	1.0	0.22	0.8	0.8	0.42	1.0	0.1	0.10						

are shellfish, and five are harvested predominantly inshore (within 0 to 3 miles of shore).

Two notable trends can be observed in the prices and landings of the species shown in Table 3. One is the presence of farmed fresh Atlantic salmon in the top four valued species. It has become a valuable species to the Northeast in just the past three years. Its presence in the table illustrates the growing importance of marine aquaculture to the Northeast economy, with more than 20 sites in Maine raising Atlantic salmon and some rainbow trout from pens. The price drop that Maine salmon suffered during 1991 proved to be temporary.

A second important trend to be noted in Table 3 concerns the region's "traditional" groundfish species. Although overall landings of all species remained about the same, landings of the region's "traditional" groundfish species (cod, haddock, and yellowtail flounder) declined from 51,600 to 35,600 mt, a 31 percent decrease. Value of these traditional groundfish landings decreased by 26 percent, from \$96.3 to \$71.2 million. Relatively few species accounted for a large part of the value of landings in the Northeast, with the top ten generating 75 percent (\$614 million) of the landings value. Of this year's ten most valuable species, eight showed decreased landings in 1992.

The most valuable species in the Northeast continue to be lobster and scallops, although each declined in value and landings from their 1991 peaks. Atlantic salmon accounted for the largest revenue gain (in absolute terms) in 1992, while Atlantic herring made the most significant absolute gain in landings. Other species that accounted for substantial gains in total value and/or landings include sea urchin, *Illex* squid, monkfish, white hake, and American plaice. On the other hand, blue crab landings decreased by 44 percent, soft shell clammers continued to see their harvest decline, and yellowtail flounder landings and value remained strikingly low.

Table 4. Permits issued in the Northeast by gear, as of September 1992

Proposed Gear Use	Number of Vessels	Number of Boats
Bottom trawls, mid-water trawls, and other trawls	1,650	238
Dredges	112	1
Gill/entanglement net	325	207
Handlines/rod and reel	875	1,085
Longlines/set lines	410	318
Other	85	50
Total permits by gear	**3,457**	**1,899**

DATA COLLECTION CONSIDERATIONS

In the Northeast, the NMFS collects information on landings through a network of 30 federal and state port agents located at 14 field offices representing the busiest ports. The principal data collection activity in these ports is the collection of "weigh-out" sales receipts at the point of first sale. A series of weekly and monthly visits to hundreds of less busy ports supplements the weigh-outs collected from the largest ports. Another part of the data collection process consists of interviews with the vessel operators conducted by port agents when fish are landed. These "interview records" contain the most reliable trip information on variables such as gear type, fishing location, and effort. The percentage of trips interviewed varies considerably, depending on, among other things, port, size of vessel, and length of trip or trip type. The records of trips that were not interviewed contain estimates based on those trips that were interviewed. Additional data are collected by conducting a monthly or annual canvas to fill in gaps. This annual canvas is usually the last data received and is missing from the weigh-out files currently available. All of the landings recorded are associated with the type of gear that produced them. However, the further removed the collection of information is from the date and place of first sale, the more difficult it is to associate those landings with a particular craft and the fishing effort that produced them.

All vessels (those craft larger than 5 gross registered tons, grt) fishing in the exclusive economic zone (EEZ) are required by law to be registered with the U.S. Coast Guard. The registration number must be clearly displayed so that vessels can be identified. In contrast, boats (those craft smaller than 5 grt) must have either a state registration number or a Coast Guard registration number displayed. In addition, all boats and vessels used to commercially exploit the species managed under federal fishery management plans (FMPs) in the Northeast Region are required to apply annually for the appropriate fishery-specific permits. The moratorium on further entry into the groundfish fishery contained in the proposed Amendment 5 to the Northeast Multispecies FMP may have prompted greater awareness of this requirement.

Table 4 shows the vessels and boats granted permits to fish certain gears as of September 1992. The largest category of permits issued for vessels was trawl gear, followed by handline/rod and reel, and longlines. Under the boat category, handline/rod and reel permits continued to be dominant. Quite often, vessel owners will apply for a permit under several gear uses. Therefore, the total permits issued according to Table 4 is far greater than the total number of vessels or boats actually using that gear in a given year.

Table 5 shows the total number of identifiable vessels using scallop dredge, otter trawl, and other gear that are represented in the weigh-out data base from 1980 through 1992. There has been a decline in the number of vessels in the otter trawl fishery and an increase in the number of vessels in the scallop dredge fishery in the Northeast. The total number of vessels in the Northeast, regardless of gear used, returned to its 1990 level.

Although a 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 revenue, are bottom otter trawls, scallop dredges, lobster pots and traps, and surfclam and ocean quahog dredges. These 4 gear types account for about 64 percent of total ex-vessel revenue, while the top 8 gears account for 75 percent of revenue. Otter trawls produce the most landings, followed by surfclams and ocean quahog dredges.

The collection of weigh-out receipts coupled with the ability to identify the particular vessel involved allows landings to be associated with vessel and gear characteristics. Table 6 examines these identified vessels and lists their landings and revenues by gear type as recorded in the data base in 1992. This table indicates that one is able to associate only a portion of total landings with the specific vessels that made those landings. These landings are about 40 percent of all landings for all fisheries in all waters of the region. The revenue represents 58 percent of the total for the region. The most obvious omission of identified vessels occurs in the lobster fishery. Vessels using otter trawl gear, once again, had the highest revenue among uniquely identified vessels.

Table 7 examines the value and landings of the identified as well as unidentified vessels, *i.e.*, it includes the portion of the total landings that we cannot associate with any given vessel. It serves to illustrate the limits to the weigh-out data in its current format.

FLEETS AND FISH

Tables 8 to 16 contain condensed pictures of the activity of known vessels 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 vessels into groups or fleets on the basis of gear use, area fished, and tonnage class. The purpose is to give some continuing set of indicators of 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 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 the region, its total activity (all trips regardless of gear used) was ascribed to that region, defined as either New England, Mid-Atlantic and Chesapeake, or the entire Northeast. Hence, several vessels and their activity may be represented in more than one table. The same multiple representation exists for use of a gear. If a vessel uses a gill net, for example, and, in the same year, a longline, its total activity will be represented in the total activity section of two tables, but its "primary gear" activity in only one - that describing gill net use or that describing longline use. For some gears this distinction between primary gear activity and total activity is not displayed because a gear's use constitutes an overwhelming majority of the activity of the fleet in question.

Weigh-out data from 1982-1992 have been aggregated from a different perspective by the Northeast Fisheries Science Center's Fleet Modeling Group to reveal the distribution of individual vessel-based statistics such as annual revenue and effort. These statistics help answer questions such as the distribution of annual days absent across vessels in a particular gear-defined fleet. More attention will be given to answering these types of questions when more appropriate data bases are available. For now, we rely mostly on the commercial weigh-out database as it exists, the standard aggregate statistics that it can provide, and the use of experimental individual vessel files.

New England Otter Trawl

The total number of vessels participating in this fishery continued its steady decline. In 1992, 795 vessels, a pre-1980 level, were in the fishery (see Table 8). Effort was increased among the vessels that remained, each of which caught less and gained less revenue, on average. Total landings decreased from 1991 levels by 12 percent. Average revenue per vessel decreased in each of the tonnage classes in 1992. The average number of days at sea increased for all tonnage classes, as did the average number of trips taken by a vessel.

Mid-Atlantic Otter Trawl

Mid-Atlantic otter trawlers primarily land summer flounder, scup, and black sea bass (Table 9). The number of vessels engaged in this fishery increased to 261 in 1992. The average number of days absent from port increased among only the tonnage class 3 vessels, however their revenues and catches declined. On average, each vessel in this fishery made fewer trips last year. Tonnage class 4 vessels experienced a very large increase in revenue and catch per day absent.

In 1992, total revenue increased negligibly, but total landings reached a new high of 66,000 mt, a four percent

Table 5. Number of identifiable vessels using otter trawl, scallop dredge, and other gear in the Northeast region by ton class,[1] by sub-region,[2] 1980-1992

Year	Scallop Dredges				Otter Trawls				All Vessels[3]			
	TC2	TC3	TC4+	Total	TC2	TC3	TC4+	Total	TC2	TC3	TC4+	Total
1980 Northeast[4]	44	191	109	344	504	434	96	1034	768	678	204	1650
New England	39	148	86	273	457	361	82	900	616	532	168	1316
Mid-Atlantic & Chesapeake	5	88	37	130	53	97	16	166	162	222	57	441
1981 Northeast	30	173	140	343	491	491	117	1099	798	752	256	1806
New England	30	141	120	291	449	386	86	921	623	550	191	1364
Mid-Atlantic & Chesapeake	1	82	51	134	49	139	37	225	189	303	106	598
1982 Northeast	18	107	111	236	538	515	140	1193	838	738	247	1823
New England	16	86	89	191	487	403	120	1010	653	533	190	1376
Mid-Atlantic & Chesapeake	2	47	34	83	56	149	38	243	201	288	96	585
1983 Northeast	61	121	109	291	496	556	140	1192	776	800	254	1830
New England	52	84	84	220	448	435	113	996	581	583	193	1357
Mid-Atlantic & Chesapeake	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 England	37	83	93	213	443	459	119	1021	611	595	217	1423
Mid-Atlantic & Chesapeake	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 England	20	64	86	170	421	422	129	972	590	554	217	1361
Mid-Atlantic & Chesapeake	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 England	10	46	80	136	379	389	126	894	540	505	209	1254
Mid-Atlantic & Chesapeake	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 England	17	47	89	153	445	369	112	926	631	493	209	1333
Mid-Atlantic & Chesapeake	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 England	26	56	109	191	422	370	126	918	651	499	242	1392
Mid-Atlantic & Chesapeake	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 England	38	57	125	220	360	374	112	846	599	509	247	1355
Mid-Atlantic & Chesapeake	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 England	32	77	133	242	373	358	108	839	598	512	252	1362
Mid-Atlantic & Chesapeake	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 England	29	65	126	220	368	339	115	822	628	469	241	1338
Mid-Atlantic & Chesapeake	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 England	48	62	119	229	374	328	93	795	681	454	227	1362
Mid-Atlantic & Chesapeake	3	71	50	124	51	174	36	261	203	333	106	642

[1] TC2 - 5 to 50 gross registered tons (grt), TC3 - 51-150 grt, TC4 - 151+ grt.

[2] 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 & Chesapeake 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.

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

[4] The "Northeast" row eliminates duplication of vessels that landed in both sub-regions.

sel declined about nine percent from 1991 levels, while both landings and vessel participation increased.

Northeast Otter Trawl

Neither New England nor Mid-Atlantic otter trawlers did a significant amount of fishing with other gears. Individual vessel data for 1992 revealed that approximately 63 percent of tonnage class 2 otter trawl vessels had revenues less than $50,000, 18 percent of the tonnage class 3 vessels earned less than $50,000, while 66 percent had revenues evenly distributed between $50,000 $400,000. Seventy-two percent of the tonnage class 4 vessels grossed more than $400,000.

There was also great variability among vessels in the number of days absent. This reflects, to some extent, the frequency of encounters with some vessels as much as it reflects actual fishing vessel behavior. Information from individual vessel files indicates that for 1992, total annual days absent for otter trawl vessels ranged from less than 10 to 75 for 63 percent of tonnage class 2 vessels. Forty-three percent of tonnage class 3 vessels were absent from port between 150 and 250 days. For comparison, in 1982, 23 percent of tonnage class 3 vessels fell in this same range. Fifty-two percent of tonnage class 4 vessels were absent from port between 200 and 250 days, doubling the percentage of ten years ago.

Northeast Pair Trawl

Thirty-four vessels participated in bottom pair trawling activities in the Northeast Region in 1992 (Table 10). Of these 34 vessels, 13 were tonnage class 3 and 20 were of the largest size category, while the remaining one was ton class 2. While the actual number of vessels may seem low, their appearance in the fishery has raised much concern, enough to jeopardize the future use of this gear type. Pair trawling activity first appeared in the data during 1990 and has increased ever since.

Table 6. Identified vessels' landings (thousands of metric tons, landed weight) and ex-vessel revenue (milllions of dollars) in the Northeast by gear used, 1992

Gear Types	Landings	Revenue
Otter trawl, bottom-fish	133.00	175.2
Dredge-sea scallop	17.06	149.4
Dredge-surfclam & ocean quahog	55.73	50.0
Longline, set line, line trawl	5.59	23.9
Pots & traps-lobster	4.13	23.2
Sink gill net	14.14	16.8
Otter trawl, bottom-shrimp	2.51	5.4
Otter trawl, bottom-scallops	0.63	4.9
Purse seine-tuna	0.95	4.5
Otter trawl, bottom-paired	1.49	3.1
Purse seine-herring	18.15	1.9
Otter trawl, midwater-paired	0.53	1.4
All other gears	19.35	9.3
Total for 1992	**273.27**	**469.0**

Table 7. All weigh-out vessels' landings (thousands of metric tons, landed weight) and ex-vessel revenue (millions of dollars) in the Northeast by gear used, 1992

Gear Types	Landings	Revenue
Otter trawl, bottom-fish	145.26	194.5
Dredge-sea scallop	17.79	156.2
Pots & traps-lobster[1]	19.66	116.0
Dredge-surfclam & ocean quahog	56.08	51.9
Longline, set line, line trawl	7.67	30.4
Sink gill net	21.30	24.6
Pots & traps-blue crab	20.73	22.3
Rakes	2.08	18.4
Diving gear	11.48	15.9
Tongs and grabs	1.80	15.7
Hoes	1.40	10.9
Hand line, other	1.14	10.7
Otter trawl, bottom-shrimp	3.43	7.3
Purse seine- herring	45.12	5.6
Otter trawl, bottom-scallops	0.64	5.0
All other gears	324.81	128.6
Total for 1992	**680.38**	**813.9**

[1] Lobster data is not yet complete in weigh-out data.

Table 8. New England otter trawl vessels, all gears used

	Ton Class 2					Ton Class 3					Ton Class 4				
	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992
Vessel count	422	360	373	368	374	370	374	358	339	328	126	112	108	115	93
Average age	23	24	24	24	22	17	16	17	18	19	9	8	10	11	12
Average grt	27	28	27	27	26	99	101	102	103	102	193	193	178	177	175
Average days absent	62	62	62	61	64	130	123	133	140	149	163	174	173	187	194
Average crew size	2.7	2.8	2.8	2.8	2.7	5.3	5.3	5.3	5.3	5.3	7.2	7.1	7.0	7.1	6.8
Revenue per day absent ($)	866	920	944	1072	955	1892	1844	1960	2136	1911	3075	3305	3321	3655	3399
Pounds per day absent	1633	1585	2020	1965	1659	2983	2685	3454	3583	3158	5107	5955	6302	6459	6454
Average number of trips per vessel	53	54	51	50	53	38	35	37	36	38	23	25	28	28	31

Table 9.Mid-Atlantic otter trawl vessels, all gears used

	Ton Class 2					Ton Class 3					Ton Class 4				
	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992
Vessel count	64	44	42	36	51	225	217	189	170	174	39	46	43	34	36
Average age	23	21	26	24	25	14	15	16	17	18	7	8	11	13	14
Average grt	31	30	30	28	29	134	103	105	104	104	176	175	175	179	178
Average days absent	37	55	63	81	64	65	70	84	99	102	102	99	135	153	125
Average crew size	2.5	2.7	2.7	2.6	2.5	4.5	4.8	4.8	5.1	4.9	7.6	7.4	7.3	7.5	7.3
Revenue per day absent ($)	910	861	731	763	741	1974	1682	1750	1896	1751	3329	3226	3020	3322	4009
Pounds per day absent	2142	2241	2057	1730	1659	3819	4536	4561	5335	4676	8559	8017	7727	8674	12740
Average number of trips per vessel	33	54	61	74	60	17	22	25	31	30	22	19	28	32	27

ing 1990 and has increased ever since. These pair trawling vessels were more efficient per vessel with significantly higher revenue per day absent and landings per day absent than otter trawlers that worked alone.

The pair trawling trips were taken consistently throughout the year. However, the cooperation between vessels on these trips was occasional, *i.e.*, not their primary means of fishing.

Table 10. Northeast bottom pair trawl vessels, all gears used and pair trawl gear only

	Ton Class 3			Ton Class 4		
	1990	1991	1992	1990	1991	1992
Vessel count	4	4	13	6	10	20
Average age	12	7	14	6	6	11
Average grt	93	122	125	175	179	176
Average days absent	168	160	165	161	187	205
Average crew size	4.0	5.8	5.9	5.0	5.8	6.3
Revenue per day absent ($)	2261	3020	2624	3961	4790	3341
Pounds per day absent	4342	4178	3474	6841	8855	5468
Average number of trips per vessel	54	46	32	32	43	34
Pair Trawl Gear Only						
Average days absent	12	18	19	36	31	21
Average crew size	4.0	5.8	5.9	5.0	5.8	6.3
Revenue per day absent ($)	4117	5016	2855	5428	4908	5592
Pounds per day absent	5918	6743	3777	8250	6498	6612
Average number of trips per vessel	3	4	3	7	6	4

Northeast Scallop Dredge

Table 11 shows the activity of the Northeast sea scallop fleet for tonnage classes 3 and 4. Tonnage class 2 vessels, which have not been included in the table prior to 1991 due to negligible levels of effort and landings, have started to account for a greater level of activity. Annual landings decreased and income earned by this fleet fell slightly during 1992. For tonnage class 3 and 4 vessels, revenue per day absent remained fairly even overall, but landings per day absent fell sharply.

Information from individual vessel files reveals that about 80 percent of tonnage class 2 scallop vessels were absent for fewer than 25 days; for tonnage class 3, the number of vessels absent for more than 200 days per year increased from 2 percent of the total in 1982 to 63 percent in 1992. For tonnage class 4 vessels, the percentage increased from 31 percent in 1982 to 74 percent in 1992. On an individual vessel basis, 92 percent of tonnage class 2 otter trawl vessels had revenues less than $50,000; only 3 percent of the tonnage class 3 vessels earned less than $50,000; and 84 percent had revenues greater than $300,000. Ninety-one percent of the tonnage class 4 vessels grossed more than $400,000.

Note that crew size numbers are based upon vessel berths and do not represent actual observations of crew at the end of a trip. For the scallop fleet, the number of people represented as full-time crew is likely to be underestimated due to incentives to carry more crew than sleeping spaces.

Northeast Shrimp Trawl

The northern shrimp fishery is seasonal. Ninety-six percent of the shrimp landings are made by vessels using the shrimp trawl, generating revenue of over $7 million in 1992. Total revenue and landings decreased from 1991 levels, but total effort increased. There were also substantial decreases in landings per day absent and revenue per day absent.

More than 80 percent of the fleet is composed of small, tonnage class 2 vessels. The principal gears used by these vessels in the six month off-season are otter trawls, gill nets and lobster traps. Table 12 show the activity of this fleet in pursuing shrimp in addition to all its other fishing activity. Shrimp trawl gear was used on 29 percent of the days these vessels spent at sea, and it contributed about 28 percent to total revenue.

Northeast Gill Net

This is a broad category of gear, but it excludes the large mesh drift net used for large pelagics. Small mesh drift and sink gill nets capture a substantial amount of pollock, a small amount of bluefish, and several other groundfish species (Table 13). Ninety-three percent of gillnetters are small tonnage class 2 vessels that employ other gear for approximately 20 percent of the year, usually otter trawls and shrimp trawls. Individual vessel files reveal that, in 1992, 42 percent of gillnetters fished in more than one statistical area compared to 24 percent 10 years ago.

The total number of vessels in this fishery increased steadily between 1986 and 1989, decreased in 1990, but increased in 1991 and again in 1992 to 258 vessels. Average revenue increased in 1992, but revenue per day absent and average landings fell for the majority of vessels.

Some restrictions on effort are being considered on the use of this gear due to conflicts arising with the interaction of marine mammals, primarily the harbor porpoise. Final implications will become apparent when the Marine Mammal Protection Act is fully implemented in October 1993.

Table 11. Northeast scallop dredge vessels, all gears used

	Ton Class 2		Ton Class 3						Ton Class 4					
	1991	1992	1987	1988	1989	1990	1991	1992	1987	1988	1989	1990	1991	1992
Vessel count	32	50	101	111	116	129	114	112	116	136	159	161	153	148
Average age	23	23	13	14	15	16	16	17	13	12	13	13	14	14
Average grt	27	26	121	119	119	118	119	121	182	181	182	181	181	182
Average days absent	53	50	147	149	149	152	178	178	182	185	182	191	213	211
Average crew size	3.0	2.9	7.8	7.5	7.7	7.3	7.5	7.7	9.8	9.5	9.3	9.2	9.6	9.5
Revenue per day absent ($)	1241	1018	3150	2682	2421	2542	2524	2475	3969	3440	3301	3399	3283	3423
Pounds per day absent	2598	2104	6583	5644	5412	5887	5483	4522	7611	7097	7249	7129	6448	5813
Average number of trips per vessel	32	20	18	18	20	19	22	22	18	19	18	19	20	19

Table 12. Northeast vessels that used shrimp trawls, all gears used and shrimp gear only

	Ton Class 2						Ton Class 3					
	1987	1988	1989	1990	1991	1992	1987	1988	1989	1990	1991	1992
All Gears												
Vessel count	198	207	169	178	165	186	61	55	49	46	33	38
Average age	18	20	20	18	20	18	19	22	20	20	22	22
Average grt	24	25	26	26	25	24	83	77	81	78	76	73
Average days absent	66	63	63	67	69	66	129	106	100	115	117	123
Average crew size	2.4	2.5	2.4	2.4	2.6	2.4	5.3	4.9	4.8	4.8	4.4	4.4
Revenue per day absent ($)	1050	831	845	873	1054	984	1953	1427	1461	1619	1925	1631
Pounds per day absent	1567	1454	1324	1673	1919	1512	3441	2914	2385	3022	3719	3216
Average number of trips per vessel	60	58	59	60	61	57	72	75	64	67	66	58
Shrimp Trawl Gear Trips												
Average days absent	28	24	28	27	24	21	37	28	35	36	34	27
Average crew size	2.4	2.5	2.4	2.4	2.6	2.4	5.3	4.9	4.8	4.8	4.4	4.4
Revenue per day absent ($)	1126	902	902	808	972	957	2211	1722	1418	1448	1740	1696
Pounds per day absent	1155	912	1006	1164	1115	984	2290	1994	1712	2271	2120	1738
Average number of trips per vessel	28	23	27	26	23	21	29	25	32	30	32	26

Table 13. Northeast vessels that used gill nets, all gears used and gill net trips only

	Ton Class 2						Ton Class 3					
	1987	1988	1989	1990	1991	1992	1987	1988	1989	1990	1991	1992
All Gears												
Vessel count	185	215	224	209	240	240	5	15	23	16	12	18
Average age	14	14	14	15	14	15	19	16	18	14	15	16
Average grt	21	22	21	22	22	22	89	79	81	80	80	83
Average days absent	62	62	67	72	73	75	79	93	92	110	74	100
Average crew size	2.8	2.8	2.6	2.7	2.6	2.7	5.0	3.6	4.3	4.3	5.8	4.0
Revenue per day absent ($)	1193	951	1117	1031	1173	1163	2227	2037	2247	1959	1743	1821
Pounds per day absent	2893	2682	3429	2407	2263	2244	2928	4344	8963	3875	3339	3601
Average number of trips per vessel	54	54	61	64	64	62	35	46	51	58	46	49
Gill Net Trips Only												
Average days absent	49	50	51	58	57	59	27	31	45	54	53	34
Average crew size	2.8	2.8	2.6	2.7	2.6	2.7	5.0	3.6	4.3	4.3	5.8	4.0
Revenue per day absent ($)	1209	908	1126	1042	1138	1152	2187	1995	2658	1949	1737	1746
Pounds per day absent	2702	2545	3006	2555	2447	2435	2230	5041	6185	5323	3848	4068
Average number of trips per vessel	43	43	47	52	49	48	20	22	21	35	40	19

Longline and Line Trawl

These related gears land the vast majority of swordfish, bigeye and yellowfin tuna, about half of the tilefish, and a small amount of cod.

Participation in this fleet remained strong with the number of vessels increasing by 5 to 208 (Table 14). Average revenue for all vessels decreased by 7 percent in 1992, while average landings increased by 15 percent over 1991 levels. Landings per day absent were significantly greater in 1992 among all size vessels. In general, the larger the vessel class, the more these two gear types contribute to total fishing activity.

Surfclam and Ocean Quahog Dredge

This fishery has stabilized in some respects due to the individual transferable quota (ITQ) management system. The number of vessels in the fishery remained at 119, the same level as in 1991. Some growth continued in the smallest vessel class at the expense of a decline in the number of larger vessels. Many of these small vessels are not limiting their activity to Mid-Atlantic ports, while the largest vessels are landing exclusively in Mid-Atlantic and Chesapeake ports.

The activity represented in Table 15 is divided between the activity of all vessels in the Northeast region using that gear and the activity of vessels that landed in the Mid-Atlantic. Of the 119 vessels operating in the region, 32 vessels landed away from Mid-Atlantic or Chesapeake ports.

An interesting event in the surfclam fishery (and the ocean quahog fishery to a lesser extent) is apparent from examining the price data. It appears that some vessels are harvesting surfclams that are owned by someone else's ITQ, thereby obtaining about half the price with the remaining value accruing to the real owner of the ITQ. The lower price received by the vessel reflects the rental price for capital and labor services used to harvest the resource, which is lower than the full market value of the clams.

The revenue for the surfclam fishery, as previously shown in Table 3, was adjusted so that the price paid to the ITQ owner was taken into account. In the case of vessel performance, Table 15, we left the revenue unadjusted, so it reflects what the vessels are actually earning.

Offshore Lobster Traps/Pots

The delineation between offshore and inshore fisheries is admittedly cloudy, as many vessels fish both sides of the three-mile line that divides inshore from offshore. Roughly 25 percent of the lobster revenue was from the use of offshore gear, while 75 percent was due to the use of inshore lobster gear.

This fleet continues to be predominantly tonnage class 2 and 3 vessels (Table 16). Annual landings of offshore lobster and fleet total revenues appear to have fallen dramatically, although this may reflect the presence of late data. Substantially less effort was expended in 1992. Landings per day absent were uniformly low and vessels were less dependent on lobster gear alone for their income.

Table 14. Northeast vessels that used longlines or line trawls, all trips regardless of gear used and longline/line trawl trips

	Ton Class 2					Ton Class 3					Ton Class 4				
	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992
All Gears															
Vessel count	75	71	90	119	135	70	62	60	76	65	19	16	11	8	8
Average age	14	15	14	13	14	11	11	12	13	13	9	6	6	7	7
Average grt	23	23	27	26	24	92	94	91	89	90	172	173	174	177	173
Average days absent	51	52	55	59	62	83	85	88	97	104	93	119	111	138	119
Average crew size	2.6	2.4	2.7	3.1	2.8	4.7	4.8	4.4	4.6	4.4	7.2	6.9	6.0	6.1	6.7
Revenue per day absent ($)	1414	1217	1334	1719	1577	2541	2382	2516	2567	2563	3503	3395	3709	3440	2890
Pounds per day absent	1654	1878	1732	1821	1846	1063	1125	1307	1538	1826	1244	1832	1911	2209	3879
Average number of trips per vessel	36	40	36	41	41	10	10	12	15	16	3	6	6	8	12
Longline/Line Trawl Trips Only															
Average days absent	39	36	32	32	33	61	65	71	71	84	92	105	103	107	114
Average crew size	2.6	2.4	2.7	3.1	2.8	4.8	4.8	4.4	4.6	4.4	7.2	6.9	6.0	6.1	6.7
Revenue per day absent ($)	1450	1239	1428	1966	1691	2538	2456	2626	2710	2506	3507	3375	3641	3686	2922
Pounds per day absent	1394	1414	1259	1529	1447	1029	949	1068	1347	1367	1243	1287	1519	1433	1533
Average number of trips per vessel	25	25	15	18	16	5	5	7	8	10	3	4	5	5	7

Table 15. Northeast region surfclam and ocean quahog vessels and Mid-Atlantic vessels, all trips

	Ton Class 2					Ton Class 3					Ton Class 4				
	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992
All regional Surfclam/Ocean Quahog Vessels															
Vessel count	11	10	9	31	36	89	87	81	60	59	44	46	43	28	24
Average age	44	42	41	13	15	22	22	23	21	22	26	25	27	21	19
Average grt	42	42	42	22	21	103	103	104	109	108	190	189	189	181	175
Average days absent	48	43	46	27	36	54	61	45	61	81	78	67	58	92	137
Average crew size	3.1	3.0	3.0	2.7	2.6	4.0	3.8	4.0	4.1	4.0	8.3	8.3	8.6	9.6	9.6
Revenue per day absent ($)	2281	2217	2254	2024	1308	4556	4633	6621	6577	5849	5509	5625	7198	7626	6281
Pounds per day absent (live wt.)	23934	22995	19854	16575	12386	63269	71479	98106	102875	92354	109027	110653	121480	127243	103491
Average number of trips per vessel	38	36	50	43	36	46	60	55	67	70	66	61	58	91	107
Mid-Atlantic Surfclam/Ocean Quahog Vessels															
Vessel count	9	8	6	11	10	81	81	78	57	53	43	46	42	27	24
Average days absent	34	37	36	15	19	50	60	45	59	83	79	67	57	93	137
Average crew size	3.1	3.0	3.0	3.1	3.3	3.9	3.9	4.0	4.1	4.1	5.6	8.3	8.7	9.4	10.3
Revenue per day absent ($)	2385	2279	2183	3203	3685	5042	4879	6699	6893	6045	5556	5625	7354	7608	6281
Pounds per day absent (live wt.)	26343	24626	21169	55225	64437	72591	76227	99907	110209	95306	110290	110653	122893	128787	103491
Average number of trips per vessel	34	36	44	15	17	46	61	56	69	72	67	61	59	93	107

Table 16. Northeast vessels using offshore lobster gear, all trips and offshore lobster trips

	Ton Class 2					Ton Class 3					Ton Class 4				
	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992	1988	1989	1990	1991	1992
All Gears															
Vessel count	26	41	61	61	57	40	42	44	39	31	4	3	4	4	3
Average age	12	15	15	15	17	10	10	10	11	12	4	5	10	11	8
Average grt	28	24	23	23	23	84	86	87	90	91	168	172	178	178	172
Average days absent	69	88	104	125	106	135	139	120	145	129	140	169	188	235	152
Average crew size	3.1	2.7	2.6	3.2	3.2	4.2	4.2	4.3	4.2	4.0	5.0	5.0	5.0	5.0	5.0
Revenue per day absent ($)	1564	1255	1246	1083	948	2469	2215	2753	2591	2996	3571	3259	2997	3382	3745
Pounds per day absent	814	549	683	674	495	1002	948	1352	1330	1228	2795	1308	3626	3095	1516
Average number of trips per vessel	34	69	86	106	92	36	35	34	39	35	43	45	74	83	42
Offshore Lobster Trips Only															
Average days absent	51	40	57	100	30	123	132	112	104	51	102	169	103	149	93
Average crew size	3.1	2.7	2.6	3.2	3.2	4.2	4.2	4.3	4.2	4.0	5.0	5.0	5.0	5.0	5.0
Revenue per day absent ($)	1728	1371	1509	1065	1420	2582	2268	2848	2686	2981	3977	3253	3228	3632	3480
Pounds per day absent	742	575	653	411	520	1000	944	1199	1133	1102	1572	1306	1616	1647	1506
Average number of trips per vessel	17	22	40	85	20	30	31	28	29	13	27	45	41	55	24

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 because of the region's proximity to Canadian fishing ports. In 1992, this deficit decreased by $162 million. Imports decreased in value by approximately $158 million while the value of exports increased by $4.6 million.

Declines in product specific imports (Table 17) were led by frozen groundfish blocks ($104.3 million), frozen groundfish and flatfish fillets ($99.4 million), canned tuna ($31.9 million), fresh or frozen salmon ($11.7 million), and minced fish ($10.6 million). These were offset partially by increases in the value of imported scallops ($29.9 million), shrimp products ($46.8 million), frozen lobster ($8.3 million), fresh whole groundfish, halibut and other flatfish ($9.4 million), salted or dried groundfish ($7.3 million), and crab products ($5.6 million).

Increases in product-specific exports (Table 18) include fresh lobster ($13.8 million), fresh or frozen dogfish ($8.0 million), fresh or frozen salmon ($7.8 million), sea urchin roe ($8.2 million), fresh or frozen squid ($3.0 million), butterfish ($1.2 million), and fish sticks and portions ($4.0 million). These increases were partially offset by decreases in product specific exports of fresh or frozen cod ($7.0 million), fresh or frozen mackerel ($3.7 million), fresh or frozen tuna ($6.2 million), fresh or frozen fish fillets ($10.7 million), fresh or frozen scallops ($8.2 million), frozen shrimp ($2.6 million), and canned shrimp ($1.9 million).

Canada has traditionally been the most important trading partner with the New England states. In 1992, imports from Canada into New England decreased (live-weight equivalent basis) in four of five market categories, scallops being the only exception (Table 19). The large, 41 percent decline in cod (live-weight equivalent) may be due to the closing of cod fishing grounds adjacent to Newfoundland by the Canadian government during 1992. Additionally, some large U.S. institutional buyers switched from cod to pollock during 1992 because of the lower cost of pollock. Imports of groundfish from Canada decreased 6 percent from 102.6 (live-weight equivalent) to 96.4 mt. Flatfish imports declined 33 percent from 50.2 to 33.5 mt (live-weight equivalent). Imports of cod from all countries other than Canada also declined from 119.7 to 115.7 mt, while imports of flatfish and other groundfish from these other countries both increased. However, the increase in imports from other countries was not enough to offset the decline in Canadian imports, meaning that the overall level of imports of cod, flatfish, and other groundfish declined. Canada was able to increase exports of scallops to New England from 6.2 to 7.6 mt, an increase of 23 percent.

Canada was also the market where the most New England fishery products were exported to on a value basis (Table 20). However, seven of the top ten countries to which New England exports on a value basis belong to the European Economic Community (EEC). Taken as a block, the value of exports to the seven listed EEC nations

Table 17. Northeast region, value of imported edible fishery products (millions of dollars) for selected years

Product Category	1991	1992
Fresh or frozen sea herring	4.20	3.46
Fresh whole groundfish, halibut and other flatfish	36.02	45.46
Frozen whole groundfish, halibut and other flatfish	14.25	7.07
Salmon, fresh or frozen	76.00	64.34
Frozen groundfish blocks	347.49	243.15
Other fish fresh or frozen	55.01	54.32
Ocean perch fillets	62.52	66.68
Fresh groundfish and flatfish fillets	42.57	39.18
Frozen groundfish and flatfish fillets	383.36	283.93
Other fresh, frozen fillets	128.72	126.58
Salted or dried groundfish	31.09	38.39
Salted herring	3.82	3.73
Canned tuna	178.81	146.94
Canned sardines	30.07	26.61
Minced fish	27.23	16.65
Clam products	8.58	10.95
Crab products	40.09	45.71
Lobster, fresh	113.18	114.12
Lobster, frozen	115.68	123.99
Other lobster products	45.03	51.04
Scallops	77.93	107.80
Shrimp products	377.24	424.08
Squid	11.20	11.44
Other fishery products	158.30	155.10
Total	**2,368.4**	**2,210.7**

exceeded the New England export value to Canada. During 1992, exports to six of these seven countries increased on a value basis, while exports to Canada decreased from 1991 levels. The leading products exported to the seven EEC nations were fresh lobster ($19.2 million), fresh or frozen dogfish ($5.8 million), fish (non-specified product form) fillets ($5.5 million), and fish sticks ($4.9 million). Together, these accounted for nearly 61 percent of the New England export value to the seven countries. The EEC is expected to continue to be an important trading partner for the New England states in the future.

Table 18. Northeast region, value of exported fishery products for selected years (millions of dollars)

Product Category	1991	1992
Herring, fresh or frozen	0.59	0.81
Processed herring products	9.63	10.06
Salmon, fresh or frozen	15.86	23.74
Cod, fresh or frozen	25.44	18.43
Mackerel, fresh or frozen	4.63	0.96
Dogfish, fresh or frozen	6.99	15.00
Butterfish	1.87	3.12
Tuna, fresh or frozen	25.56	19.34
Other fish, fresh or frozen	52.18	49.34
Fish fillets, fresh or frozen	41.21	30.53
Fish sticks & portions	8.88	12.90
Sea urchin, live	5.76	6.64
Sea urchin, roe	12.75	20.98
Other roe products	7.39	6.61
Shrimp, fresh	2.55	2.74
Shrimp frozen	27.62	25.00
Shrimp canned	11.13	9.22
Lobster, fresh	62.17	76.00
Lobster, frozen	2.94	3.91
Other lobster products	1.97	1.25
Crab products	5.41	6.53
Squid, fresh or frozen	12.73	15.71
Shellfish, fresh	5.38	5.39
Clam products	5.18	4.43
Scallop, fresh or frozen	16.62	8.44
Other shellfish	3.47	1.86
Other edible fishery products	27.91	29.52
Totals	**403.82**	**408.46**

PROCESSING

Fish processing in the Northeast Region uses domestic landings and, increasingly, imported product for its supplies. The most important materials processed continue to be imported frozen blocks of fish followed by industrial grade menhaden and herring. Edible fish product processing of regionally caught species was again headed by surfclam 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 survey conducted by the port agents, are shown in Table 21 for 1988 to 1992. In 1992, the total number of plants increased slightly. The level of employment has fallen, though, as the average number of employees per plant declined. The number of processing firms has fallen in recent years, resulting from a shrinking supply of fresh domestic fish, while the number of wholesaling firms has remained fairly steady.

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 starting in 1982. Since that time, directed foreign fishing has been phased out and, as of 1992, no foreign fishing was allocated. Also in 1992, there were no nations participating in joint ventures with the U.S. within the EEZ. Since the U.S. demand is low relative to the potential sustainable yields of Atlantic mackerel, this species is still considered a viable one for future joint venture operations.

RECREATIONAL FISHING

At press time for this volume, NMFS had not finished analyzing all data from its 1992 Marine Recreational Fishing Statistics Survey. However, the Fisheries of the United States, 1992 (NMFS 1992) reports that anglers caught roughly 100 million marine finfish during more than 19 million fishing trips in the Northeast Region during 1992. This catch was nearly 40 percent less than during 1991. Fishing from private or rental boats was the most common mode (55 percent of total fishing trips), followed by shore fishing (37 percent of trips), and then party and charter boat fishing. Most activity took place in the Mid-Atlantic area (81 percent of catch and 67 percent of trips).

The most-caught species was summer flounder followed in decreasing order by spot, Atlantic croaker, scup, bluefish, and black sea bass. Scup and bluefish led in New England, and spot, summer flounder, and Atlantic croaker topped the list in the Mid-Atlantic.

Although poorly understood in the Northeast, progress was made on studying the economic demand for and value of recreational fishing. The Woods Hole Oceanographic Institution's Marine Policy Center received Saltonstall-Kennedy funding to study the recreational component of the U.S. Atlantic bluefin tuna fishery. In addition, the Northeast Fisheries Science Center of NMFS expects funding to collect substantial economics data from the Marine Recreational Fishing Statistics Survey during 1994. However, there is still a need to understand the true impacts of anglers' expenditures on local and regional economies. Some popular varieties of economic impact analysis are generally believed to exaggerate the expected impacts of management on income and employment in the Northeast (see Edwards 1991).

Table 19. New England imports (thousands of metric tons) of selected fishery products from Canada and all other sources 1991-1992[1,2]

Product	1991		1992	
	Canada	Other	Canada	Other
Cod	210.86	119.71	124.43	115.66
Groundfish[3]	102.56	135.2	96.36	136.94
Flatfish[4]	50.18	10.06	33.48	14.79
Other finfish	27.87	41.54	26.62	52.13
Scallops	6.24	1.33	7.6	1.27

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

Table 20. Top ten countries to which New England states export, ranked by value of exports in dollars, 1991-1992[1]

Country	Value	
	1991	1992
Canada	59,795,583	54,752,180
France *	21,719,717	29,195,613
Italy *	7,169,458	7,440,918
Japan	8,394,191	6,730,695
Belgium *	3,353,261	6,067,408
United Kingdom *	4,307,153	5,539,260
Germany *	4,255,778	5,389,655
Norway	1,326,127	3,036,712
Spain *	2,786,843	2,607,364
Portugal *	1,835,397	1,997,709
Total	**114,943,508**	**122,757,514**

[1] * denotes EEC country

NET NATIONAL BENEFITS

The Magnuson Fishery Conservation and Management Act of 1976 (Magnuson Act) was enacted, in part, to create, sustain and improve economic benefits from exploitation of fishery resources within 200 miles of the U.S. shoreline. Although its meaning and scope are poorly understood, economic efficiency is central to the well-being of the U.S. fishing industry, to processors, and to thousands of fresh seafood consumers in the Northeast. See last year's report for a discussion of economic efficiency and why it is important.

The economic value of a natural resource, such as marine fish, an oil pool on the continental shelf, or waterfront property, is known as resource rent in economics circles. With the notable exception of surfclam and ocean quahog resources, which are subject to individual transferable quota property rights, there was little progress toward improving the resource rents of fish resources in the region during the past year. The renewable fish resources themselves remain subject to virtual open access, hence only harvest is valued. Past attempts by management authorities to regulate harvest by means of traditional effort and quota restrictions have served only to increase the costs of management, enforcement, and fishing. A good illustration is in the New England groundfish fishery, which is now widely recognized as being grossly overcapitalized and its resources severely depleted. Foreign resource rents in this fishery run into the hundreds of millions of dollars annually (*e.g.*, Edwards and Murawski in press).

There are indications of change during 1992, however. The New England Fishery Management Council, against considerable odds, proposed moratoria in two of the region's most important fisheries--Atlantic sea scallops and groundfish. Moratoria alone will add little immediately to resource rents in these fisheries. However, without moratoria, resource rents--or what would most likely translate in financial terms to considerably more income for the fishing and processing industries--are inconceivable.

Table 21. Marine products processing and wholesaling establishments and their employment levels for 1988-1992

	Processing		Wholesaling		Total	
	Plants	Employees	Plants	Employees	Plants	Employees
1988						
New England	261	6582	627	2470	888	9052
Mid-Atlantic & Chesapeake	210	7739	363	2760	573	10499
Northeast Region	471	14321	990	5230	1461	19551
1989						
New England	252	6182	682	2745	934	8927
Mid-Atlantic & Chesapeake	191	7472	371	2860	562	10332
Northeast Region	443	13654	1053	5605	1496	19259
1990						
New England	247	5649	691	2918	938	8567
Mid-Atlantic & Chesapeake	176	6483	361	2687	537	9170
Northeast Region	423	12132	1052	5605	1475	17737
1991						
New England	245	5530	685	2974	930	8504
Mid-Atlantic & Chesapeake	165	6384	335	2554	500	8938
Northeast Region	410	11914	1020	5528	1430	17442
1992[1]						
New England	243	5516	689	2760	932	8276
Mid-Atlantic & Chesapeake	169	6212	360	2125	529	8337
Northeast Region	412	11728	1049	4885	1461	16613

[1] 1992 figures are preliminary

For Further Information

Edwards, S.F. 1991. A critique of three "economics" arguments commonly used to influence fishery allocations. *No. Am. J. Fish. Manage.* 11: 121-130.

Edwards, S.F. and S.A. Murawski. In press. Potential economic benefits from efficient harvest of New England groundfish. *No. Am. J. Fish. Manage.*

HEALTH OF THE ECOSYSTEM

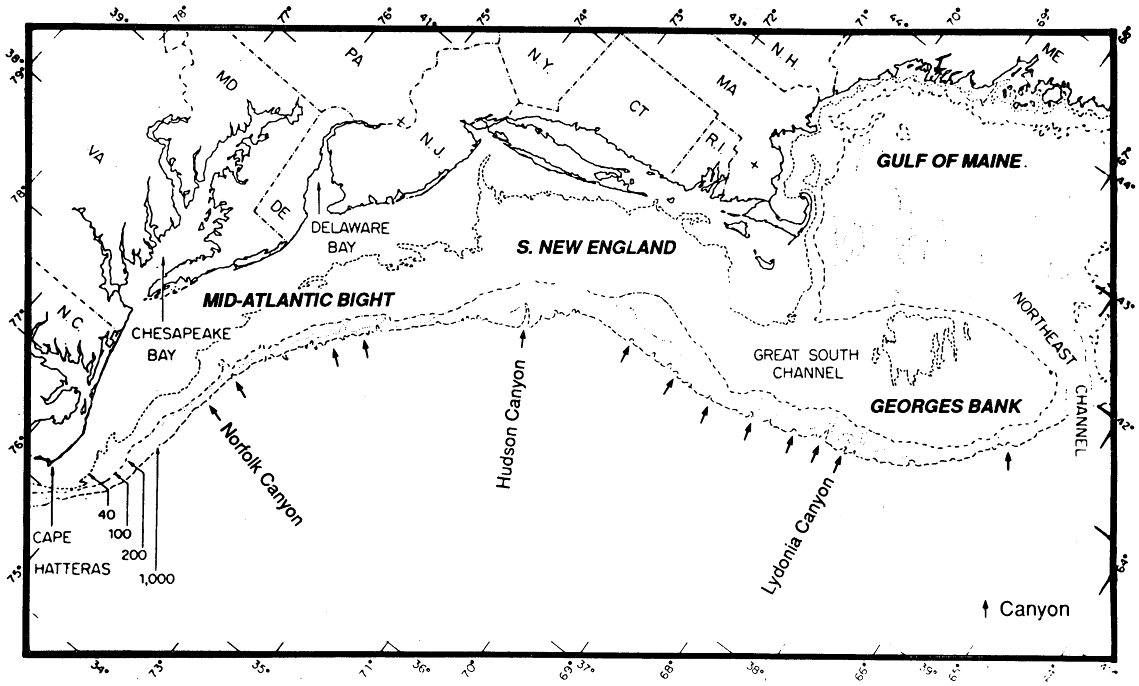


Figure 7. Bottom topography of the Northeast Shelf of the United States, from Cape Hatteras to the Gulf of Maine.

This report is based in part on an earlier article appearing in *Nor'Easter, Magazine of the Northeast Sea Grant Programs* 4(2):14-19.

ECOSYSTEM FEATURES

The Northeast continental shelf ecosystem consists of a broad shallow shelf, a cold, deep-water basin - - the Gulf of Maine - - and its surrounding watersheds (Figure 7).

It is the interaction of submarine topography with currents, water temperatures, salinities, and nutrient run-off from the rivers and estuaries of the region that shapes the characteristics of the natural productivity of the coastal waters from the Gulf of Maine to Cape Hatteras. The assemblages of microscopic plant plankton (phytoplankton) and animal plankton (zooplankton), fish, marine mammals, and marine birds that inhabit these waters have evolved over the millennia within the distinctive bathymetry, hydrography, and productivity of the waters of the Northeast Continental Shelf into an interactive and changing large marine ecosystem (LME). The Northeast Shelf is one of seven LMEs located around the margins of the United States (Figure 8). The LMEs of the United States are highly productive. In the absence of intervention by humans, the marine populations inhabiting these waters would be flourishing. Unfortunately, the normal activities of urban society have intervened with the natural cycles of production of LMEs. Refuse has been dumped in them. Aerosols from automobile exhausts and industrial stacks fall out into the coastal waters. Tons of dissolved organic compounds and heavy metals from coastal urban centers, along with nitrates and phosphates released from waste treatment plants contribute an over-supply of nutrients that tend to "overload" the natural productivity cycles in near-coastal waters. The effect of this contamination of coastal ecosystems appears to have taken the form of more frequent and extensive unusual algal blooms.

For the 260,000 km^2 Northeast Continental Shelf LME, extending from the Gulf of Maine to Cape Hatteras, it is important to assess, as a basis for remedial action, the effects of pollutants from the activities of 54 million people generating about 7 billion gallons of wastewater per day and the impacts of contaminants from atmospheric deposition, and from 500,000 km^2 of watersheds, on the billion-dollar-a-year fisheries industry and the multibillion-dollar recreation and tourism industries that depend on a healthy ecosystem.

Within the Northeast Shelf Ecosystem, massive outbreaks of algal blooms off the coasts of New York and southern New England severely damaged the annual multimillion dollar bay scallop industry in 1985. In recent years, toxic algal blooms have been suspected as the source of mortalities of marine mammals (whales and dolphins) found washed ashore along the East Coast. The same coastal areas have been impacted by floatables, including coastal litter composed of discarded plastics and medical wastes (*e.g.*, syringes, blood vials, surgical tubing) that have washed up on beaches, particularly in the New York area.

Human interventions continue to exert significant impacts on the natural biological cycles of the Northeast Shelf Ecosystem. The adverse impact of an expanding urban population in the northeast (Figure 9a,b) is evident in the deteriorating quality of the coastal environment. The sources of deterioration include: municipal and industrial waste effluents, organic matter, and suspended solids (increasing biochemical oxygen demand, nutrient overenrichment, and spills of toxins). Direct or indirect physical disturbance of habitats, loss of wetland nursery grounds, and losses of the full economic potential of fish and shellfish harvests have been occurring from the impacts of pathogens, biotoxins, and excessive harvesting rates.

Evidence of potential human health problems, stresses on different components of the coastal ecosystem, and warning signs of environmental degradation of the Northeast Shelf Ecosystem often result in emergency management responses that include:

- closure of shellfish harvests due to pathogens or biotoxins resulting in loss of livelihood and economic hardship;
- closure of recreational use of beaches (*i.e.*, swimming, strolling, and sunbathing) due to bacterial abundance in the water and soil;
- closure of recreational facilities due to accumulation of garbage, medical wastes, and other floatables on beaches;
- issuance of advisories concerning high concentrations of pollutants in the fish, sediment, and other parts of the coastal environment; and
- notifications regarding closure of public access to resources or amenities, fish kills, putrefaction of organics, and loss of valued wildlife and fishery resources due to chronic pollution or an accidental event.

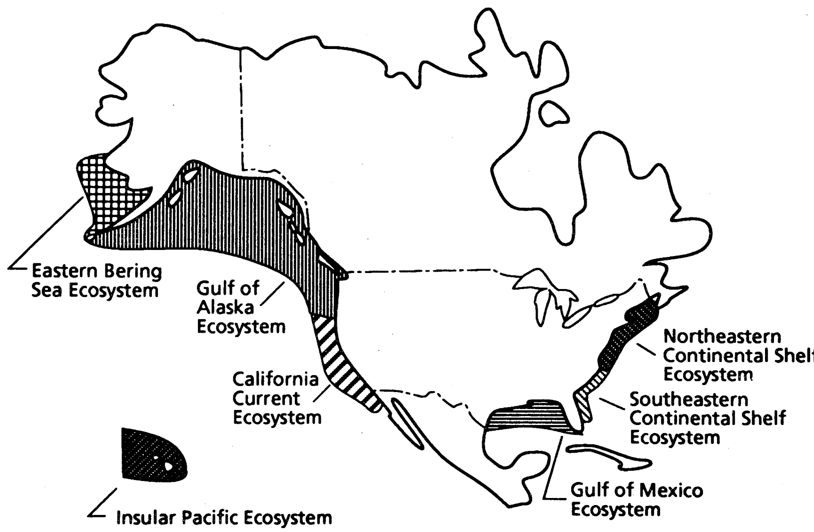


Figure 8. The seven large marine ecosystems of the United States, including the insular Pacific Hawaiian Islands.

Changing Ecosystem States and Health Indices

As the near-coastal area of the Northeast Shelf Ecosystem continues to deteriorate under the stresses imposed by the growing needs of a sprawling coastal megalopolis from Washington to Boston, concern for the "health" of the ecosystem is growing. Increasing attention has been focused over the past few years on synthesizing available information on factors influencing the natural productivity of the fishery biomass and the changing states and health of the Northeast Shelf Ecosystem in an effort to identify and, where appropriate, to mitigate principal, secondary, and tertiary driving forces causing major changes in ecosystem states and biomass yields. Ecosystem "health" is a concept of wide interest for which a single precise scientific definition is problematic. Ecosystem health is used in this report to describe the resilience, stability, and productivity of the Northeast Shelf Ecosystem in relation to the changing states of marine ecosystems. A means for assessing the "health" of the ecosystem is based on a series of indicators and indices (Costanza 1992, Rapport 1992, Norton and Ulanowicz 1992, Karr 1992). The overriding objective is to monitor changes in "health" from an ecosystems perspective as a measure of the overall performance of a complex system (Costanza 1992). The "health" paradigm is based on the multiple-state comparisons of ecosystem resilience and stability, and is an

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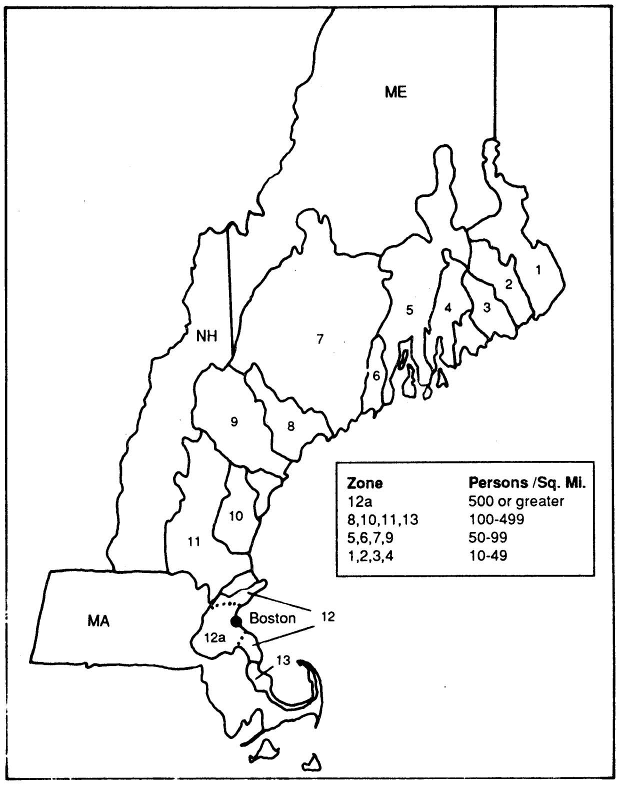

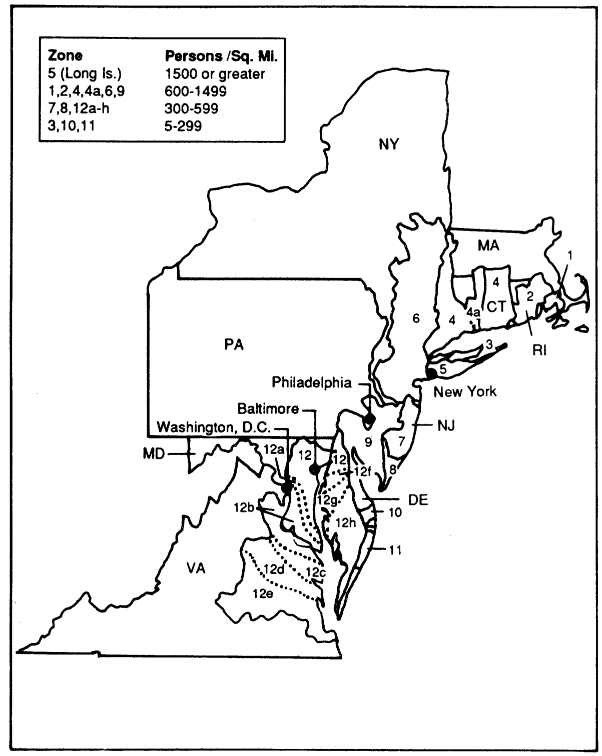

Mid-Atlantic Bight
Estuarine Dependent Areas

1. Buzzards Bay
2. Narragansett Bay
3. Gardiners Bay
4. Long Island Sound
4a. Connecticut River
5. Great South Bay
6. Hudson River/Raritan Bay
7. Barnegat Bay
8. New Jersey Inland Bays
9. Delaware Bay
10. Delaware Inland Bays
11. Chincoteague Bay
12. Chesapeake Bay
12a. Patuxent River
12b. Potomac River
12c. Rappahannock River
12d. York River
12e. James River
12f. Chester River
12g. Choptank River
12h. Tangier/Pocomoke Sounds

Gulf of Maine
Estuarine Dependent Areas

1. Passamaquoddy Bay
2. Englishman Bay
3. Narraguagus Bay
4. Blue Hill Bay
5. Penobscot Bay
6. Muscongus Bay
7. Sheepscot Bay
8. Casco Bay
9. Casco Bay
10. Great Bay
11. Merrimack Bay
12. Massachusetts Bay
12a. Boston Bay
13. Cape Cod Bay

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Population Density, 1960-2010

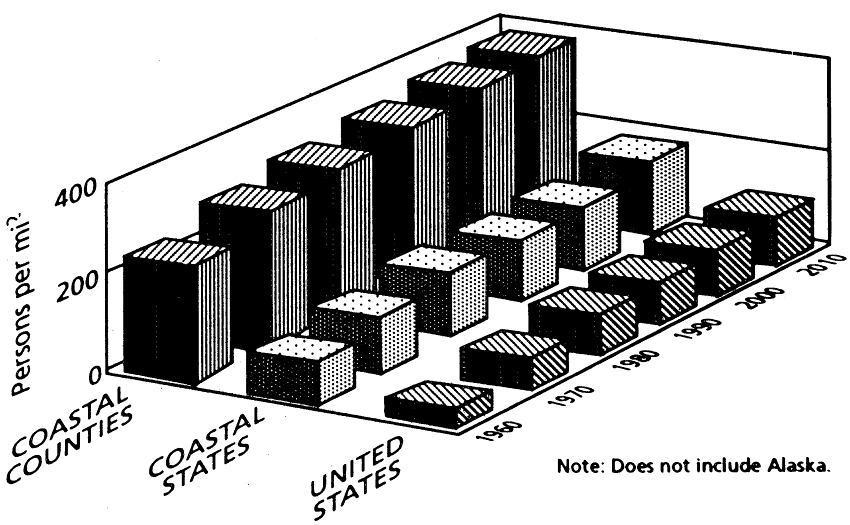

Figure 9. A. Population density and associated estuarine dependent areas (EDAs) along the Northeast Shelf Ecosystem. B. Actual population density and projected population density of coastal counties in coastal states of the United States, 1960-2010.

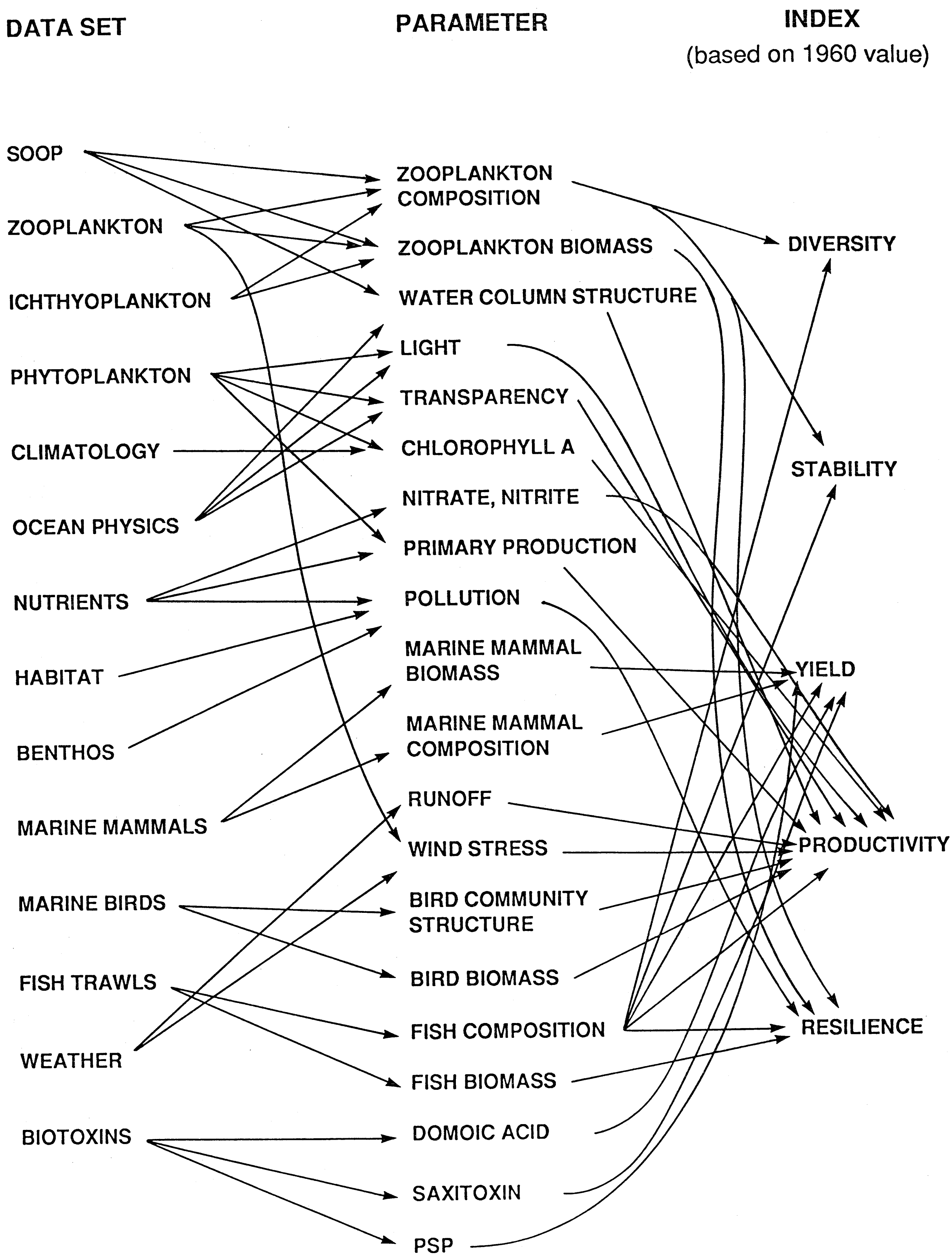

Figure 10. A schematic representation of the data bases and experimental parameters for indexing the changing states of large marine ecosystems. The data base represents time-series measurements of key ecosystem components from the U.S. Northeast Continental Shelf ecosystem. Indices will be based on changes compared with the ecosystem state in 1960.

evolving concept (Pimm 1984, Holling 1986, Costanza 1992). Following the definition of Costanza (1992), to be "healthy" an ecosystem maintains its internal structure and organization, when under stress. Among the indices being developed to measure the changing states and health of the Northeast Shelf Ecosystem are: (1) biodiversity, (2) stability, (3) yield, (4) productivity, and (5) resilience.

The data from which to derive ecosystem indices are obtained from time-series monitoring of key ecosystem parameters. An effort to validate the utility of the indices is under development by the Northeast Fisheries Science Center in collaboration with the Marine Policy Center of the Woods Hole Oceanographic Institution. The ecosystem sampling strategy is focused on parameters relating to resources at risk from overexploitation, species protected by legislative authority (marine mammals), and other key biological and physical components at the lower end of the food chain (plankton, nutrients, hydrography). The parameters used in ecosystem indexing are depicted in Figure 10. They include zooplankton composition, zooplankton biomass, water column structure, photosynthetically active radiation (PAR), water transparency, chlorophyll-a, nitrate, nitrite, primary productivity, pollution, marine mammal biomass, marine mammal composition, runoff, windstress, seabird community structure, seabird counts, finfish species composition, and finfish biomass. Also included are data on the extent and frequency of phytoplankton-related stress from domoic acid, saxitoxin, and paralytic shellfish poisoning (PSP) events. These ecological parameters incorporate the behavior of individuals and the responses of population and communities to perturbations including their interactions with the physical and chemical environment. These selected parameters are used to measure the changing ecological states and "health" of the Northeast Shelf Ecosystem.

Based on recent analyses on the changing states and "health" of the Northeast Shelf Ecosystem (Sherman and Solow 1992), it is clear that significant changes have occurred in the system's biodiversity as defined by dominance shifts in the fish community and both biomass and associated economic yields of the ecosystem. However, the *stability* and *resilience* of the zooplankton and physical patterns of the system remain essentially unchanged for the past 80 years, since the first systematic observations of the ecosystem were made by Henry Bigelow and his colleagues (Bigelow 1926, 1933; Bigelow and Sears 1939, Bigelow, Lillick and Sears 1940, Sherman et al. 1983, 1988, Sherman and Busch, in press).

Biodiversity and Sustainability of Yields

If properly restored and managed, fisheries of the Northeast Shelf LME have a potential annual yield of about 1.1 million mt per year. Current landings are considerably below this total, owing to the overexploitation of some stocks (principal groundfish, scallops, *etc.*) and the underutilization of others (Atlantic mackerel, Atlantic herring, butterfish, *etc.*) In order to produce the yield potential of the system on an annual basis, two things must be accomplished for overexploited stocks: (1) spawning stock biomasses must be increased substantially so that recruitment success improves, and (2) exploitation rates must be reduced to ensure adequate survival of breeders, and to even out year-to-year variations in catch. Restoration of spawning biomasses and lower overall exploitation rates would have several additional positive benefits to the fisheries, including: (1) higher catch per unit of effort, resulting in greater profitability per day fished, (2) larger average fish sizes (which generally result in higher value per unit weight), (3) less variation in landings from trip-to-trip and year-to-year (and thus a more sustainable yield pattern, and (4) less reliance on incoming year classes to support the fishery. The latter benefit is particularily important because discarding rates are very high on new recruits at this time, since there is generally little else to target.

Increased exploitation of underutilized resources such as mackerel, herring, and dogfish would likewise increase overall landings relative to yield potential, and may increase productivity of their prey and competitors. Proper exploitation of the various components of the system should contribute to higher overall yields that are less variable from year-to-year, and which retain the inherent rich diversity in species composition extant in the Northeast Shelf LME.

Environmental Degradation

Human interventions continue to exert significant impacts on the natural biological cycles of the Northeast Shelf Ecosystem. Scientists from NEFSC consider the importance of multispecies interactions in providing advice on management strategies aimed at achieving long-term biological and economic sustainability of the fish populations of the Northeast Shelf Ecosystem. Other considerations are also necessary. In addition to the changing abundance levels of fish stocks within the ecosystem, other recent changes have been observed. The frequency and extent of harmful blooms of planktonic algae have been increasing. The algal species involved have been implicated in oxygen depletions leading to mortalities in shellfish. Other algal species have been responsible for massive mortalities of bay scallops and other molluscan populations in embayments along the southern New England coast. Elevated levels of nutrients, possibly from human sources including wastewater in estuaries and nearshore coastal areas, have been suggested as possible cause for the blooms. Whether the algal blooms are the result of excessive nitrates and phosphates entering coastal waters from waste water is an open question that is under investigation by state and federal scientists.

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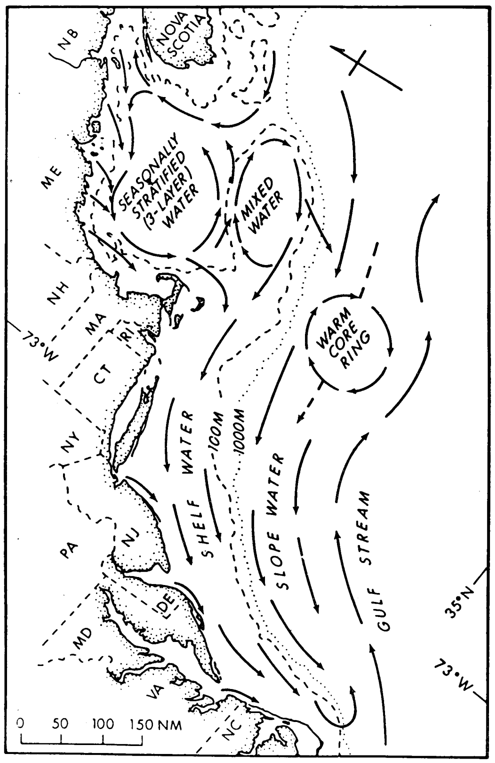

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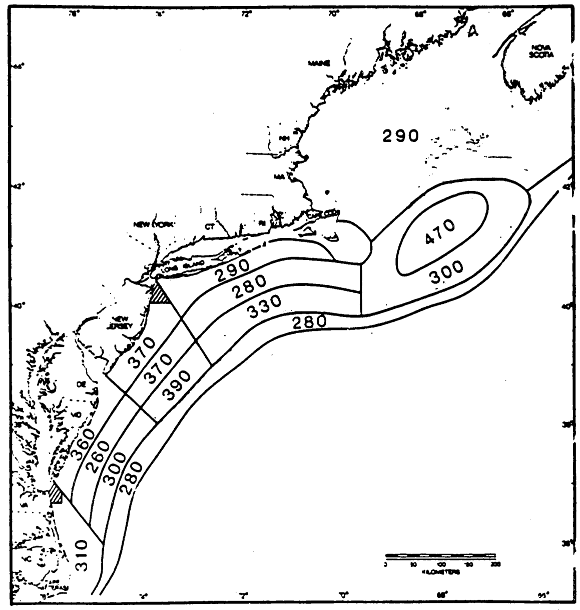

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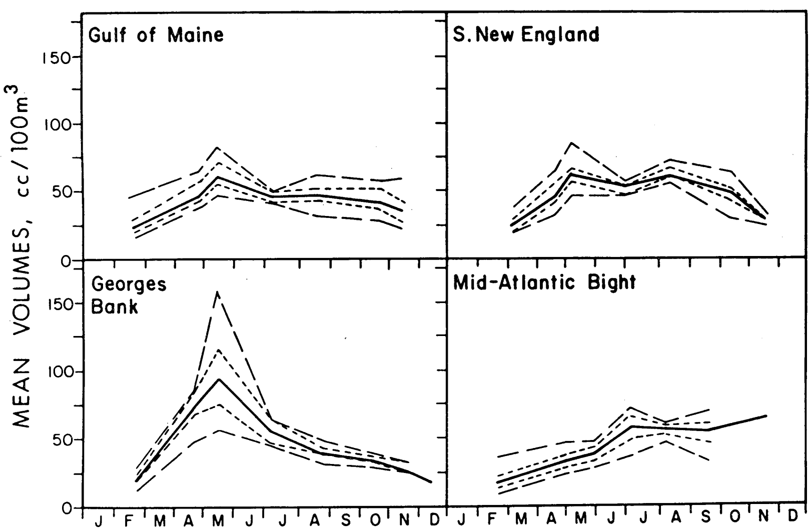

Figure 11. A. Mean, non-tidal surface circulation in the Gulf of Maine, Georges Bank, Southern New England, and the Middle Atlantic Bight. The northern sector of the shelf ecosystem is characterized by a cyclonic gyre and a seasonally stratified three-layered water-mass system over the deep basins of the Gulf of Maine, and a mixed water with an anticyclonic gyre over the shoal bottom of Georges Bank. Farther south, the waters move southwesterly along the broad shelf of Southern New England to the narrower, gently sloping shelf plain of the Middle Atlantic Bight. B. Estimated annual total primary production (particulate and dissolved organic carbon) from Cape Hatteras to Nova Scotia by sub-area ($gC/m^2/yr$ [1 gC = 10 kcal = 41.67 kJ]). C. Seasonal changes in the standing stocks of zooplankton for four areas on the northeast shelf--Gulf of Maine, Georges Bank, Southern New England, and the Middle Atlantic Bight--based on mean monthly volumes in cm^3 $100 m^{-3}$. The short dashed line represents one standard error; the longer dashed line represents the range.

In other parts of the globe, where coastal ecosystem health has been neglected, severe damage to ecosystem productivity and structure has been observed and massive economic losses incurred. Plankton blooms and sewage contamination have also caused health problems from contaminated shellfish. In the more enclosed waters of the Black Sea ecosystem, jellyfish populations are increasing, while the finfish populations are in decline. Reports from the region suggest that these changes reflect a structural change in the species composition and biodiversity of the ecosystem leading to a series of severe economic losses attributed to increasing levels of eutrophication from excessive nutrient loadings from coastal cities and the Danube, Dnieper, Don, Dniester, and Kuban Rivers.

Following a series of outbreaks of toxic planktonic algal blooms causing deaths to thousands of tons of fishes and the occurrence of massive mortality of seals in 1988 from viral infections in the coastal waters of the North Sea Ecosystem, the ministers of eight North Sea States (Belgium, Denmark, France, Germany, Netherlands, Norway, Sweden, United Kingdom) organized a North Sea Task Force to provide a status report on the health of the North Sea ecosystem before the end of 1993. The mortalities were attributed to a growing problem of excessive nutrient loading of coastal waters adjacent to large urban centers and river drainage basin outflows. Remedial efforts are underway to reduce the impact of nutrients from waste treatment plants by 50 percent before the end of 1995.

Stability and Resilience of the Ecosystem

State and federal government agencies in the U.S. and elsewhere are assuming an increasing responsibility for managing marine fisheries, protecting endangered species, reducing pollution levels, and restoring degraded coastal habitats. It is, therefore, not surprising that interest is growing in developing strategies for monitoring, assessing changes, and managing entire marine ecosystems. Studies conducted by the scientists at NEFSC conclude that the Northeast Shelf Ecosystem as a whole remains healthy. The full recovery of herring and mackerel stocks when examined in relation to the system's circulation, productivity levels, and composition of the zooplankton community, attests to the robustness of the ecosystem health (Figures 11a,b,c). However, warning signs have been detected. Nearshore waters are showing signs of stress. It is in these areas that algal blooms may be a response to increased nutrient loadings from waste waters from the urban population centers along the coast (Figure 11b). Treatment of waste waters to remove excessive nitrates and phosphates is under consideration by the Environmental Protection Agency (EPA) as an option for controlling further increases in coastal eutrophication.

It is likely that scientific and management strategies will be more tightly linked in the future. Presently under evaluation are adaptive management strategies that will consider the effects of changes on principal biological populations and their environments from the perspective of the dynamics of whole ecosystems. This is an approach to marine resource utilization that will be focused on the health of coastal ecosystems, their key components, and the economies that are dependent on them (NOAA 1993).

SUMMARY

(1) The Northeast Shelf ecosystem is stressed in the nearshore areas from growing eutrophication and pollution. Relatively small areas considered toxicological "hotspots" have been identified from the monitoring efforts of NOAA and EPA. In these, contaminant loadings of the sediments are quite high. Toxicological effects are expressed in pathological conditions among fish and shellfish. However, no persistent finfish or shellfish population mortalities are associated with present "toxic pollution" levels.

(2) Signs of increasing levels of nutrient overload or eutrophication, resulting in depletion of dissolved oxygen are evident in estuaries and coastal estuarine plumes. The cumulative effects on the nearshore ecology of the Northeast Shelf ecosystem are unknown.

(3) It is not clear if the increasing incidence of biotoxins causing mortalities among marine fish, shellfish, and mammals is associated with an increased frequency and extent of phytoplankton blooms.

(4) Loss of estuarine habitat for spawning and feeding areas by several species continues to be of concern. It is a problem that can be addressed by judicious application of funds accrued from fines levied on polluters to support restoration ecology projects. Restoration projects to reclaim loss of habitat due to pollution have been initiated.

(5) The more open waters of the Northeast Shelf ecosystem are "healthy". The structure and function of the lower end of the food chain is highly productive.

(6) Major shifts in the dominance of the finfish community from gadoids (cod, haddock, pollock, hake) in the 1960s to a predominately elasmobranch (dogfish and skates) and pelagic biomass in 1992 are attributed to perturbations caused by excessive fishing mortality on gadoids and flatfish. The loss of consistently high recruitment of high value gadoids and flounders contributes to the depleted state of the economically desirable fish stocks. Efforts are presently underway to reduce significantly the amount of fishing

effort on the depleted stocks as a part of a program of fish stock rebuilding to be implemented by the New England and Mid- Atlantic Fishery Management Councils.

(7) Consideration is being given to "adaptive management" strategies focused on the effects of directed removals of low-economic yield species (*e.g.*, spiny dogfish, skates, and mackerel) to perhaps enhance recovery of the depleted gadoid and flounder stocks.

(8) Marine mammal populations at risk from fishery-caused mortalities are being subjected to increasing research and monitoring efforts by NMFS-NOAA and other scientific groups and institutions in an effort to ensure recovery of depleted populations and to reduce bycatches in the fisheries that could be detrimental to reproductive and recruitment success, as well as to the rebuilding of depleted populations.

(9) Coordinated programs of principal federal agencies are under way as a result of the recent legislation by the U.S. Congress to improve monitoring strategies aimed at supporting efforts to mitigate detrimental effects of habitat loss, coastal pollution, eutrophication, and overexploitation of marine resources. These efforts are described in NOAA's Strategic Plan for Coastal Ecosystems Health (NOAA 1993).

(10) Pending legislation to provide funds for additional waste-treatment facilities for municipalities, and best management practice for non-point sources along the coast of the Northeast Shelf ecosystem, will aid in reducing the loadings of nutrients and thereby serve to reduce the threat of eutrophication within the estuaries of the region.

REFERENCES

Bigelow, H. B. 1924. Physical oceanography of the Gulf of Maine. *Bull. U.S. Bur. Fish.* 40(Part II):511-1027.

Bigelow, H. B. 1926. Plankton of the offshore waters of the Gulf of Maine. *Bull. U.S. Bur. Fish.* 40:(Part II):1-509.

Bigelow, H. B. 1933. Studies of the waters of the continental shelf, Cape Cod to Chesapeake Bay. I. The cycle of temperatures. *Pap. Phys. Oceanogr.* 2(4):135.

Bigelow, H. B. and M. Sears. 1939. Studies of the waters on the continental shelf, Cape Cod to Chesapeake Bay. III. A volumetric study of the zooplankton. Mem. Mus. Comp. Zool. at Harvard University 54:179-378.

Bigelow, H. B., L. C. Lillick, and M. Sears. 1940. Phytoplankton and planktonic protozoa of the offshore waters of the Gulf of Maine. I. Numerical distribution. *Trans. Am. Philos. Soc., N.S.* 31(Part III):149-191.

Costanza, R. 1992. Toward an operational definition of ecosystem health. *In* R. Costanza, B. G. Norton, and B. D. Haskell, eds., Ecosystem health: New Goals for Environmental Management, p. 239-256. Washington, D.C.: Island Press.

Holling, C. S. 1986. The resilience of terrestrial ecosystems local surprise and global change. *In* W. C. Clark and R. E. Munn, eds., Sustainable Development of the Biosphere, p. 292-317. London: Cambridge University Press.

Karr, J. 1992. Ecological integrity: Protecting earth's life support systems. *In* R. Costanza, B. G. Norton, and B. D. Haskell, eds., Ecosystem health: New Goals for Environmental Management, p. 233-238. Washington, D.C.: Island Press.

NOAA [National Oceanic and Atmospheric Administration]. 1993. NOAA's Strategic Plan for Ecosystem Health 1995-2005. Washington, DC.: USDOC/NOAA.

Norton, B. G. and R. E. Ulanowicz. 1992. Scale and biodiversity policy: A hierarchical approach. *Ambio* 21(3).

Pimm, S. L. 1984. The complexity and stability of ecosystems. *Nature* 307:321-326.

Rapport, D. J. 1992. What is clinical ecology? *In* R. Costanza, B. G. Norton, and B. D. Haskell, eds., Ecosystem health: New Goals for Environmental Management, p. 144-156. Washington, D.C.: Island Press.

Sherman, K. J., R. Green, J. R. Goulet, and L. Ejsymont. 1983. Coherence in zooplankton of a large Northwest Atlantic ecosystem. *Fish. Bull., U.S.* 81:855-862.

Sherman, K., M. Grosslein, D. Mountain, D. Busch, J. O'Reilly, and R. Theroux. 1988. The continental shelf ecosystem off the northeast coast of the United States. *In* H. Postma and J. J. Zijlstra, eds., Ecosystems of the World 27: Continental Shelves, Chapter 9, p. 279-337. Amsterdam: Elsevier Press.

Sherman, K. and A. R. Solow. 1992. The changing states and health of a large marine ecosystem. *ICES* [International Council for Exploration of the Sea] *C.M.* 1992\L:38.

Sherman, K., and D. Busch. In press. Assessment and monitoring of large marine ecosystems. Paper presented at the IOC, UNESCO 26th Annual Meeting, Paris, France, 25 February 2-March 1993. Paris: UNESCO/IOC.

Species Synopses

The synopses of information on the status of the stocks of the 37 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 of groundfish, flounders, pelagics, elasmobranchs, invertebrates, anadromous species, and harbor porpoise. 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 target stocks, and where possible, predicts future stock status for possible developments within the fishery.

For each stock or species a summary table[1] of catch statistics is included, along with one or more graphs showing how landings and, stock abundance have varied over time. The measures of stock abundance used include trawl 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, Fogarty *et al.* 1988, NEFC 1988, Pennington, 1985; 1986). The approach was based on the concept that the biomass of multi-age class stocks would not be expected to change radically from year to year without the identification of a reasonable causative agent. The objective of using the ARIMA model was to filter the effects of measurement error (random within-survey variation) in the survey abundance indices from true variation in population levels and therefore provide 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 due primarily to the shorter durations of these time series.

References in the text to catches or indices of abundance are usually to values given in these tables and figures, although some summary statistics are given in the text for different areas, fishing gears, or data sources which are not in the tables and figures.

Catch statistics in the tables are given in thousands of metric tons, rounded to the nearest 100 metric tons; values less than 100 mt are indicated as <0.1. Values quoted in the text are also usually rounded to the nearest 100 mt when greater than that value, and are rounded to the nearest 10 mt when less. Values less than 10 mt are indicated by a dash. Values that are not yet available are indicated by N/A.

Many of the assessments reported on here are described in NEFSC Reference Documents at the Northeast Fisheries Science Center, which may be obtained upon request. The most recent complete assessment for each stock is cited. Additionally, in recent years the NEFSC has reviewed assessments of selected species-stocks in semi-annual workshops. The reports of those workshops are cited in the species synopses sections for those species which have been reviewed.

A new feature of this document is a status summary for a marine mammal species: harbor porpoise.

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.

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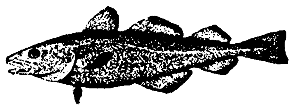
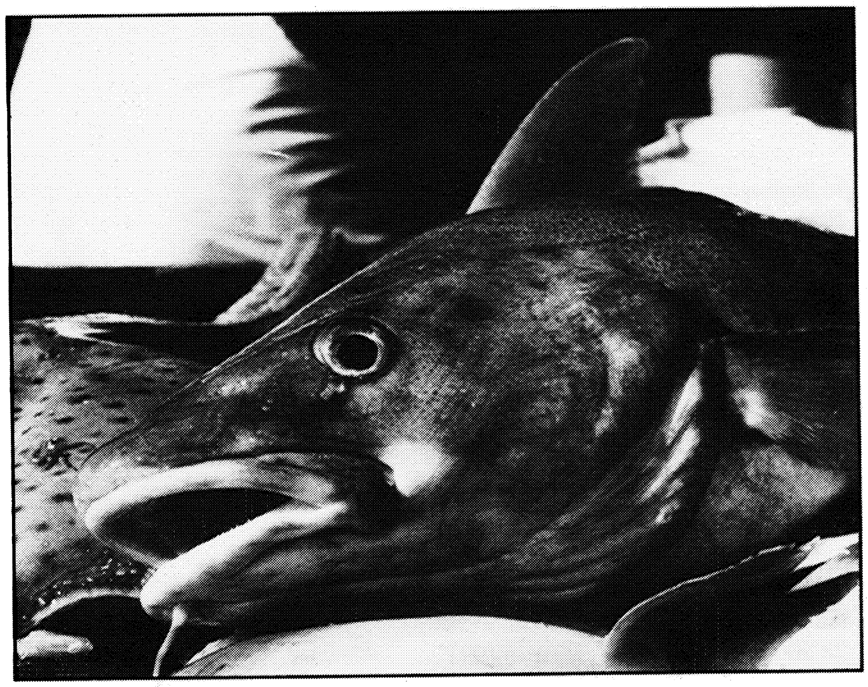


Atlantic Cod



Atlantic cod

NMFS photo by Brenda Figuerido

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 occur in both stocks. The commercial fisheries are conducted year round with otter trawls and gill nets 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.

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 1992 were 39,400 mt, down 29 percent from 55,400 mt in 1991. United States commercial landings in 1992 totaled 27,800 mt, 34 percent less than in 1991 (42,000 mt), and the lowest since 1987.

Gulf of Maine

Total nominal commercial catch (exclusively United States) in 1992 was 10,900 mt, a 39 percent decline from the record-high 1991 total of 17,800 mt.

United States otter trawl fishing effort (nominal days fished), which accounted for 64 percent of the 1992 landings, was 5 percent higher in 1992 than in 1991 and the third highest ever. United States commercial CPUE (catch per day fished for all trips catching cod) decreased by 50 percent in 1992 to the pre-1990 level. Directed trips, which accounted for between 15 and 49 percent of the annual U.S. otter trawl catch during 1984-1989, accounted for about 70 percent of the 1990 and 1991 total landings, but the fraction declined to 51 percent of the total in 1992.

Fishery age composition data indicate that commercial landings in 1992 continued to be dominated by the 1987 year class; this cohort accounted for 55 percent of the 1992 landings by number and weight. The 1986 and 1988 year classes were also important, together accounting for 20 percent of the 1992 landings by number and 25 percent by weight.

The NMFS research vessel weight-per-tow indices declined in both the autumn 1991 and 1992 surveys, but markedly increased in the spring 1992 survey and remained relatively high in the spring 1993 survey. Survey catch-at-age data indicate that the strong 1987 year class continues to dominate the stock and that recruitment since 1988 has either been average or below average.

Fishing mortality in 1992 remained at the same level as in 1991 (F = 1.14). Fishing mortality in 1992 was far beyond F_{max} (F=0.25) and well in excess of the F needed to attain 20 percent maximum spawning potential ($F_{20\%}$ = 0.36), the management target established for this stock. As such, the stock continues to be overfished.

Spawning stock biomass (SSB) peaked in 1990 at 27,500 mt, due to recruitment of the strong 1987 year class to the spawning stock. However, SSB declined in 1991 to about 21,000 mt and declined further in 1992 to 14,000 mt as the 1987 cohort was fished down. SSB is expected to remain at record low levels (between 12,000 mt and 13,000 mt) in 1993 and 1994 as the much weaker 1988-1990 year classes recruit to the spawning stock.

At the current level of fishing mortality, commercial landings are expected

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"United States commercial CPUE (catch per day fished for all trips catching cod) decreased by 50 percent in 1992 to the pre-1990 level."

to decline to 7,000 mt in 1993 and are likely to remain at or below that level in 1994. By 1994, the 1987 year class will no longer be a major component of the stock. To halt the declining trend in SSB, fishing mortality needs to be markedly reduced.

Atlantic Cod
Gulf of Maine

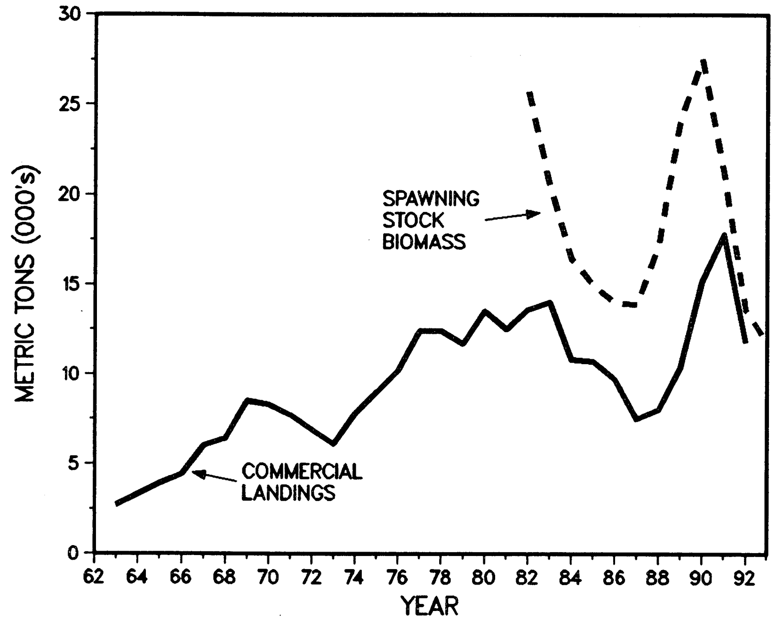


Table 1.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	4.6[1]	2.6	2.7	3.0	2.4	2.6	3.0	4.2	3.5	2.5	0.7
Commercial											
United States	10.5	14.0	10.8	10.7	9.7	7.5	8.0	10.4	15.2	17.8	10.9
Canada	<0.1	-	-	-	-	-	-	-	-	-	-
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	15.1	16.6	13.5	13.7	12.1	10.1	11.0	14.6	18.7	20.3	11.6

[1]1979-1982

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	=	$F_{20\%} = 0.36$

$M = 0.20$ $F_{0.1} = 0.15$ $F_{max} = 0.25$ $F_{20\%} = 0.36$ $F_{1992} = 1.14$

Georges Bank and Areas to the South

Total commercial landings (United States and Canada) in 1992 were 28,500 mt, 24 percent less than in 1991 (37,600 mt). The 1992 U.S. catch (16,800 mt) was the lowest since 1976, and well below the 1977-1991 annual average of 28,700 mt. Canadian 1992 landings totaled 11,700 mt, 13 percent lower than in 1991.

United States otter trawl fishing effort (nominal days fished), which accounted for nearly 70 percent of the 1992 U.S. commercial catch, remained at about the 1991 level and was only slightly lower (-8 percent) than the record high 1988 effort. United States commercial CPUE in 1992 was a record low, declining sharply (-38 percent) from 1991.

Commercial landings in 1992 were dominated by the 1987 and 1990 year classes. Together, these two cohorts accounted for 58 percent of the catch by number and 48 percent by weight.

The NMFS research vessel survey indices in 1992 and in spring 1993 were the lowest in the survey time series, and indicate that the stock is at an extremely low level. The 1990 year class dominates the stock, with older fish almost nonexistent. The 1991 and 1992 year classes currently appear to be below average in strength.

Spawning stock biomass in-

"Total commercial landings (United States and Canada) in 1992 were 28,500 mt, 24 percent less than in 1991 (37,600 mt)."

creased from 55,000 to 70,000 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 1992 fell to a record low 41,000 mt. Spawning stock biomass is expected to decline further in 1993 as the 1990 year class is fished down and the much weaker 1991 and 1992 cohorts recruit to the spawning stock.

Fishing mortality in 1992 (F=0.87) was near the highest on record, and was far in excess of the F needed to attain 20 percent maximum spawning potential ($F_{20\ percent}$ = 0.35), the management target established for this stock.

The Georges Bank cod stock is at a very low biomass level and is overexploited. Recovery of the stock will require a marked reduction in fishing mortality.

For further information

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.

Mayo, R.K., L. O'Brien, and F.M. Serchuk. 1993. Assessment of the Gulf of Maine cod stock for 1992. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Reference Document* 93-04. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543-1097.

Serchuk, F.M., L. O'Brien, R.K. Mayo and S.E. Wigley. 1993. Assessment of the Georges Bank cod stock for 1992. *NEFSC Reference Document* 93-05. Woods Hole, MA: NOAA/NMFS/NEFSC. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543-1097.

Atlantic Cod
Georges Bank and South

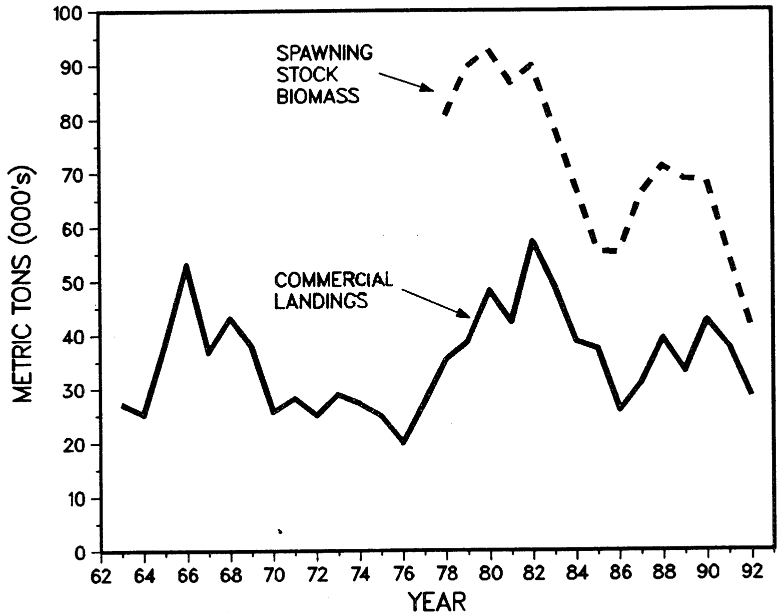


Table 1.2 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	2.8[1]	4.9	2.4	4.6	1.1	1.2	4.3	1.9	1.7	1.3	0.6
Commercial											
United States	24.8	36.8	32.9	26.8	17.5	19.0	26.3	25.1	28.2	24.2	16.8
Canada	6.1	12.1	5.8	10.5	8.4	11.9	12.9	8.0	14.3	13.4	11.7
Other	3.3	-	-	-	-	-	-	-	-	-	-
Total nominal catch	37.0	53.8	41.1	41.9	27.0	32.1	43.5	35.0	44.2	38.9	29.1

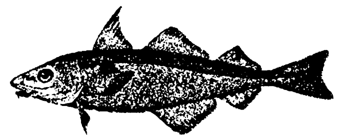
[1]1979-1982

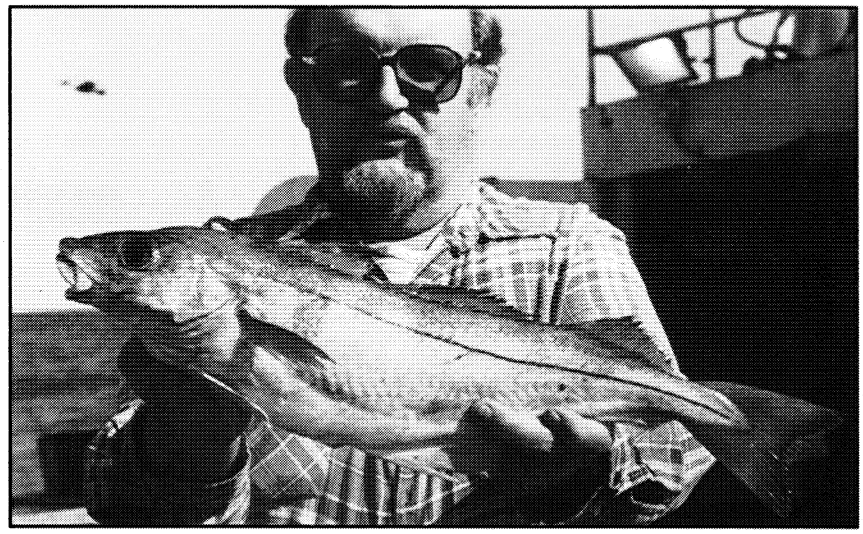
Georges Bank Atlantic Cod

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	=	$F_{20\%}$ = 0.35

M = 0.20 $F_{0.1}$ = 0.16 F_{max} = 0.29 $F_{20\%}$ = 0.35 F_{1992} = 0.87

Haddock





NMFS photo by Brenda Figuerido

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; these are termed 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 the age 2 female haddock are mature. Although the presence of early maturing fish increases spawning stock biomass, it is uncertain if these younger spawners are spawning successfully or producing eggs of sufficient quality to contribute strongly to the reproductive success of the population. 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 to catch 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, overfishing for haddock is defined to occur 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 0.40. Currently, the primary management measures include a 48 cm (19 in.) minimum size, 140 mm (5.5 in.) minimum mesh size across most of the fishing grounds for haddock, and two areas closed to fishing from February through the end of May. Total landings (United States and Canada) in 1992 were 6,400 mt, 12 percent lower than 1991 (7,300 mt). United States landings increased, however, from 1,800 mt in 1991 to 2,300 mt in 1992.

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 (400 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 in the U.S. fishery.

Autumn NEFSC survey abundance indices (adjusted for changes in survey gear) have declined steadily since 1978. Since 1989, the fall survey index has set a new record low each year, reaching 0.09 in 1992. This value is less than 0.4 percent of the peak survey index in 1963. Survey catch at age data indicate that recruitment has been poor since 1982.

The 96 percent decline in landings observed from 1983 to 1992 (7,600 to 300 mt) and 98 percent decline in the fall research index (5.22 to 0.09 kg per

"Since 1989, the fall survey index has set a new record low each year, reaching 0.09 in 1992. This value is less than 0.4 percent of the peak survey index in 1963."

tow) are indicative of the status of this stock. Abundance of this stock is at an all time low and continues to decline. 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 needs to be reduced significantly in order to enhance prospects for resource recovery.

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 5,300 and 6,800 mt. In 1992, landings were 6,100 mt, slightly less than the 6,800 mt landed in 1991. Of the 1992 total, U.S. landings accounted for 33 percent (2,000 mt), while Canadian landings accounted for 67 percent (4,100 mt).

The NEFSC spring and autumn bottom trawl surveys indicate that the biomass of haddock has declined markedly since the late 1970s. The 1992 autumn survey index (3.17 kg per tow) is higher than the time series minimum of 0.94 kg per tow set in 1991, but remains very low relative to historical levels. Population estimates derived from virtual population analysis indi-

Haddock
Gulf of Maine

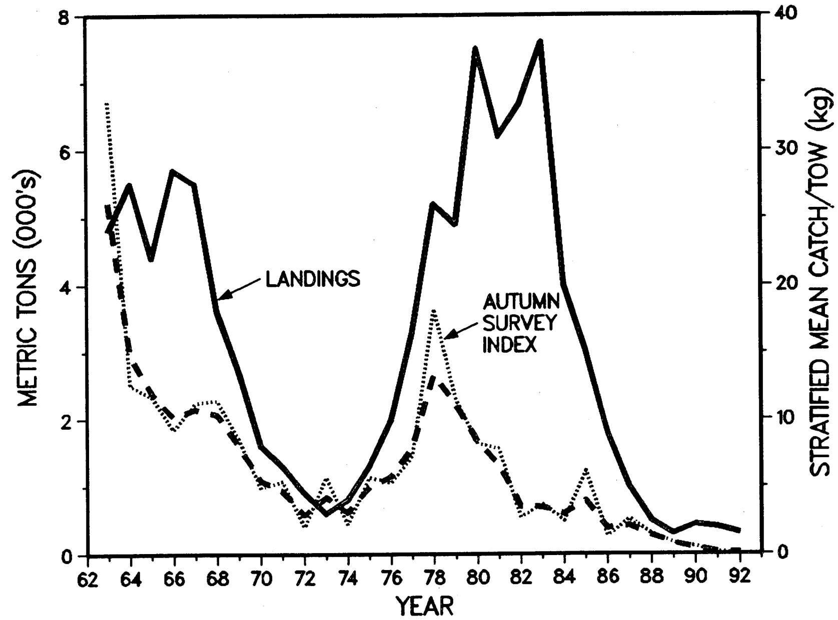


Table 2.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
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	3.3	5.6	2.8	2.2	1.6	0.8	0.4	0.3	0.4	0.4	0.3
Canada	0.3	2.0	1.2	0.8	0.2	0.2	0.1	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.6	7.6	4.0	3.0	1.8	1.0	0.5	0.3	0.4	0.4	0.3

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	=	0.40

$M = 0.20$ $F_{0.1} = 0.24$ $F_{30\%} = 0.40$ $F_{1992} > F_{30\%}$

"... poor recruitment is expected for the near future, perpetuating the severely depleted condition of this stock."

cate that this stock is in a severely depleted state. Abundance and biomass are at or near all-time lows; approximately 17 million fish with a biomass of 22,500 mt. This is in contrast to abundance during 1979 (for example) when there were an estimated 132 million haddock with a biomass of 113,600 mt. During the 1980s, recruitment was poor; the 1989 and 1990 year classes continued this trend, each with roughly 4 million age 1 fish. Fishing mortality on age 4 and older haddock was estimated to be 0.51 in 1990 and is likely to be at a similar level currently. From 1980 to the present, fishing mortality has averaged 0.40; a value at or above $F_{30\%}$. Population projections suggest that if recruitment and fishing mortality remain at current levels the abundance and biomass of this stock will continue to decline. Because of the low level of spawning stock biomass, poor recruitment is expected for the near future, perpetuating the severely depleted condition of this stock. Recovery of this stock will require that fishing mortality be reduced to the lowest level possible.

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.

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. Available from: Northeast Fisheries Center, Woods Hole, MA 02543.

Haddock
Georges Bank

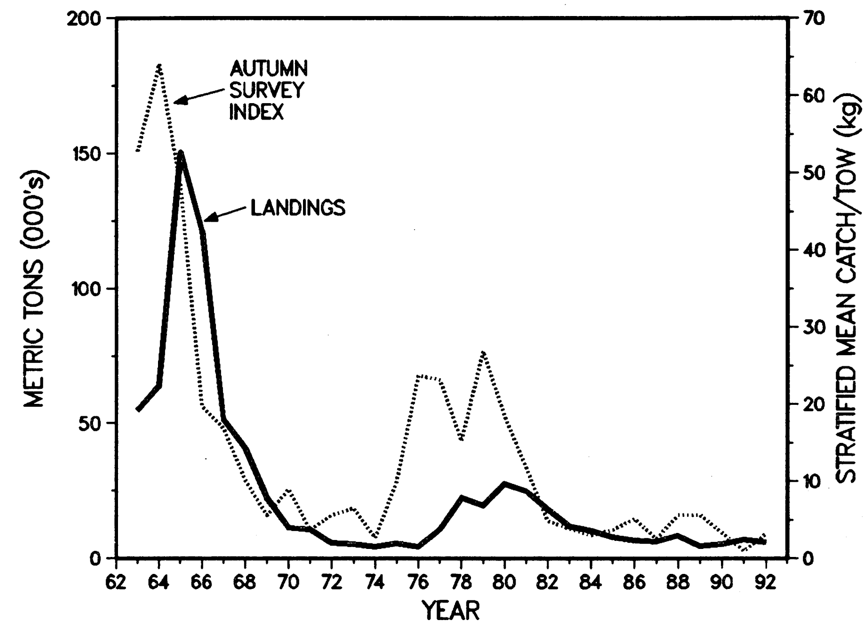


Table 2.2 Recreational catches and commercial landings (thousand metric tons)

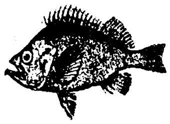
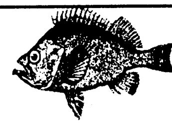
Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	<0.1	<0.1	<0.1	-	-	-	-	-	-	-
Commercial											
United States	9.1	8.7	8.8	4.3	3.3	2.2	2.5	1.4	2.0	1.4	2.0
Canada	4.1	3.2	1.4	3.5	3.4	4.1	5.9[1]	3.1	3.3	5.5	4.1
Other	0.4	-	-	-	-	-	-	-	-	-	-
Total nominal catch	13.6	11.9	10.2	7.8	6.7	6.3	8.4[1]	4.5	5.3	6.9	6.1

[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	=	0.40

$M = 0.20$ $F_{0.1} = 0.24$ $F_{30\%} = 0.40$ $F_{1992} = 0.50$

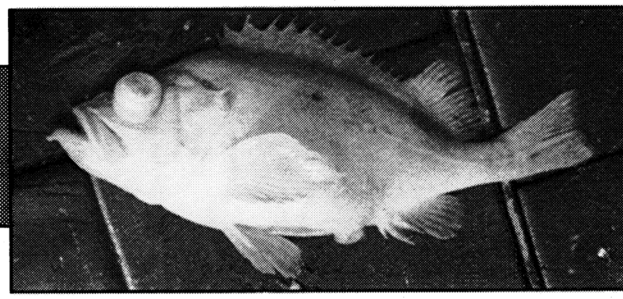



Redfish

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 to catch 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. This is the first year since 1979 that annual redfish landings from the Gulf of Maine have increased.

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 in recent years increased from approximately 10,000 to 11,000 mt during 1974-76 to approximately 14,000 to 15,000 mt in 1978-79. In 1989 and 1990, however, catches declined to 600 mt, and further declined to 530 mt in 1991, the lowest annual figures 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 this fishery. However, length composition data from bottom trawl surveys suggest that one or more moderately strong year classes produced in the mid-1980s will recruit 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.



NMFS 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. Although the 1986 autumn index increased to 8.0 kg per tow, estimates for 1987-89 have averaged only 6.2 kg per tow. The 1990 autumn biomass indices of 12.2 kg per tow was the highest since 1980 but was still well below the average of the 1960s and early 1970s.

Biomass indices in 1991 and 1992 declined to 8.4 and 8.1 kg per tow, respectively, but are still at about twice the level observed in 1983 and 1984. The increased biomass in 1990-92 is consistent with incremental increases in survey abundance indices (mean number per tow) noted during the past two to three years, and reflects accumulated recruitment and growth of one or more recent year classes, the strength of which is likely to be greater than the 1980s average.

Estimates of exploitable biomass (ages 5 and older) from virtual population analysis declined by 75 percent, from 136,000 mt in 1969 to 32,000 mt in 1985. Projections are not available for 1992 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. In addition, the combination of declining overall stock size and increased fishing effort on the 1971 year class produced fishing mortality rates that were 50 percent greater than F_{max} and three times $F_{0.1}$ in the late 1970s. Fishing mortality has likely declined in recent years to a point 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 is about 14,000 mt. Given the current 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 decline in nominal catches.

Although landings increased in 1992, the level still remains extremely low, reflecting low levels of stock abundance and fishing mortality. Given the present pattern of exploitation, the fishery remains extremely dependent on recruitment. Recruitment has been poor since 1971, except for the moderate 1978 year class and recent indications of some modest recruitment from the mid-1980s. Despite the low levels of catch seen in recent years, stock biomass remains low. Unless recruitment improves, biomass and yield are

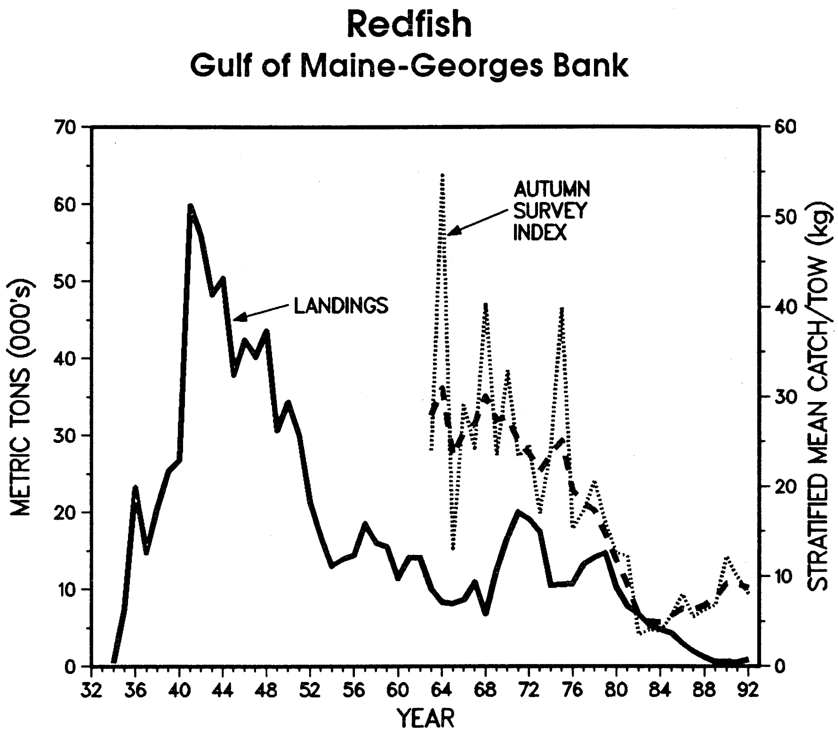


Table 3.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	10.9	5.2	4.7	4.2	2.9	1.9	1.1	0.6	0.6	0.5	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	1.4	-	-	-	-	-	-	-	-	-	-
Total nominal catch	12.4	5.3	4.8	4.3	3.0	2.0	1.2	0.6	0.6	0.5	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** **$F_{1992} \leq F_{0.1}$**

"In the past 20 years, only two strong year classes, those produced in 1971 and 1978, have recruited to this fishery."

not expected to increase substantially; the population remains overexploited. Even modest recovery of the stock could be jeopardized by any increase in landings.

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.

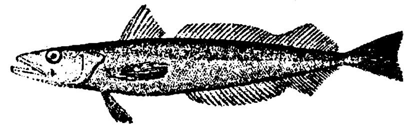
Mayo, R. K., U. B. Dozier, and S. H. Clark. 1983. An assessment of the redfish, *Sebastes fasciatus*, stock in the Gulf of Maine - Georges Bank region. Woods Hole, MA: *NOAA/ NMFS/NEFSC. Lab. Ref. Doc. 83-22.*

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*, B. R. Melteff, coordinator, p. 335-353. Anchorage, Alaska, October 20-22, 1986. Fairbanks, AK: University of Alaska Sea Grant College Program. *Alaska Sea Grant Report* 87-2.

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

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.

Silver Hake



NMFS photo by Brenda Figuerido

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 migration is extensive, with wintering 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 the autumn. Peak spawning occurs earlier in the southern stock area (May and June) than in the northern stock area (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 percent 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.

The otter trawl is the principal gear used in the commercial fishery and the recreational fishery is insignificant. The commercial fishery is currently managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Total nominal catches decreased by 22 percent between 1990 and 1992 (20,000 to 15,600 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 percent of the total. Activity by distant-water fleets diminished after 1977 and U.S. landings increased slightly during the early 1980s, reaching 8,500 mt by 1986. Since 1986,

"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. . ."

landings have varied without significant trend and have averaged 6,200 mt. Commercial landings were 5,300 mt in 1992.

Discarding of silver hake occurs in the large mesh (>5.5 in. mesh), small mesh (<5.5 in. mesh), and shrimp fisheries of this region. Although highly variable depending on season and area fished, discard rates can range between 70 and 100 percent of the total catch by weight in the large mesh and shrimp fisheries. Discarding of silver hake is generally much lower in the small mesh fishery, with lower rates (on the order of 20 percent) attributed to the relatively "clean" regulated fishery on Cultivator Shoals of Georges Bank.

The NEFSC autumn bottom-trawl survey biomass index declined during the period of heavy exploitation by distant-water fleets of the 1960s, 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 slightly thereafter through 1981. Biomass indices have increased significantly (with fluctuation) over the past decade and recruitment in most recent years appears to be above that of the mid-1970s.

Fishing mortality rates (F) for fully recruited fish fluctuated in the range 0.38 to 1.1 during the period 1973 to 1982; and generally increased from 1982 (0.45) through 1988 (0.70). Although not available for the most recent years (1989-1992), estimates of

Silver Hake
Gulf of Maine-Northern Georges Bank

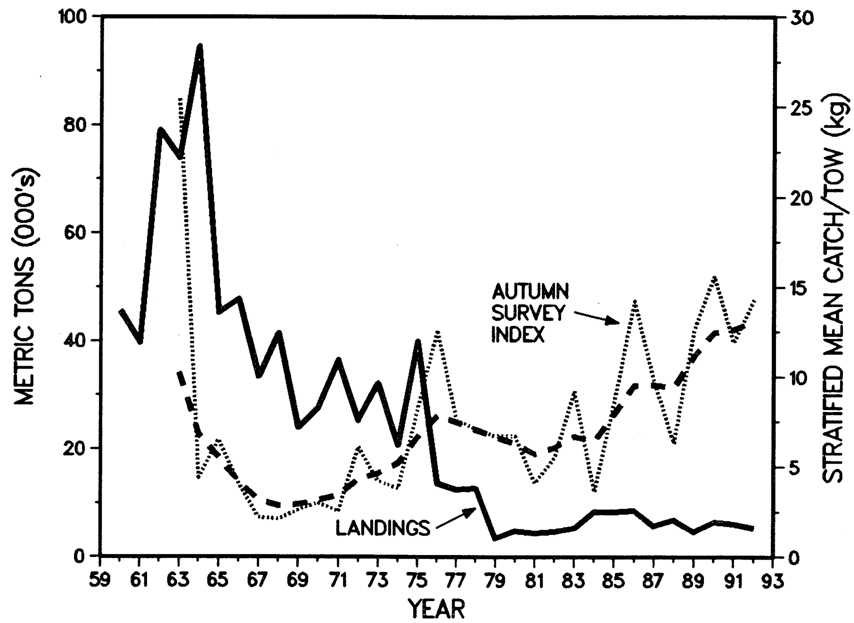


Table 4.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year 1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	8.7	5.3	8.3	8.3	8.5	5.7	6.8	4.6	6.4	6.1	5.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	7.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	15.8	5.3	8.3	8.3	8.5	5.7	6.8	4.6	6.4	6.1	5.3

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	=	0.51

$M = 0.40$ $F_{0.1} = 0.44$ $F_{max} = N/A$ $F_{1988} = .70$

"It seems unlikely that F will decline below 0.3 to 0.4 in the near future, and given the rapid removal of recruits from the stock in recent years, it appears this stock cannot support increased fishing and must be considered fully exploited."

mortality based on spring and autumn NEFSC survey abundance indices suggest F may still be quite high.

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. Until these inconsistencies are resolved, the precise level of exploitation remains uncertain. However, since it is not likely that F will decline substantially below the 0.4 to 0.5 range in the near future, 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 in 1965, declined sharply through 1970, and increased to a secondary peak of 109,900 mt in 1974. Landings declined thereafter and have remained below 15,000 mt since 1980. Prior to inception of the MFCMA, distant-water fleet landings composed about 87 percent of total commercial landings. Catches by distant-water fleets were taken primarily as bycatch in the squid fishery during the early

Silver Hake
Southern Georges Bank-Middle Atlantic

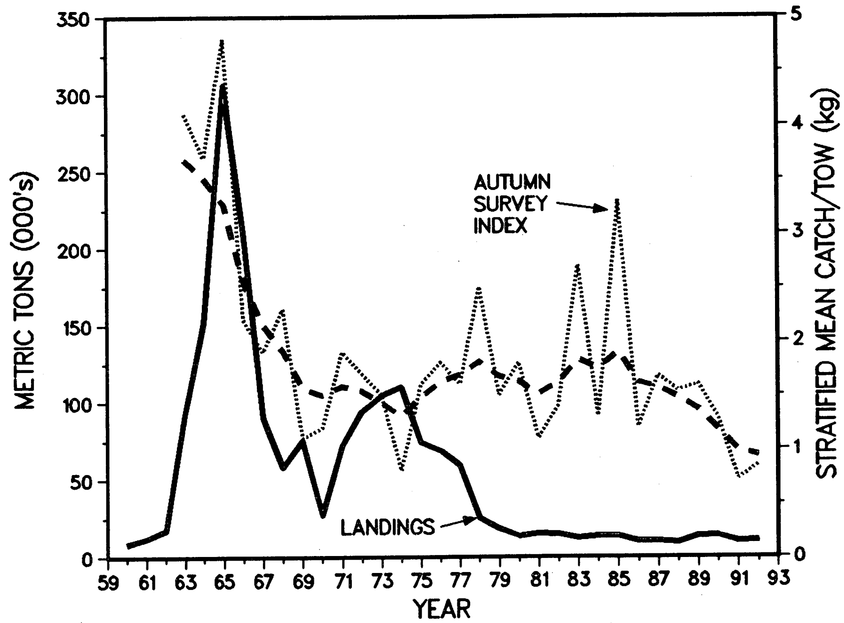


Table 4.2 Recreational catches and commercial landings (thousand metric tons)

Category	Year 1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	0.6	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	9.6	11.5	12.7	11.8	9.4	9.8	9.2	13.2	13.6	10.1	10.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	44.2	0.6	0.4	1.3	0.5	-	-	-	-	-	-
Total nominal catch	54.4	12.1	13.1	13.1	10.0	9.8	9.2	13.2	13.6	10.1	10.3

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	=	Fully 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 $F_{0.1}$ = 0.35 F_{max} = N/A F_{1988} = 0.42

and mid-1980s, but this bycatch has been insignificant since 1987. In 1992, commercial landings were 10,300 mt. Recreational landings have been insignificant since 1986.

Discarding occurs in both large mesh (>5.5 in. mesh) and small mesh (<5.5 in. mesh) fisheries of this region. Although variable depending on season and area fished, discard rates have ranged between 20 and 90 percent of the total catch by weight. Overall, discarding of silver hake in the large mesh fishery has averaged about 60 percent between 1989 and 1992, while in the small mesh fishery discard rates have declined from 70 percent (1989) to 20 percent (1992).

After dropping sharply throughout the 1960s, the NEFSC autumn trawl survey index has fluctuated without major trend. However, after reaching a minor apogee in 1985, the index declined continuously, reaching a record low in 1991.

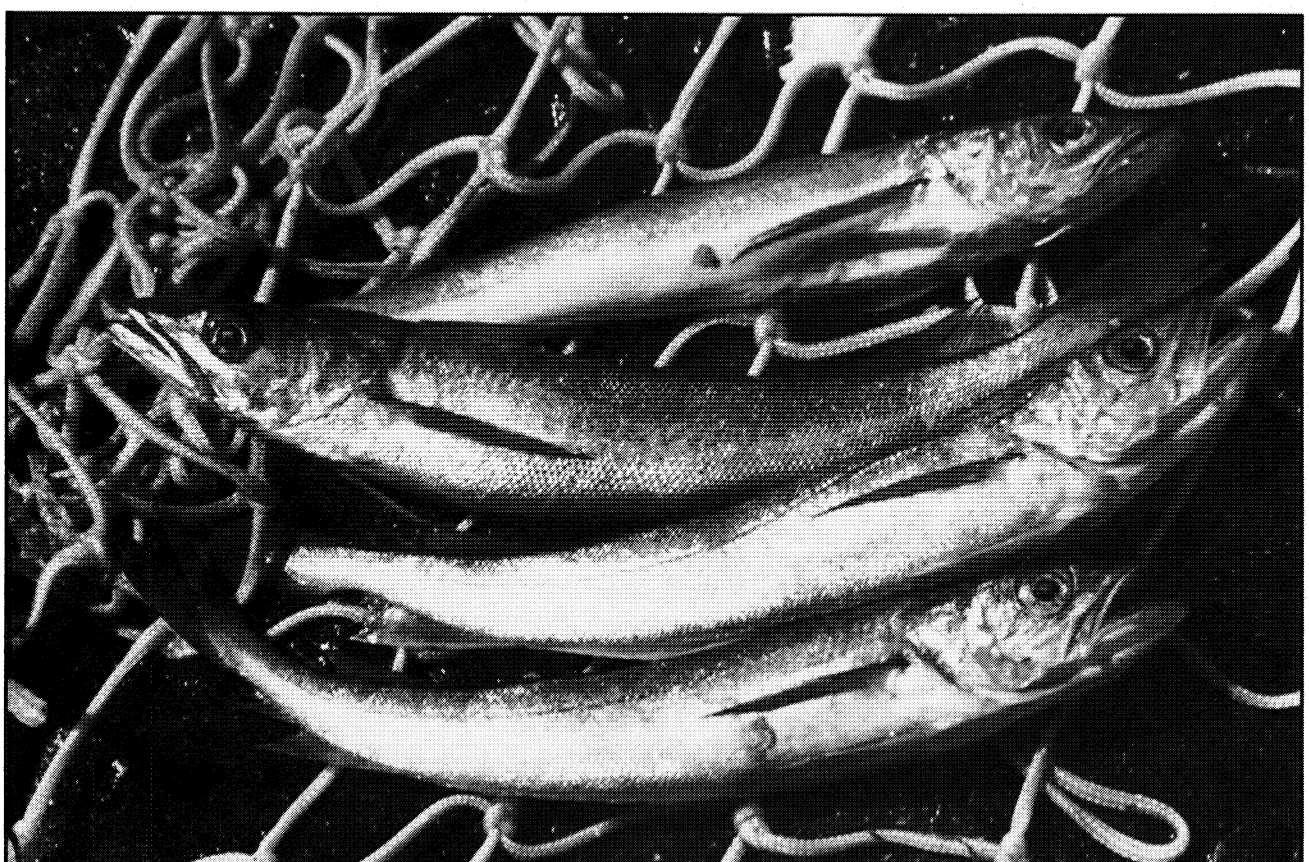
Before introduction of the distant-water fleet, fishing mortality (F) was relatively low, ranging from 0.09 to 0.41 (average = 0.24) between 1955 and 1962. With increased fishing effort on the stock beginning in 1963, F rose rapidly and reached 0.98 by 1965. Since passage of the MFCMA in 1977, F has averaged 0.82. Increased landings in 1989 and 1990, coupled with relatively low survey biomass indices suggest that F may have increased somewhat above the 1988 level. Virtual population analysis estimates of spawning stock biomass have decreased steadily since 1973, and in the late 1980s were only about 10 percent of the biomass estimates for the mid-1970s. In contrast, bottom trawl survey results indicate that the silver hake biomass has remained fairly constant since the late 1960s. Until these inconsistencies are resolved, the status of exploitation remains uncertain. It seems unlikely that F will decline below 0.3 to 0.4 in the near future, and given the rapid removal of recruits from the stock in recent years, it appears this stock cannot support increased fishing and must be considered fully exploited.

For further information

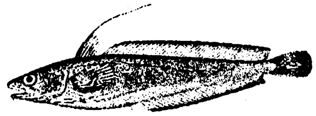
Almeida, F. P. 1987. Status of silver hake resources of the northeast coast of the United States - 1987. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Lab. Ref. Doc.* 87-03. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

NEFSC [Northeast Fisheries Science Center]. In press. Report of the Seventeenth Northeast Regional Stock Assessment Workshop (17th SAW), Fall 1993. Woods Hole, MA: NOAA/NMFS/NEFC.

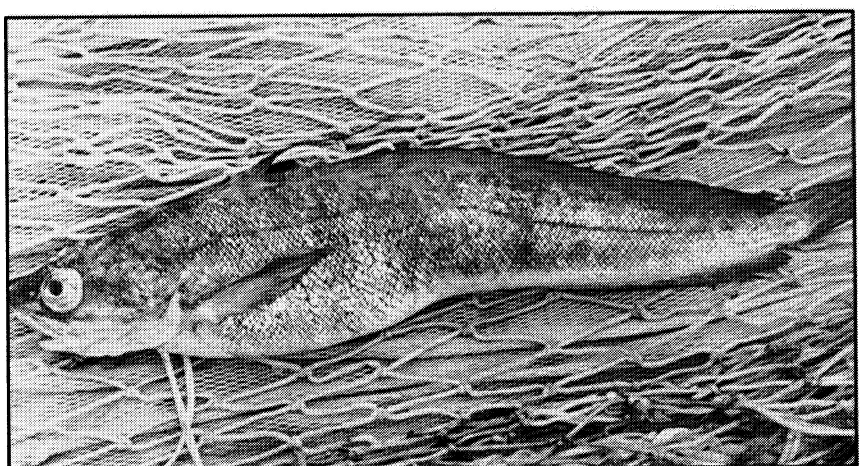
NEFC [Northeast Fisheries Center]. 1990. Report of the Eleventh Stock Assessment Workshop (11th SAW), Fall 1990. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Ref. Doc.* 90-09. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.



NMFS photo by Brenda Figuerido



Red Hake



NMFS photos by Brenda Figuerido

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.). The maximum age of red hake 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. The fishery is managed under Amendment 4 to the New England Fishery Management Council's Multispecies Fishery Management Plan. Total commercial landings in 1992, taken exclusively by the United States, were 2,000 mt. Although this represents an increase over 1991 when 1,600 mt were landed, commercial landings remain far below historic levels.

Gulf of Maine - Northern Georges Bank

Landings from the Northern red hake stock in 1992 were relatively low, at 900 mt. 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 5,000 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 percent of the total annual landings were taken by the distant-water fleets (DWF) on northern Georges Bank. Following implementation of the Magnuson Fisheries Conservation and Management Act (MFCMA) in 1977, both total landings and the proportion of landings by the DWF dropped sharply. From 1977 to the present, annual landings from this stock have averaged only 1,100 mt and have been less than 1,000 mt since 1988.

The NEFSC autumn bottom trawl survey index has shown two general levels of stock abundance. From 1964 to 1976, abundance was relatively low, with survey indices ranging from 0.2 to 1.8 kg per tow. Following 1976, survey indices increased and have remained at relatively high levels (1.3 to

"The combination of low landings and modest year classes has allowed the stock to maintain itself at moderate to high levels of biomass."

7.9 kg per tow) since that time. The survey index has declined during the past three years, from 4.2 kg per tow in 1990 to 2.4 kg per tow in 1992, and is now near the long-term average of 2.3 kg per tow. This decline does not appear to be due to the fishery, given the low level of landings from this stock. 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 1992 landings from the southern red hake stock were 1,300 mt, slightly higher than in 1991 when 1,100 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 landings averaged 35,000 mt from 1967-1972 but declined markedly after DWF landings were reduced. From 1978 to 1984, the DWF landings averaged 10 percent of the total annual landings (compared to 83 percent from 1965-1976) due to restrictions placed on the fleet 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 remained at

Red Hake
Gulf of Maine-Northern Georges Bank

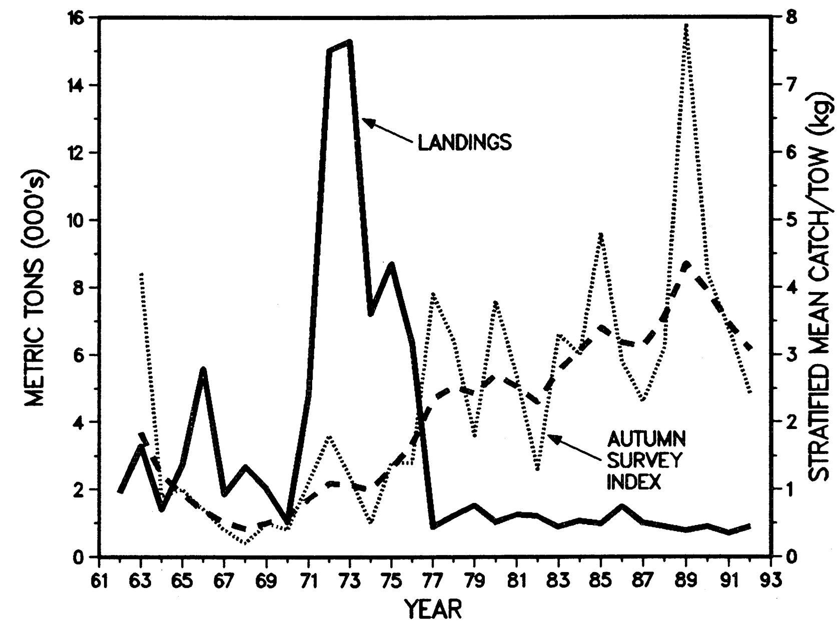


Table 5.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	0.8	0.9	1.1	1.0	1.5	1.0	0.9	0.8	0.8	0.7	0.9
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	4.5	-	-	-	-	-	-	-	-	-	-
Total nominal catch	5.3	0.9	1.1	1.0	1.5	1.0	0.9	0.8	0.8	0.7	0.9

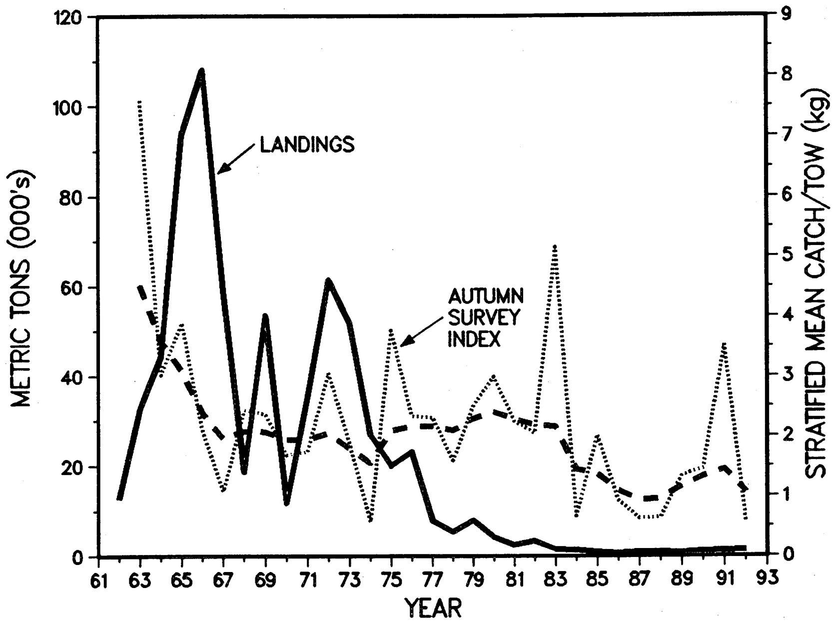
Gulf of Maine-Northern Georges Bank Red Hake

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	=	None
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.4$ $F_{0.1} = 0.5$ F_{max} = None $F_{1992} < F_{0.1}$

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

Red Hake
Southern Georges Bank-Middle Atlantic



about 4,000 mt per year between 1967 and 1979. Throughout the 1980s and 1990s, landings from this stock have been very low, ranging between 800 and 1,400 mt per year.

The NEFSC autumn bottom trawl survey index declined from its highest levels in the early 1960s to a relatively constant level between 1968 and 1982. In 1983, the survey index reached its second highest value in the time series, but subsequently declined through 1988. From 1988 to 1991, the survey index increased substantially, but in 1992 the survey index dropped sharply to the lowest value observed. The decline of the autumn index from 1982-1988 and the decline during 1992 do not appear to be due to the fishery; landings during the entire time period were low (less than 2,000 mt per year) compared with the late 1960s and early 1970s (more than 20,000 mt most years) when the survey index was stable. As such, this stock is underexploited and could support substantially higher catches.

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

Category	Year 1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	0.5	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.2
Commercial											
United States	3.2	1.3	1.2	0.8	0.6	0.9	0.9	0.8	0.8	0.9	1.1
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	16.0	0.1	0.1	0.1	-	-	-	-	-	-	-
Total nominal catch	19.7	1.5	1.3	0.9	0.6	0.9	0.9	0.8	0.8	1.1	1.3

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	=	None
fishing mortality rate corresponding to overfishing definition	=	N/A

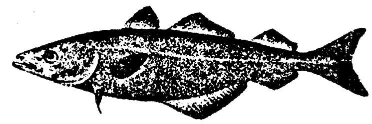
$M = 0.4$ $F_{0.1} = 0.5$ F_{max} = None $F_{1992} < F_{0.1}$

For further information

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

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. Available from: Northeast Fisheries Science Center, Woods Hole, MA 02543.

Pollock



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 most fish are mature by age 4. 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 bycatch in the demersal otter trawl fishery, but in recent years, directed effort has increased substantially. Much of this increase in effort has occurred in the winter gill net fishery. 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. Total nominal catches decreased by 14 percent in 1992 (from 49,100 to 42,400 mt); most of the decrease was due to a 15 percent decline in the combined Canadian and distant-water fleet catches on the Scotian Shelf. United States commercial landings declined by 9 percent in 1992 (7,900 mt to 7,200 mt).

Nominal commercial catches from the entire Scotian Shelf, Gulf of Maine, and Georges Bank region increased from an annual average of 38,200 mt during 1972-76 to 68,500 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, have declined from an annual average of 9,800 mt during 1970-73, to fewer than 1,400 mt per year during 1981-88. The distant-water fleet catch increased to 1,800 mt in 1989, and has averaged 2,100 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, after declining for four consecutive years, increased slightly in 1991 but declined again in 1992. Most of the decline since 1986 was due to sharp reductions in U.S. landings in 1987, 1988, and 1989, followed by a substantial decline in Canadian landings in 1990 and 1992.

Total stock size, after increasing throughout the late 1970s and early 1980s, has declined substantially since the mid-1980s. 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 also declined sharply in this region in 1991 and 1992. Commercial catch per unit effort (CPUE) indices for U.S. trawlers fishing predominantly in the Gulf of Maine increased 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 between 1974 and 1984, but have declined steadily since 1985; CPUE indices for both countries increased in 1992, but still remain well below historic levels.

Virtual population analyses have indicated a gradual increase in spawning stock biomass during the 1970s followed by a 40 percent decrease between 1985 and 1991. 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. The most recent strong year class was produced in 1982; it contributed to this earlier increase in stock biomass and became fully recruited to the fishery in 1989. Year classes produced between 1983 and 1986 were all average or below average, but the 1987 and 1988 year classes appear to be well above the long-term mean. In 1992, these two year classes accounted for 58 percent of the total commercial landings by number and 48 percent by weight. The 1989 through 1991 year classes, however, appear to be below average.

Increases in total landings during the mid-1980s (in excess of 63,000 mt per year between 1985 and 1987) re-

Pollock
Scotian Shelf-Gulf of Maine-Georges Bank

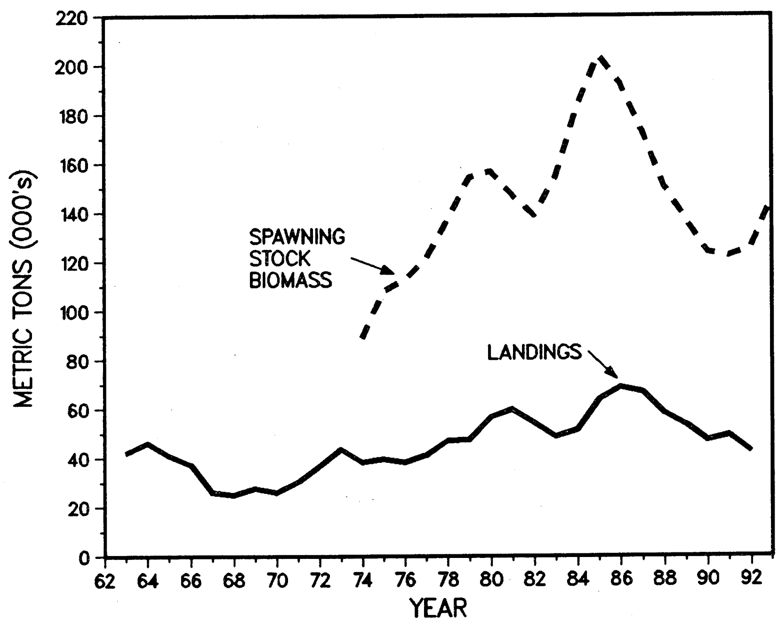


Table 6.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year: 1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	0.8	1.3	0.2	0.7	0.2	0.1	0.2	0.4	0.1	0.1	<0.1
Commercial											
United States	12.6	14.0	17.9	19.5	24.5	20.4	15.0	10.6	9.6	7.9	7.2
Canada	28.7	32.7	33.5	43.3	43.2	45.3	41.8	41.0	36.2	37.9	33.1
Other	3.1	0.5	0.3	0.5	1.1	0.8	1.3	1.8	1.3	3.3	2.1
Total nominal catch	45.2	48.5	51.9	64.0	69.0	66.6	58.3	53.8	47.1	49.2	42.4

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

$M = 0.20$ $F_{0.1} = 0.20$ $F_{max} = 0.76$ $F_{1992} = 0.72$

sulted 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) and is expected to decline further in 1993 as the strong 1987 and 1988 year classes account for a greater portion of the fishable biomass. 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 remains at least fully exploited.

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.

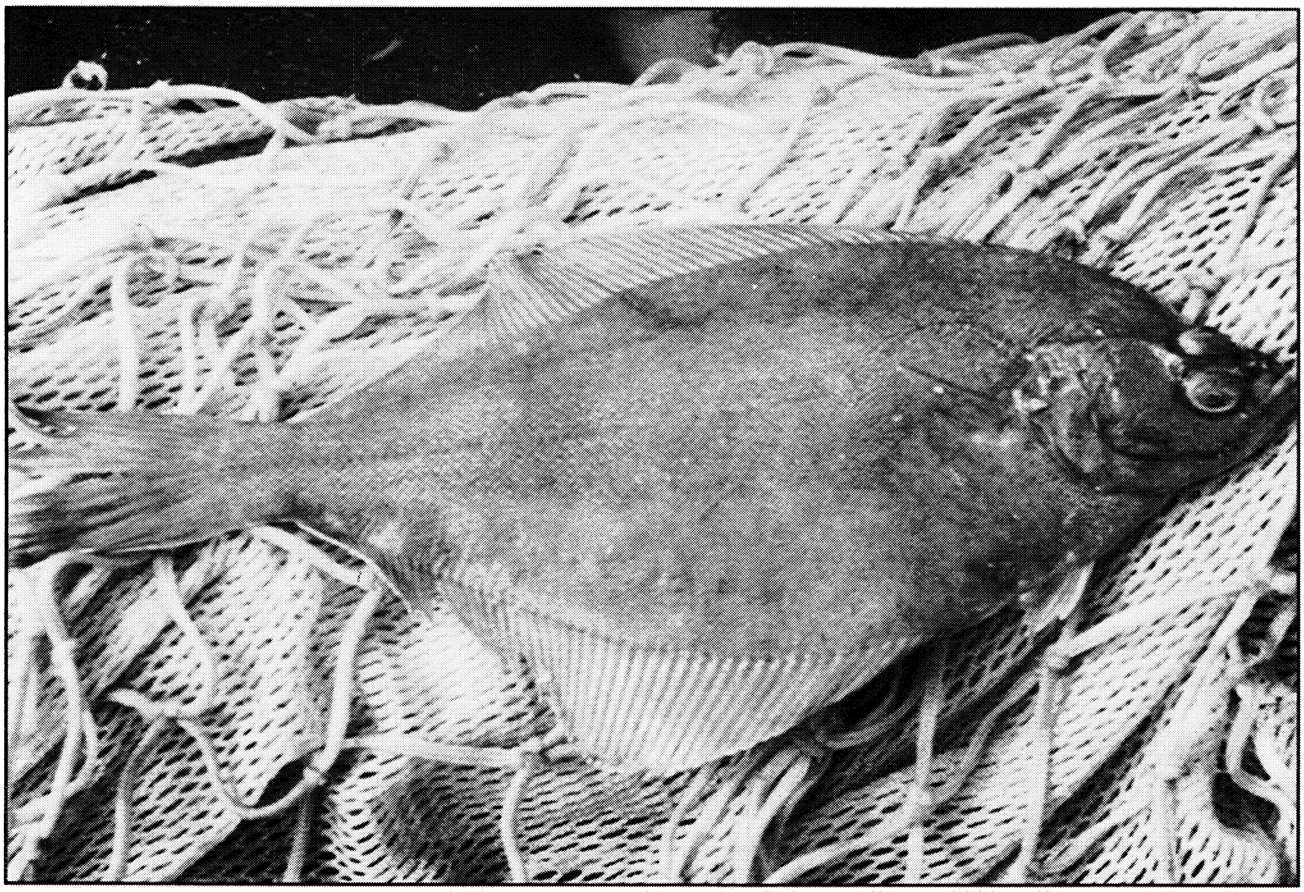
Annand, C., and D. Beanlands. 1992. Assessment of pollock *(Pollachius virens)* in Divisions 4VWX and Subdivision 5Zc for 1991. CAFSAC [Canadian Atlantic Fisheries Scientific Advisory Committee] *Res. Doc.* 92/44.

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. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

Yellowtail Flounder



NMFS photo by Brenda Figuerido

The yellowtail flounder, *Pleuronectes ferrugineus,* ranges 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). Fishing for yellowtail by the U.S. fleet also occurs in the northern Gulf of Maine, in the Mid-Atlantic Bight, and on the Grand Banks of Newfoundland outside the Canadian 200-mile limit (the Tail of the Bank). Yellowtail commonly attain lengths up to 47 cm (18.5 in.) and weights up to 1.0 kg (2.2 lb); commercial catches tend to be dominated by smaller fish. 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.

Tagging studies and other information indicate that Southern New England, Georges Bank, and Cape Cod yellowtail flounder form relatively discrete groups, although some intermingling occurs among these groups of fish.

The principal fishing gear used to catch yellowtail flounder is the otter trawl. Current levels of recreational and foreign fishing are insignificant. The U.S. fishery is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Total landings of yellowtail flounder decreased by 46 percent in 1991 to 7,500 mt.

Georges Bank

Total landings of yellowtail from Georges Bank averaged 16,300 mt

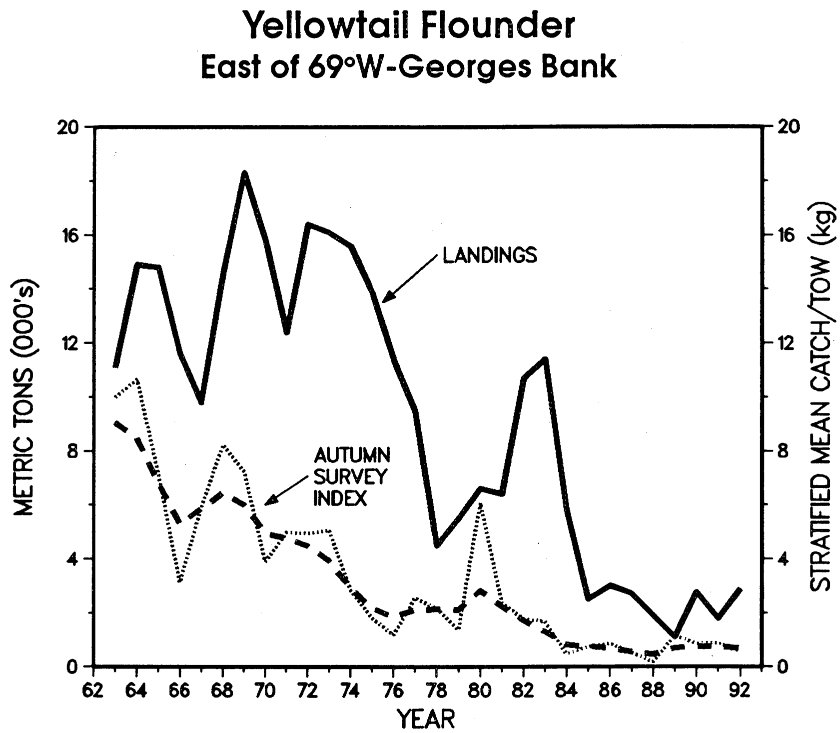


Table 7.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	10.9	11.4	5.8	2.5	3.0	2.7	1.9	1.1	2.7	1.8	2.9
Canada	-	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	<0.1
Other	0.4	-	-	-	-	-	-	-	-	-	-
Total nominal catch	11.3	11.4	5.8	2.5	3.0	2.7	1.9	1.1	2.7	1.8	2.9

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	=	26 cm (10 in.)
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.58

$M = 0.20$ $F_{0.1} = 0.25$ $F_{max} = 0.63$ $F_{1990} = 0.82$

"Recent recruitment following the 1987 cohort appears to be poor. Hence, rebuilding of the stock will require a major reduction in fishing mortality and several years of improved recruitment."

during 1962-1976 but declined to an average of 5,800 mt between 1978 and 1981. Landings increased to more than 11,000 mt in 1982 and 1983 due to strong recruitment from the 1979 and 1980 year classes. Since then, landings have generally declined, reaching a record low of 1,100 mt in 1989, increasing slightly to 2,859 mt in 1992.

The NEFSC autumn survey biomass indices for Georges Bank yellowtail declined between 1963 and 1976, stabilized at relatively low levels during 1977-1983 (with the exception of the elevated 1980 index), and subsequently fell to record low levels during 1984 and 1988. After increasing slightly in 1989, due to above average recruitment from the 1987 year class, the survey index declined again in 1990, remained stable in 1991, and dropped again in 1992.

Fishing mortality rates ranged between 0.5 and 0.8 between 1969 and 1973, but increased to well over 1.0 during 1974-1988. An apparent drop in F in 1989 was followed by an increase to 0.82 in 1990.

Although abundance of the Georges Bank stock increased modestly in 1989 due to the above average 1987 year class, the stock is still at a very low level and is composed of few age groups. Recent recruitment following the 1987 cohort appears to be poor. Hence, rebuilding of the stock will require a major reduction in fishing mortality and several years of improved recruitment. This stock is overexploited, and is at a low level of abundance.

Yellowtail Flounder
West of 69°W-Southern New England

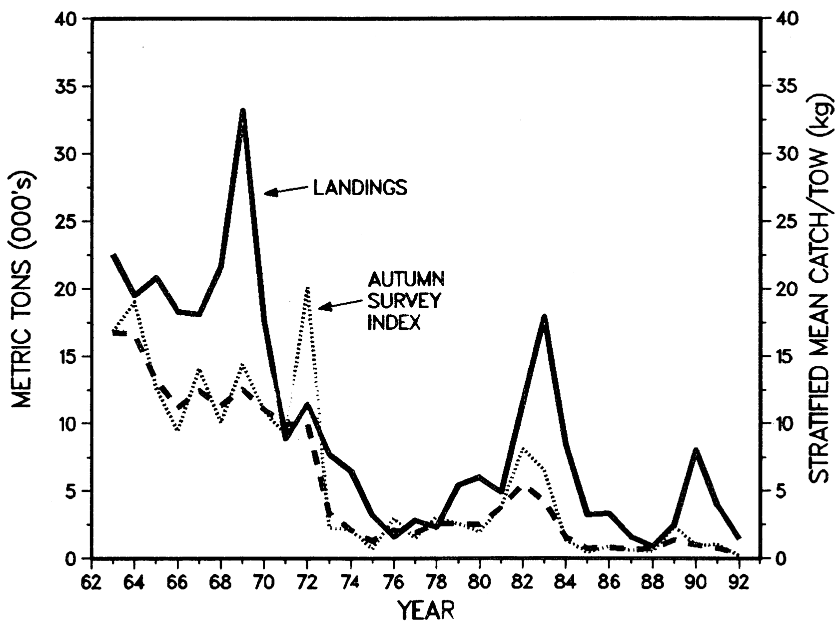


Table 7.2 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	5.8	17.0	7.9	2.7	3.3	1.6	0.9	2.5	8.0	3.9	1.5
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	0.3	-	-	-	-	-	-	-	-	-	-
Total nominal catch	6.1	17.0	7.9	2.7	3.3	1.6	0.9	2.5	8.0	3.9	1.5

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 **$F_{0.1} = 0.22$** **$F_{max} = 0.48$** **$F_{1990} = 1.61$**

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

"This stock is over-exploited and at an extremely low level of abundance."

Southern New England

Landings of yellowtail flounder from the Southern New England stock averaged 28,000 mt during 1963-1970 but declined rapidly afterward, reaching a low of 1,700 mt in 1976. Landings increased during 1977-1983, peaking at 18,500 mt in 1983, but subsequently declined to a record low of only 900 mt in 1988. In 1989 and 1990, landings increased to 2,500 mt and 8,008 mt respectively, due to recruitment from the strong 1987 year class, declined in 1991 to 3,910 mt, and dropped further to 1,458 mt in 1992.

NEFSC autumn survey abundance and biomass indices were at historically high levels between 1963 and 1972, but declined markedly in 1973 and remained very low until 1982 when both abundance and biomass values increased due to strong recruitment from the 1980 and 1981 cohorts. These increases, however, were short-lived; survey indices during 1985-1988 were among the lowest on record. The 1989 indices increased to their highest levels since 1983 due to strong recruitment from the 1987 year class. However, this increase was again short-lived, as the 1990 index dropped precipitously, declined further in 1991, and dropped to the lowest level in the 30-year series in 1992.

Fishing mortality rates (on the fully recruited ages) fluctuated between 0.6 and 1.0. during 1973 to 1979. After 1979 fishing mortality rates were generally well in excess of 1.0, with a peak of 1.9 in 1984 and a recent high of 1.6 in 1990.

Abundance of the Southern New England stock improved in 1989 and 1990 due to the strong 1987 year class. This cohort was relatively stronger in Southern New England than on Georges Bank, and essentially constitutes the entirety (97 percent) of the

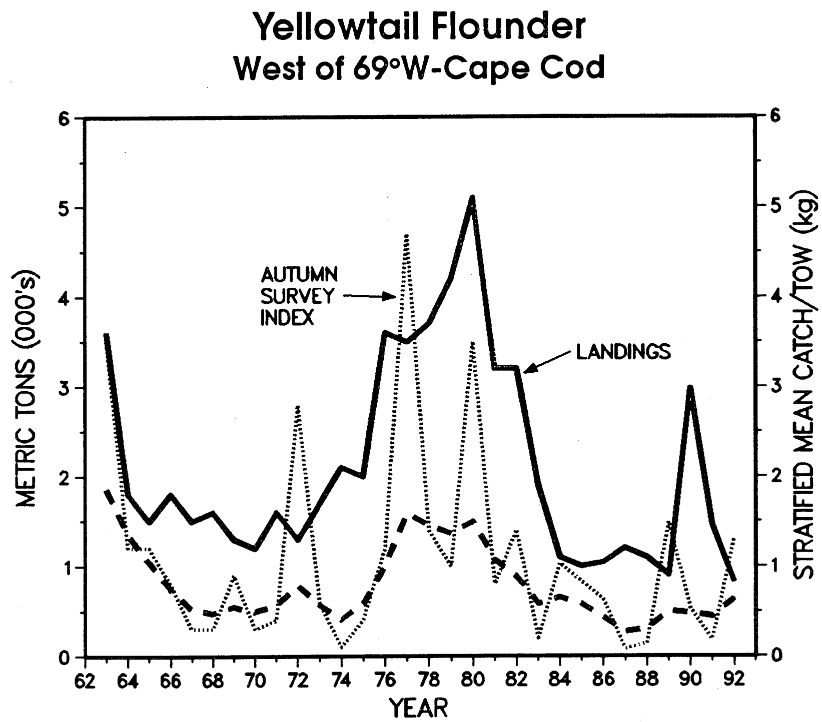


Table 7.3 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	3.3	1.9	1.1	1.0	1.0	1.2	1.1	0.9	3.0	1.5	0.8
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.3	1.9	1.1	1.0	1.0	1.2	1.1	0.9	3.0	1.5	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	=	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_{1991} = Unknown

"A short-term increase in landings associated with the 1987 year class occurred in 1990, but the stock is considered to be overexploited."

Southern New England stock. Significant quantities of this cohort were discarded in 1989 since, as two-year-olds, virtually all fish were less than the minimum legal-landing size of 13 in. Significant discarding continued on this year class in 1990, especially early in the year.

At this level of catch (*i.e.*, landings plus discards), the 1987 year class will not sustain the fishery beyond 1991. Since recruitment from recent year classes appears to be poor, landings and stock size will likely remain low.

This stock is overexploited and at an extremely low level of abundance.

Cape Cod

Total landings of yellowtail flounder from the Cape Cod stock generally fluctuated between 1,500 and 2,000 mt in the 1960s, increased during the 1970s to approximately 5,000 mt in 1980, and then declined, reaching record low levels during the 1980s. Landings in 1990 were 2,979 mt, 1,466 mt in 1991, and 823 mt in 1992.

The NEFSC autumn survey indices have been highly variable, but have reflected the general pattern of landings. The 1989 value was the highest since 1980, due to the strong 1987 year class, but the index declined again in 1990, dropped even lower in 1991, and increased in 1992.

Recent declines in landings and the corresponding general downward trends in the survey indices suggest that stock biomass has been reduced by the high catches of the late 1970s and early 1980s. A short-term increase in landings associated with the 1987 year class occurred in 1990, but the stock is considered to be overexploited.

Yellowtail Flounder
West of 69°W-Middle Atlantic

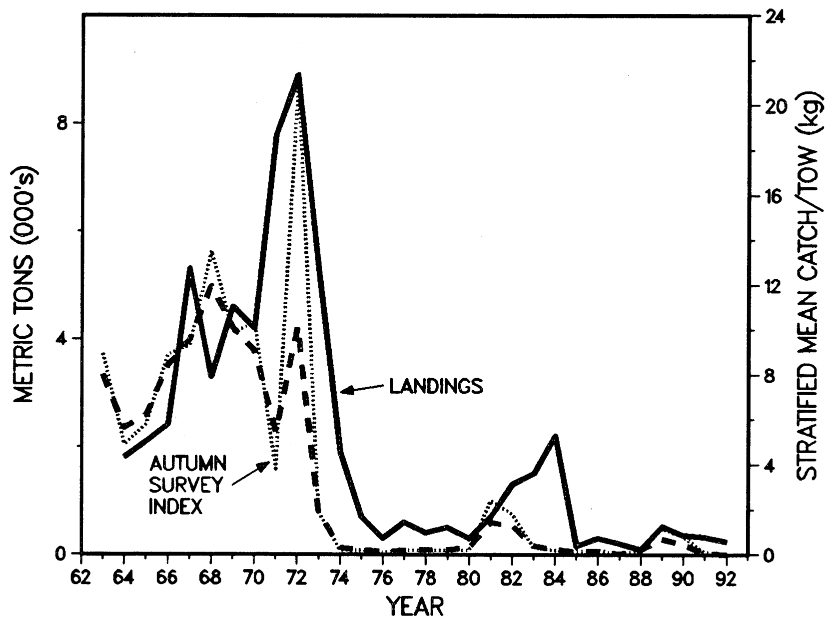


Table 7.4 Recreational catches and commercial landings (thousand metric tons)

Category Average	Year 1972-82	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.9	1.5	2.2	0.2	0.3	0.2	<0.1	0.5	0.4	0.3	0.2
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	1.9	1.5	2.2	0.2	0.3	0.2	<0.1	0.5	0.4	0.3	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_{1991} = Unknown**

Middle Atlantic

Trends for the Mid-Atlantic 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. Landings increased gradually during the early 1980s, from 300 mt in 1980 to 1,500 mt and 2,200 mt in 1983 and 1984, respectively, reflecting improved recruitment. Landings have since declined to the low levels of the late 1970s. Landings in 1990 declined to 400 mt, 325 mt in 1991 and 240 mt in 1992. The NEFSC autumn survey indices declined to very low levels in the mid-1970s, followed by an increase during 1981-82 with improved year class strength. Subsequent indices have declined to levels similar to those observed during the mid- to late 1970s, with the 1987 autumn survey value representing the lowest on record. Although survey indices improved in the late 1980s and in 1990, the index for 1991 dropped to a very low level and stayed low in 1992. The assessment level for yellowtail in this region is too low to evaluate the current status of exploitation.

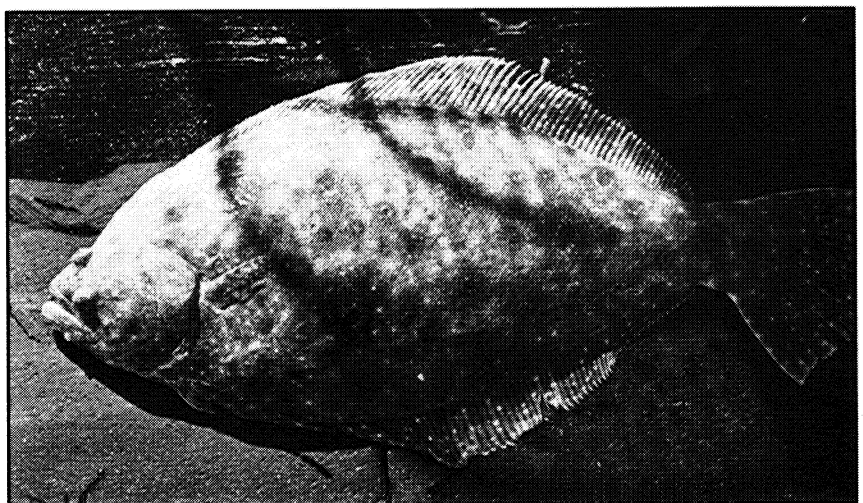
For further information

Clark, S. H., M. M. McBride, and B. Wells. 1984. Yellowtail flounder assessment update - 1984. *Woods Hole, MA: NOAA/NMFS/NEFC. Lab. Ref. Doc.* 84-39. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

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. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

Summer Flounder

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 coastal embayments 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 the larvae are transported toward coastal areas by prevailing water currents. Development of post-larvae and juveniles occurs primarily within embayments and estuarine areas, notably Pamlico Sound and Chesapeake Bay. Female summer flounder may 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).



NMFS photos 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.-Canadian border. Amendment 2 to the FMP made several major changes in fishery regulations for 1993. Among these were commercial and recreational fishery landings quotas, a commercial vessel permit moratorium, commercial fishery minimum mesh size (5.5 in. diamond or 6.0 in. square), and minimum fish size (13 in.) regulations, and a recreational fishery possession limit (6 fish), minimum fish size regulation (14 in.), and restricted fishing season (15 May to 30 September). The total fishery quota for 1993 was 9,400 mt, with the commercial quota at 5,600 mt and the recreational share at 3,800 mt. The FMP has 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 18,900 mt during 1983-1991, peaking at 30,200 mt in 1984. Total landings in 1992 (10,700 mt) were 10 percent higher than in 1991 (9,700 mt). The principal gear used in commercial fishing for summer flounder is the otter trawl. Commercial landings of summer flounder averaged 11,400 mt during 1983-1991, reaching a high of 17,100 mt in 1984. Commercial landings in 1992 were 7,300 mt, an 18 percent increase from the 1991 level of 6,200 mt. The recreational fishery for summer flounder harvests a significant proportion of the total catch of this species, and in some years, recreational landings have exceeded the commercial landings. Recreational landings historically constitute about 40 percent of the total landings. The estimated recreational landings of summer flounder averaged 7,500 mt during 1983-1991, peaking in 1983 at 16,400 mt. The recreational landings decreased dramatically (by 82 percent) between 1988 and 1989 to 1,500 mt, the lowest level since 1979, when the current system to monitor the recreational fishery was implemented. Recreational landings have since rebounded to 3,500 mt in 1991 and 3,400 mt in 1992.

Based on NEFSC survey indices, stock biomass is currently at the lowest average level since the late 1960s and early 1970s, and is about one-quarter of the level observed in the mid-1970s. The spring survey index (mean weight per tow) rose from a low point in 1970 to a peak in 1976, was at an average level during the late 1970s and early 1980s, and then declined dramatically from 1985 to 1989. Survey indices suggest a slight increase in stock biomass since 1989. Catch curve analysis of NEFSC survey and commercial fishery age composition data collected from 1976 through 1983 indicated fishing mortality rates of about 0.6 to 0.7, well in excess of F_{max} (NEFSC 1986).

Recent analyses 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 suggest that fishing mortality rates during the past decade have been very high, peaking at 1.8 in 1988-1989, but declined to 1.1 in 1992. Spawning stock biomass has increased from a record low in 1989 (5,600 mt) to about 15,000 mt in 1992, but the age structure of the stock remains trun-

"The 1991 year class, which is of about average size, provides an opportunity for continued rebuilding of the spawning stock..."

cated, with only 11 percent of the biomass at ages 3 and older. Recruitment has improved in recent years, but remains at or below an average level. The assessment through 1992 indicated that the stock was significantly overexploited, with fishing mortality rates greatly exceeding those resulting in maximum yield per recruit. However, fishing mortality in 1993 is expected to decline further to about 0.5 if the 1993 quota is landed. The 1991 year class, which is of about average size, provides an opportunity for continued rebuilding of the spawning stock if it and subsequent year classes continue to be conserved by reduced fishing mortality.

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.

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.

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.

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.

Summer Flounder
Georges Bank-Middle Atlantic

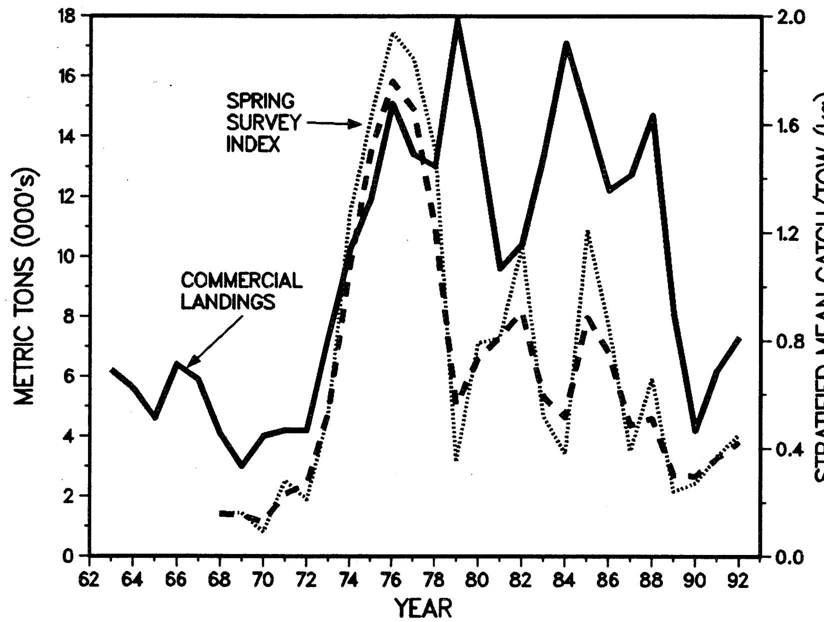


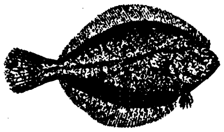
Table 8.1 Recreational and commercial landings (thousand metric tons)

Category	Year 1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	9.9	16.4	13.1	7.6	8.5	5.7	8.5	1.5	2.4	3.5	3.4
Commercial											
United States	11.6	13.4	17.1	14.7	12.2	12.3	14.7	8.1	4.2	6.2	7.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	<0.1	<0.1	-	-	-	-	-	-	-	-	-
Total nominal catch	21.5	29.8	30.2	22.3	20.7	18.0	23.2	9.6	6.6	9.7	10.7

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	=	VPA
Overfishing definition	=	F_{max}
Fishing mortality rate corresponding to overfishing definition	=	0.23

$M = 0.20$ $F_{0.1} = 0.14$ $F_{max} = 0.23$ $F_{1992} = 1.1$



American Plaice

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 and 0.4 lb). After age 4, females grow faster than males.

NMFS photo by Brenda Figuerido

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 catches increased 53 percent in 1992 (from 4,300 to 6,600 mt).

Landings of American plaice increased from an average of 2,300 mt during 1972-1976 to greater than 10,000 mt per year during 1979-1984. Subsequently, annual landings declined and are now at similar levels as in the late 1970s.

Between 1960 and 1974, 67 percent of U.S. landings were from deepwater areas on Georges Bank. Since then, Gulf of Maine landings have greatly exceeded those from Georges Bank. The U.S. 1992 Gulf of Maine catch (4,600 mt) was more than twice as large as that from Georges Bank (2,000 mt).

United States commercial catch per unit effort (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 1992 index increased 4 percent from 1991.

Virtual population analyses indicate that fishing mortality on fully recruited ages (6 to 9+) more than doubled from 1981 (F=.36) to 1987 (F=.87) and subsequently declined to a low in 1990 (F=.47). Fishing mortality in 1991 was estimated to be 0.58, well above F_{max}=.29 and the F needed to attain 20 percent maximum spawning potential ($F_{20\%}$=.49), which is the management target established for this stock. Based on the landings, fishing mortality was projected to increase to 1.0 in 1992.

Stock sizes (in numbers) declined 72 percent from 1980 (204 million) to 1986 (58 million). In 1990, stock size increased 81 percent (105 million) as the outstanding 1987 year class recruited into the fishery. Stock sizes declined 13 percent in 1991 (91 million) and were projected to decline further in 1992 (86 million).

Spawning stock biomass declined from 41,400 mt in 1980-1982 to 10,333 mt in 1989-1991. In 1991, the spawning stock biomass increased to 13,400 mt as the 1987 year class began to recruit to the spawning stock. Spawning stock biomass was projected to remain stable in 1992.

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

Abundance and biomass indices from autumn NEFSC surveys reached record low values in 1987 but increased until 1990 as the 1987 year class recruited to the survey gear. The indices subsequently declined to near record low levels in 1992. Survey number per tow indices indicate the strongest year classes occurred in 1978, 1979, and 1987 and above average year classes occurred in 1986 and 1989. The 1989 year class will enter the commercial fishery during mid-year 1994.

American Plaice
Gulf of Maine-Georges Bank

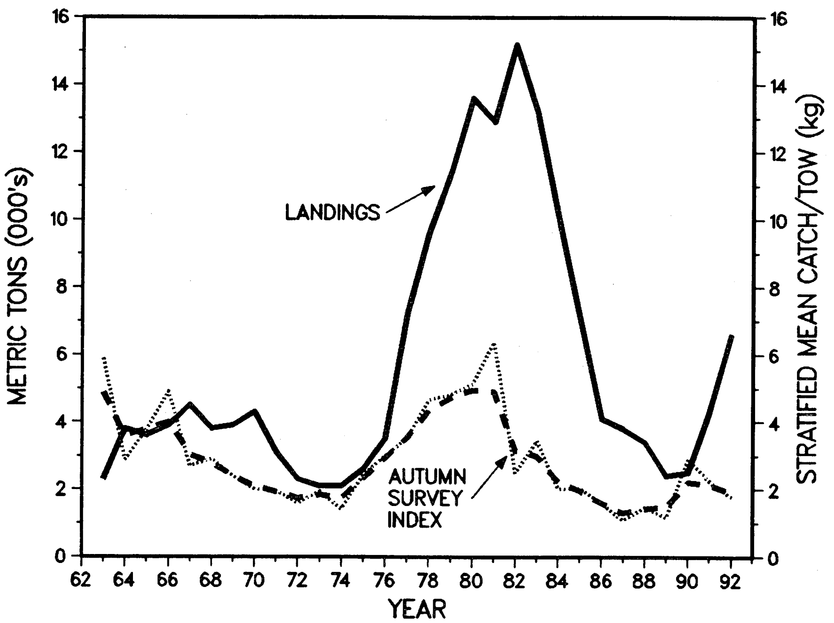


Table 9.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	7.4	13.2	10.1	7.0	4.1	3.8	3.3	2.3	2.5	4.3	6.6
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	7.4	13.2	10.1	7.0	4.1	3.8	3.4	2.4	2.5	4.3	6.6

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_{1992} = 1.00**

[1] Excluding discards

The decline in landings that began in 1983 reflects a declining trend in harvestable biomass, as indicated in both catch per unit effort and survey indices. Although landings increased in 1992, due to the recruiting 1986 and 1987 year classes , stock biomass is still at a low level. The 1989 year class represents the next opportunity to increase 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 and landings of American plaice are expected to remain low and the stock will continue to be overexploited.

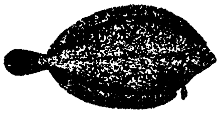
For further information

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

Mayo, R.K., O'Brien, L., 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. Res. Doc. SAW14/3 *In* 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.

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.

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. Res. Doc. SAW 14/2 *In* 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.



Witch Flounder

NMFS photo by Greg Power

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 60 cm (24 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 Multi-species Fishery Management Plan. Total landings increased slightly in 1992 (from 1,800 to 2,200 mt) but were still among the lowest in the 28 year time series.

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 area; however, the majority (65%) of the 1992 landings were taken from Georges Bank. Canadian nominal catches from both areas have been minor (less than 70 mt annually since 1970). Distant-water fleet catches on Georges Bank averaged 2,600 mt in 1971-1972, but subsequently declined sharply and have been negligible since 1977. After averaging 2,800 mt during 1973-1981, nominal catches increased sharply during the early 1980s and peaked at 6,500 mt in 1984. Since 1984, landings have steadily declined. A Grand Banks fishery for witch flounder, which developed in 1985 and continued through 1990, accounted for an annual U.S. harvest of 400 mt; however, no landings have been reported since 1991. Also, 62 mt was harvested in 1992 in the Mid-Atlantic region.

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 3.2 kg per tow in 1966-1970 to 1.5 kg per tow in 1975. Biomass increased in 1977-78 due to reduced effort in the northern shrimp fishery. Subsequent indices, however, have declined steadily to the lowest levels on record. The 1992 value of 0.2 kg per tow represents a further decline in the resource condition from 1991.

Witch Flounder
Gulf of Maine-Georges Bank

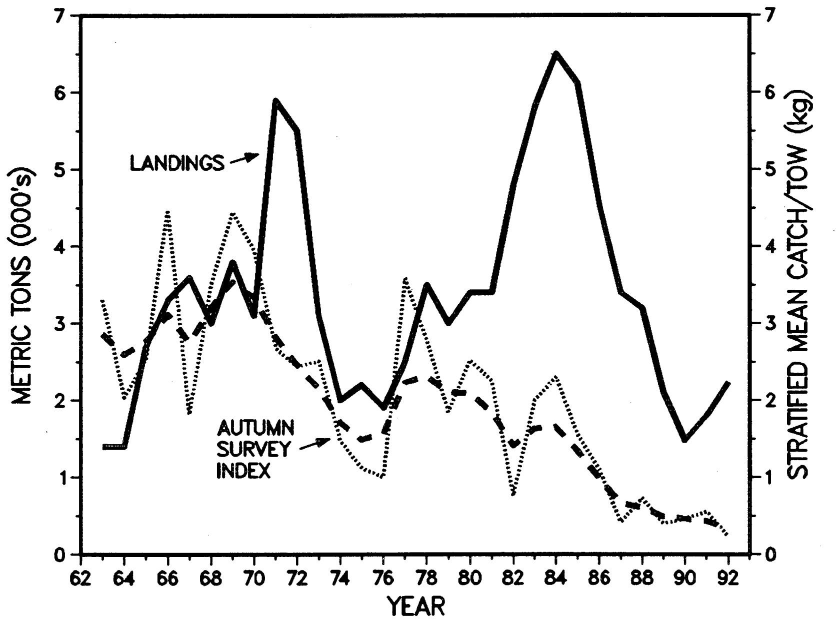


Table 10.1 Recreational and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	2.9	5.8	6.5	6.0	4.5	3.4	3.2	2.1	1.4	1.8	2.2
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	3.3	5.8	6.5	6.1	4.5	3.4	3.2	2.1	1.4	1.8	2.2

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	=	Index
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	0.46

M = 0.15 **$F_{0.1}$ = 0.16** **F_{max} = 0.39** **F_{1992} = >$F_{20\%}$**

"Given the life history of this slow-growing, late-maturing species, this species cannot withstand high fishing mortality."

The low level of landings since 1988 reflect a declining biomass, as indicated by the steady decline in bottom trawl survey and catch per unit effort indices since the mid-1980s. The 1992 CPUE index was among the lowest in the time series. These declines suggest that this resource has been adversely affected by high levels of exploitation. Given the life history of this slow-growing, late-maturing species, this species cannot withstand high fishing mortality. Additionally, discarding of juvenile witch flounder are associated with the small mesh Northern shrimp fishery in the Gulf of Maine. It appears that harvests of 3,000 mt or more cannot be sustained over the long term. The current stock size is less than one-fifth of the level seen in the late 1960s and early 1970s. Fishing mortality since 1984 has been at or above $F_{20\%}$ and as such the stock is considered overexploited.

For further information

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.

Burnett, J. and S. H. Clark. 1983. Status of witch flounder in the Gulf of Maine - 1983. Woods Hole, MA: NOAA/NMFS/NEFC. Woods Hole Lab. Ref. Doc. 83-36. Available from: NEFSC, 166 Water St., Woods Hole, MA 02543.

Winter Flounder

NMFS photo by Brenda Figuerido

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, small-scale seasonal migrations occur to estuaries, embayments, and saltwater ponds to spawn, and from these locations to deeper water during summer. There is evidence that 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 discrete 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 Multi-species Fishery Management Plan. Total commercial landings in 1992 (6,100 mt) declined from 1991 levels (7,500 mt), remaining near record-low levels.

Gulf of Maine

Commercial landings from the Gulf of Maine increased from a steady 1,000 mt for the period 1961 to 1977 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 percent reduction in recreational landing estimates and a 25 percent reduction in commercial landings. Since then, landings in the recreational fisheries have fluctuated, but landings in both fisheries have continued to trend downward. Combined landings in 1992 were only 900 mt, a record low for the 14-year time series. Estimated recreational catches in 1992 (<100 mt) were the lowest levels observed. Commercial landings of 800 mt were the lowest since 1967.

Winter Flounder
Gulf of Maine

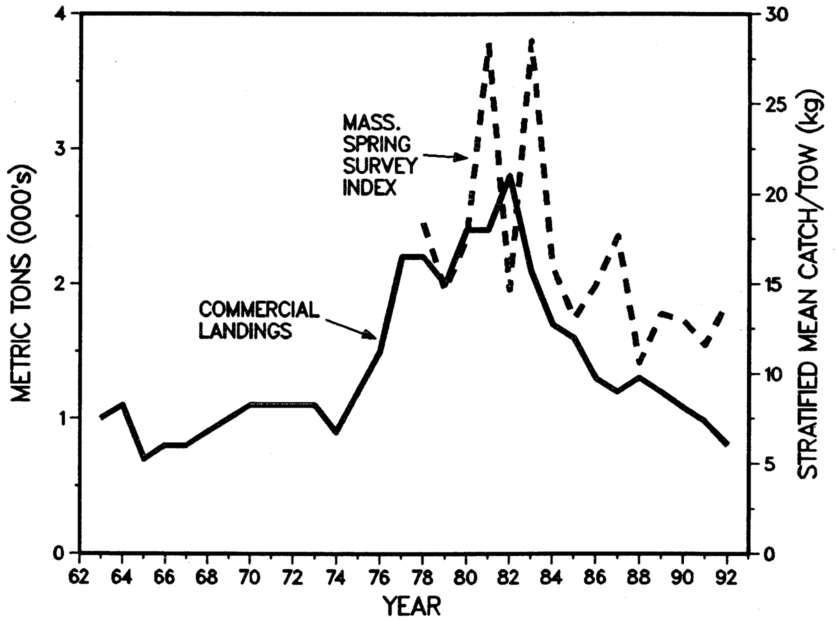


Table 11.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	4.4[1]	1.3	1.2	2.0	0.3	1.9	1.0	0.9	0.4	<0.1	0.1
Commercial											
United States	1.8	2.1	1.7	1.6	1.3	1.2	1.3	1.2	1.1	1.0	0.8
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	6.2	3.4	2.9	3.6	1.6	3.1	2.3	2.1	1.5	1.1	0.9

[1] Based on MRFSS statistics 1979-82

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 (NEFMC) FMP for Inshore Stocks of Winter Flounder (ASMFC)
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	=	>0.49

M = 0.28 **$F_{0.1}$ = Unknown** **F_{max} = Unknown** **F_{1992} = 1.0**

"Combined landings in 1992 were only 900 mt, a record low for the 14-year time series."

Bottom trawl survey abundance indices from the Massachusetts Division of Marine Fisheries spring survey for the Massachusetts Bay-Cape Cod Bay areas decreased after 1983, and have trended downward to the lowest values in the series in 1988-1992. 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 index has declined steadily since then, to remain at record low levels, averaging 0.9 mt per df in 1986-1991. The 1992 value (0.7 mt per df) is the lowest in the 29-year time series.

The continuing low level of landings, continuing low levels in commercial CPUE indices, and the low trawl survey indices in recent years indicate that winter flounder abundance in the Gulf of Maine has been reduced substantially by recent exploitation. Because the recreational component of catch has been significant, future improvements in the condition of the stock will depend on decreases in exploitation in both recreational and commercial sectors, and on improved recruitment. The stock at present is considered to be overexploited.

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 per yr). Between 1985 and 1988, landings averaged 2,400 mt per yr; but in recent years (1991-1992) averaged 1,800 mt per yr. No recreational catches have been reported from this stock.

Landings in 1992 (1,800 mt) remained near the lowest on record. Catch per unit effort indices in 1992 were also among the lowest ever observed. The NEFSC autumn survey stock biomass index has generally trended downward

Winter Flounder
Georges Bank

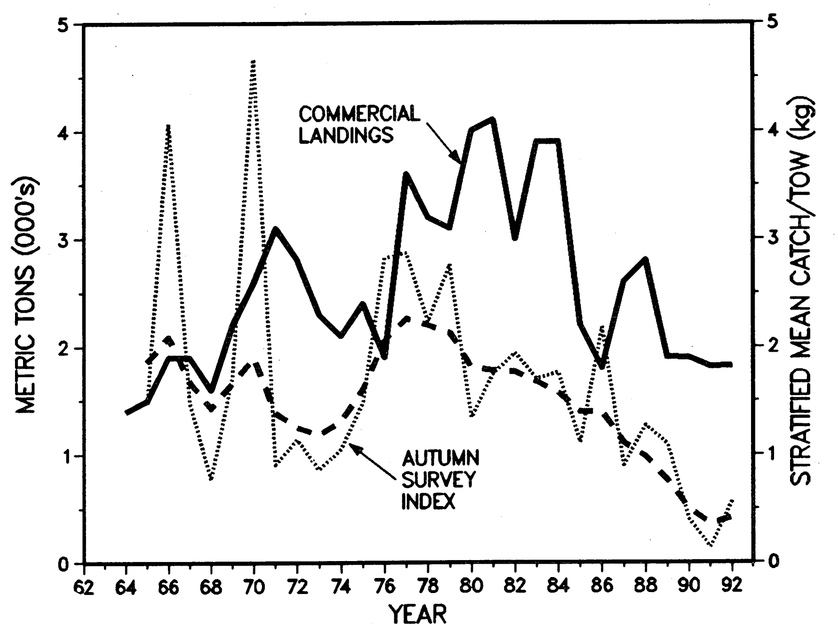


Table 11.2 Recreational catches and commercial landings (thousand metric tons)

Category	Year 1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	2.9	3.9	3.9	2.2	1.8	2.6	2.8	1.9	1.9	1.8	1.8
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Other	0.2	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.1	3.9	3.9	2.2	1.8	2.6	2.8	1.9	1.9	1.8	1.8

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_{1992} = Unknown**

"...commercial and survey data both indicate that the stock has declined to record low levels..."

since 1977. The survey index increased slightly in 1992 to the third lowest value in the 29-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 about 35 percent between 1991 and 1992, from 5,800 mt to a record low of 3,800 mt in the 14-year time series. Commercial landings in 1992 (3,400 mt) reached near-record low levels, compared to historical averages of 6,800 mt (1964-1991). Recreational landings declined from 2,000 mt in 1989 to approximately 400 mt in 1992, again a record low level.

NEFSC spring survey indices show trends similar to those of commercial catches since about 1975, increasing through 1981 and generally declining, with the exception of 1985, to near record-low levels between 1989 and 1991. Indices increased slightly in 1992 (to the seventh lowest level in the 29-year time series). Commercial CPUE indices (tonnage class 3 otter trawlers) showed a continuous decline from the 1964-1983 average of 2.7 mt per df to a record low of 0.8 mt per df in 1989, and have remained low since

Winter Flounder
Southern New England-Middle Atlantic

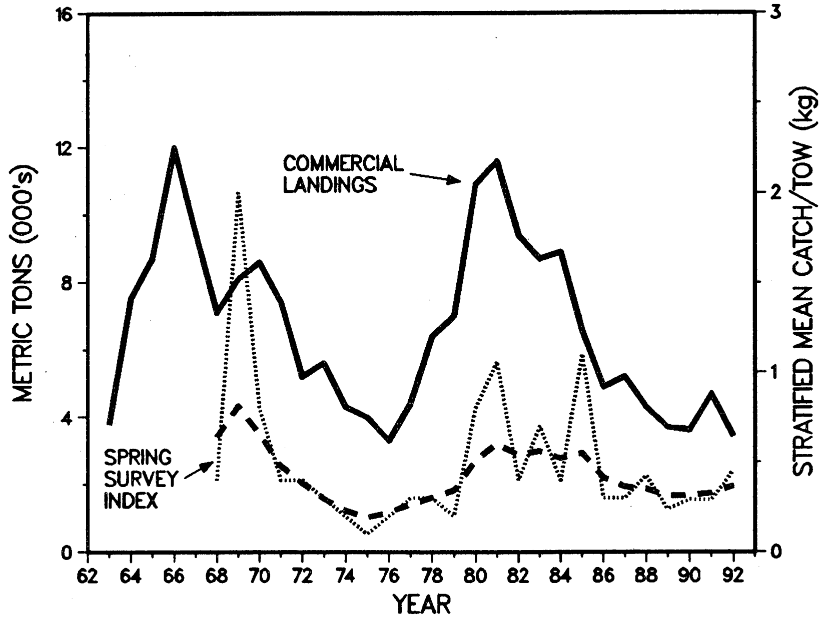


Table 11.3 Recreational catches and commercial landings (thousand metric tons)

Category	Year 1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	3.7[1]	5.0	6.4	7.9	3.3	4.0	3.9	2.0	0.9	1.1	0.4
Commercial											
United States	6.6	8.7	8.9	6.6	4.9	5.2	4.3	3.7	3.6	4.7	3.4
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-
Other	0.3	-	-	-	-	-	-	-	-	-	-
Total nominal catch	10.6	13.7	15.3	14.5	8.2	9.2	8.2	5.7	4.5	5.8	3.8

[1] Based on MRFSS statistics 1979-82

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 (NEFMC) FM|P for Inshore Stocks of Winter Flounder (ASMFC)
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_{1992} = 1.0

"The status of the stocks cannot be determined with certainty without increasing the level of the assessment..."

then (0.7 mt per df in 1992, record low).

Continued low commercial and survey indices in the recent years suggest that any increases in landings will not be sustainable in the near future. 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. The status of the stocks cannot be determined with certainty without increasing the level of the assessment, although it appears that on average the stocks are overexploited.

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.

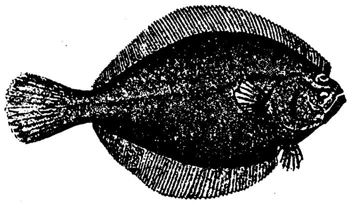
Foster, K. L. 1987. Status of winter flounder *Pseudopleuronectes americanus* stocks in the Gulf of Maine, Southern New England and Middle Atlantic areas. Woods Hole, MA: NOAA/NMFS/NEFC. *Lab. Ref. Doc.* 87-06.

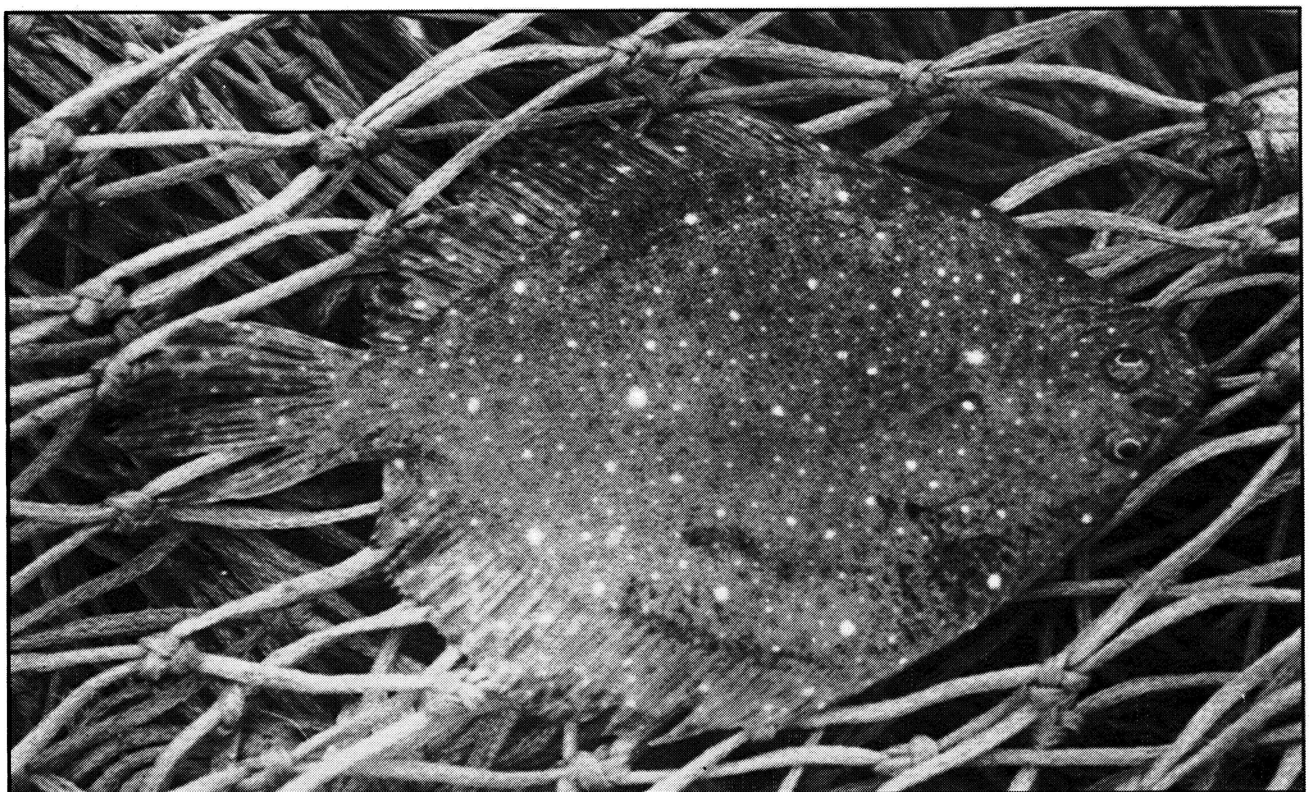
Gabriel, W.L. 1985. Spawning stock biomass per recruit analyses for seven northwest Atlantic demersal finfish species. *Woods Hole, MA: NOAA/NMFS/NEFC. Lab. Ref. Doc.* 84-04.

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

Windowpane Flounder





NMFS photos by Brenda Figuerido

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 principle 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 windowpane fishery is managed under the New England Fishery Management Council's Multi-species Fishery Management Plan. United States landings in 1992 (2,100 mt) were about 40 percent lower than those in 1991 (3,700 mt), and were about 10 percent greater than recent average landings (1,900 mt, 1987-1991).

Windowpane were first exploited as a commercial species in 1943-45 during the end of World War II. Between then and 1975, these fish were exploited (and reported) only as an industrial species. Separate commercial landings data for this species were first available in 1975. Commercial

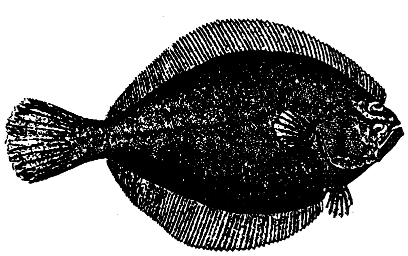
" Landings in 1992 (1,500 mt) show a 47 percent decrease from 1991 peak levels."

landings declined from 1975 to 1976, to a low of 900 mt in 1980. Subsequently, annual landings increased to a peak of 4,200 mt in 1985 and are now at 50 percent of this record level, at 2,100 mt.

Gulf of Maine-Georges Bank

Commercial landings from the Gulf of Maine-Georges Bank area have fluctuated between 400 and 2,900 mt through 1991, and have averaged 1,100 mt since 1975. Landings in 1992 (1,500 mt) show a 47 percent decrease from 1991 peak levels. 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 are highly variable, but have declined substantially since 1984. Preliminary indices of commercial catch-per-unit-effort (CPUE) show a declining trend since 1975. It is thus likely that this stock is overexploited.



Windowpane Flounder
Gulf of Maine-Georges Bank

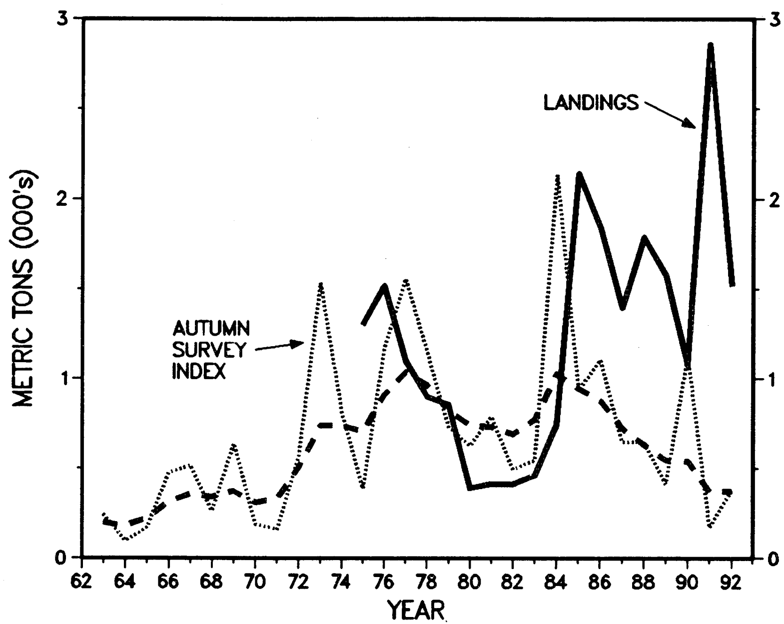


Table 12.1 Recreational catches and commercial landings (thousand metric tons)

Category	1975-82[1] Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	0.8	0.5	0.7	2.1	1.8	1.4	1.8	1.6	1.1	2.9	1.5
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.8	0.5	0.7	2.1	1.8	1.4	1.8	1.6	1.1	2.9	1.5

[1] Landings not reported by individual species before 1975

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	=	Unknown
Size at 50% maturity	=	22 cm (8.7 in.)
Assessment level	=	Index
Overfishing definition	=	Under development
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1991} = Unknown

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

Southern New England-Middle Atlantic

Commercial landings from the Southern New England to Mid-Atlantic area averaged 700 mt in the first decade of the fishery. Landings between 1986 and 1991 averaged 1,100 mt and have generally declined since 1985 peak levels of 2,100 mt. No recreational catches have been reported from this area. Landings in 1992 (600 mt) declined 28 percent from 1991 and approach the low levels observed prior to 1985.

Both NEFSC autumn offshore survey indices and preliminary indices of commercial CPUE have declined since the early 1980s to record low levels in recent years. This indicates that the stocks are overexploited.

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. In press. Maturation of nineteen species of finfish off the northeast coast of the United States, 1985-1990. *NOAA Tech. Rep.*

Windowpane Flounder
Southern New England-Middle Atlantic

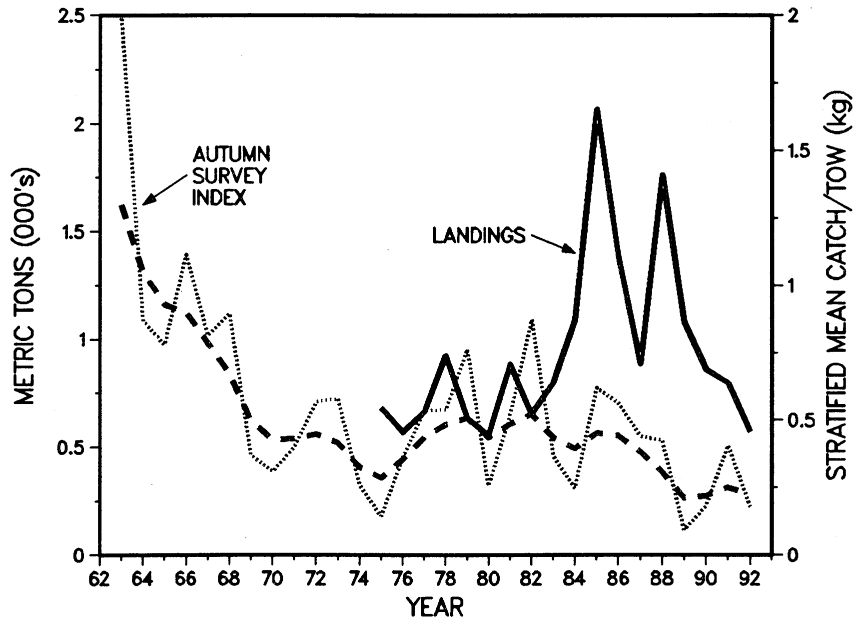


Table 12.2 Recreational catches and commercial landings (thousand metric tons)

Category	1975-82[1] Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	0.7	0.8	1.1	2.1	1.4	0.9	1.8	1.1	0.9	0.8	0.6
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.7	0.8	1.1	2.1	1.4	0.9	1.8	1.1	0.9	0.8	0.6

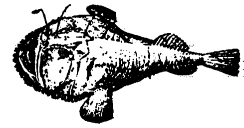
[1] Landings not reported by individual species before 1975

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	=	Unknown
Size at 50% maturity	=	21 cm (8.3 in.)
Assessment level	=	Index
Overfishing definition	=	Under development
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1992} = Unknown

Goosefish



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. These fish occur from the tideline to as deep as 840 m, although few larger individuals are found deeper than 400 m (475 fathoms). Goosefish have been found in waters ranging from 0° to 24°C (32° to 74°F), but are most abundant in the range of 3° to 11°C (38° to 52°F), depending on the region. Seasonal migrations appear to be related to avoiding water warmer than 15°C (60°F), or availability of preferred foods such as squids, butterfish, hakes, and sand lance.

NMFS photo by Bob Brigham

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.

Female goosefish mature after about 4 years, 49 cm (19.3 in.), and males after 3 years, 37 cm (14.5 in.). Goosefish spawn in spring, summer, and early autumn (depending on latitude). This a protracted period during which the females lay a nonadhesive, mucoid egg raft or veil that is buoyant and contains a complex structure of individual chambers, each containing one to three eggs and an opening for water circulation. This veil is unique to goosefishes, and can be as large as 12 m (39 ft) long by 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 have historically been almost exclusively a bycatch of groundfishing and scalloping ventures. Until recently, this species was not common in U.S. markets, consequently, most of the U.S.-caught fish went to shack. Now, however, goosefish, or poor man's lobster, is being sold in response to the dwindling supply (and rising prices) of traditional species of groundfish. In the last ten years, goosefish livers have also found a growing market (mostly as exports to Japan), and as a result landings have shown a steady increase from 1970 to 1990. Landed weight of tails rose from 19.3 mt in 1964 to 643 mt in 1975, and from 1975 to 1980 increased to 2,305 mt. By 1989, 4,323 mt were landed (representing about 11,000 mt of live weight) before dropping to 3,844 in 1990 and rising again in 1991 to 4,532 mt, and again in 1992 to 6,097 mt. Over the last ten years, calculated live weight for all goosefish parts (tails, whole fish, livers, cheeks, and belly flaps) landed has risen steadily from around 2,600 mt in 1982 to 13,800 mt in 1991, and to 15,997 mt in 1992. From 1964 to the mid-1970s, the majority of landed goosefish were taken in otter trawls in the southern Gulf of Maine and northwestern Georges Bank regions. In the late 1970s, otter trawls began landing measurable quantities from Southern New England and a greater portion of the Gulf of Maine and Georges Bank. At the same time, scallop dredges working on Georges Bank and in Southern New England and the mid-Atlantic began landing goosefish tails in increasing numbers. At the present, scallop dredges account for about 42 percent of the landed tails. Otter trawls and scallop dredges have accounted for more than 90 percent of all landings. In the last five years, there has been a constant increase in the number of trips that are landing goosefish in all areas. There also seems to be an increase in the number of directed goosefish trips for some vessels fishing with trawls, scallop dredges and sink gill nets, the latter now accounting for around 6 percent of tail landings.

The steady growth of the liver market has also been of interest. From 1982, when 10 mt where landed, this product jumped to 28 mt in 1985 and to 180 mt in 1990. In 1991, 271 mt of this product were landed, rising to 317 mt in 1992. Along with this increase in landings, there has been a significant increase in ex-vessel price. With prices rising from \$0.92 per lb in 1982, to

Goosefish
Gulf of Maine-Middle Atlantic

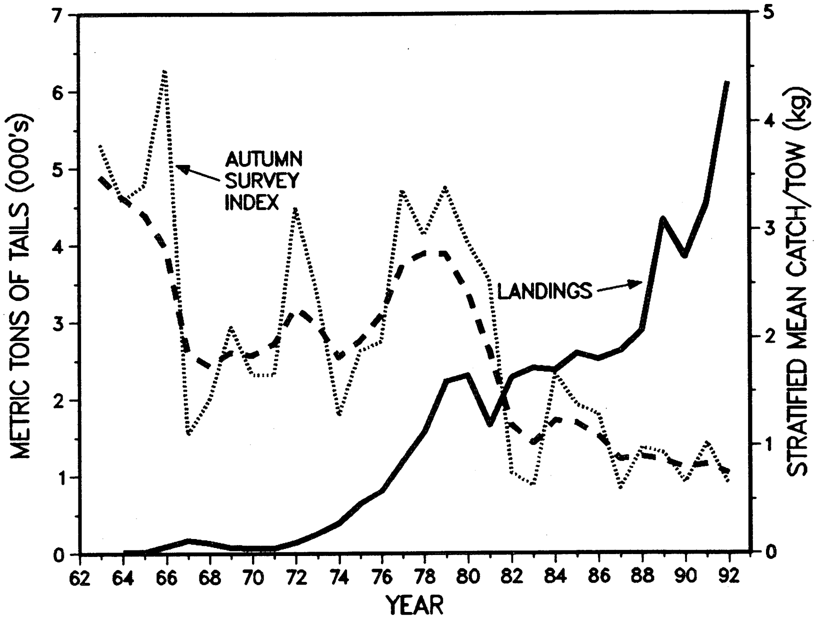


Table 13.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
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	1.2	2.6	2.6	3.0	2.4	6.9	8.1	11.6	10.6	12.8	16.0
Canada	<0.1	<0.1	0.3	1.3	0.3	0.7	0.9	1.2	1.6	1.0	0.5
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	1.2	2.6	2.9	4.3	2.8	7.7	9.0	12.8	12.2	13.9	16.5

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	=	Overfished
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 = 0.2 **$F_{0.1}$ = Unknown** **F_{max} = 0.2** **F_{1991} = >F_{max}**

$4.23 per lb in 1992, the proportion of total goosefish revenues represented by livers has grown from less than 1 percent to almost 13 percent in that time. The liver market is highly seasonal, as evidenced by the range of prices (1992: from $0.19 to $9.51). Additionally, in 1991 a new market category was added. Pee-wee tails are tails that weigh less than one-half pound. These "drumsticks" come from fish that are slightly less than 15 in. long. In 1991, 80,000 lb (36 mt) of this size category were landed, and in 1992 this figure rose to 404,000 lb (183 mt).

Since this fish was until recently only bycatch from other fisheries, catch per unit effort (CPUE) data are difficult to obtain. However, the NEFSC autumn survey biomass index shows a reasonably sharp decline over the last 15 years. The average standardized catch per tow over the last 10 years is 1.05 kg per tow, compared with 2.38 kg per tow, the average of preceding years. In the last 6 years, this value has been less than 1.0 kg per tow and in 1992, the value of 0.75 kg per tow was the lowest on record. Given the record low abundance of the stock, the sharp increases in landings in recent years, and the small size of the animals targeted in the fishery, the stock appears to be overfished.

For further information

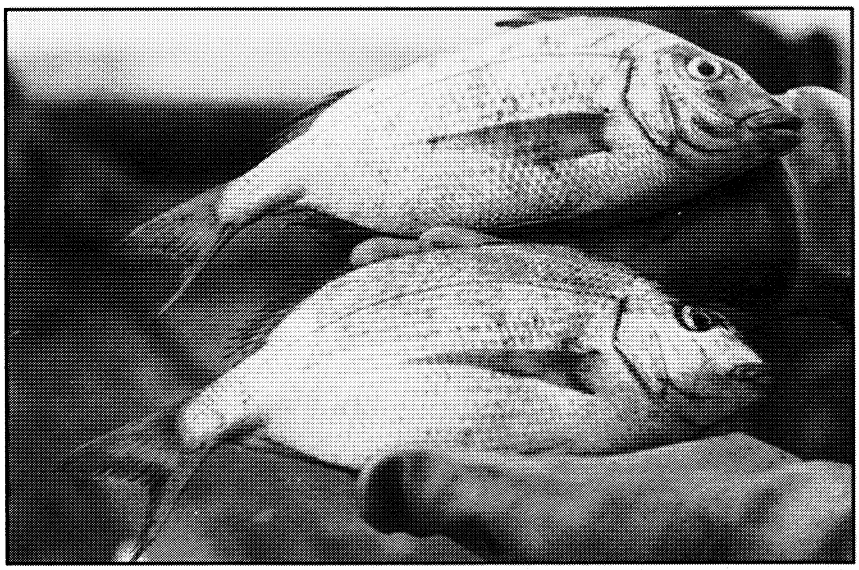
Armstrong, M.P. 1987. Life history of the goosefish, *Lophius americanus*. Williamsburg, Virginia: College of William and Mary. Master's thesis.

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.

Scup



NMFS photo by Brenda Figuerido

Scup or porgy, *Stenotomus chrysops*, occurs 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 2 at a total length of 19 cm (7.5 in.); spawning occurs during summer months. Although ages up to 20 years have been reported, recent catches have been dominated by age 2 to 3 fish. Scup attain a maximum length of about 40 cm (16 in.). Tagging studies have indicated the possibility of a Southern New England stock and another stock extending south from New Jersey. Because the separation of stocks is not well-defined spatially, this separation is not used here.

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 being projected. Landings decreased 27 percent in 1992 (from 10,400 mt to 7,600 mt), with lower catches reported in both commercial and recreational fisheries.

Nominal commercial catches by U.S. vessels fluctuated between 18,000 and 22,000 mt annually between 1953 and 1963, but declined to between 4,000 and 5,000 mt during the early 1970s. Nominal catches by distant-water fleets peaked at 5,900 mt in 1963, but declined to less than 100 mt per year after 1975. Beginning in the early 1970s, the U.S. nominal commercial catch steadily increased and reached a peak of 9,800 mt in 1981. Landings declined significantly thereafter. Commercial landings declined thereafter to record low levels (3,600 mt) in 1989. An upward trend in landings between 1990-1991 (to 6,700 mt in 1991) was not maintained in 1992, however, when commercial landings declined 16 percent to 5,600 mt.

Most of the increase in landings during the 1970s is attributable to increased fixed-gear and otter trawl catches in the Southern New England-New Jersey area. The Virginia winter trawl fishery, which produced nominal catches in excess of 5,000 mt in the early 1960s, has averaged less than 350 mt in the past 10 years. The proportion taken by the Virginia fishery has declined from 40 to 60 percent of the total prior to 1967, to 2 to 16 percent since 1973. Recreational catches represent 20 to 50 percent of total nominal catches during the past ten years. The 1992 recreational catch (2,000 mt) is about half the 1991 level (3,700 mt) and about 35 percent below the 1981-1991 mean (3,100 mt).

Catch-per-unit-effort (CPUE) of Southern New England otter trawlers decreased from 6.2 mt per day fished in 1977-79 to 5.8 mt per day fished in 1982-84, and to 3.0 mt per day fished in 1989-90, approaching record low levels of 1971-72. Although values increased in 1991 to 5.8 mt per day fished, this increase was not sustained in 1992, when CPUE declined to 4.8 mt per day, below the 1982-1984 average. The NEFSC autumn offshore survey index (age 1 and older) is quite variable. The index increased sharply from 1979 to the second highest value in the time series in 1981. Since 1981, the index has fluctuated widely, but is trending downward. The 1987-88 indices were the lowest observed in the time series. The 1992 index, although above 1990-1991 levels, is unlikely to reflect any significant stock increase, given the historic variability in the index.

A comparison of scup length-frequencies from the commercial fisheries during 1983-1991 reveal that commercial length-frequency distributions have shifted to smaller fish (including young-of-year). There are generally few older scup, those longer than 35 cm (14 in.) and older than 7 years, in either commercial or recreational fisheries. The maximum length observed in NEFSC autumn surveys has declined from a mean of 30 cm (14 in.) between 1982 and 1986, to 24 cm (9.5 in.) between 1987 and 1992. Instanta-

Scup
Southern New England-Middle Atlantic

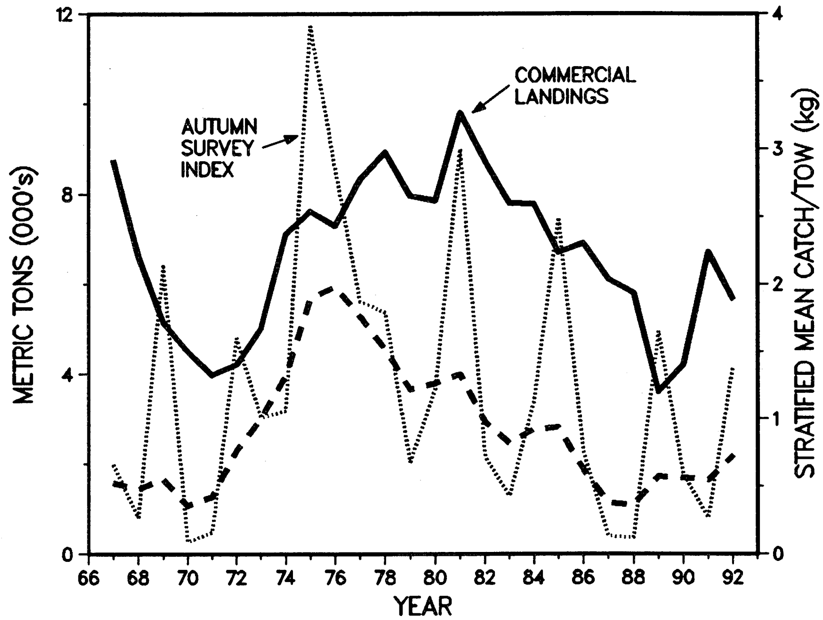


Table 14.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	3.2[1]	3.4	1.4	3.3	5.9	3.2	2.3	3.2	1.9	3.7	2.2[2]
Commercial											
United States	7.4	7.8	7.8	6.7	6.9	6.1	5.8	3.6	4.2	6.7	5.6
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	0.5	-	-	<0.1	<0.1	<0.1	-	-	-	-	-
Total nominal catch	11.1	11.2	9.2	10.0	12.8	9.3	8.1	6.8	6.1	10.4	7.7

[1] Based on 1979-1982 MRFSS statistics
[2] Preliminary estimate

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	=	None
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	15.5 cm (6.1 in.)
Assessment level	=	Yield per recruit
Overfishing definition	=	Under development
Fishing mortality rate corresponding to overfishing definition	=	Under development

$M = 0.20$ $F_{0.1} = 0.20$ $F_{max} = 0.35$ $F_{1992} > F_{max}$

"The 1992 recreational catch (2,000 mt) is about half the 1991 level (3,700 mt) and about 35 percent below the 1981-1991 mean (3,100 mt)."

neous fishing mortality (F) in the Southern New England area was estimated to be about 0.3 in 1981 but has probably exceeded F_{max} in recent years.

Although landings and CPUE increased in 1991 from near record lows in 1989-1990, those increases have not persisted in 1992, and the overall declining trend in survey indices suggest that recent exploitation has reduced stock abundance substantially. The truncated age distributions suggest that exploitation is focusing on young fish, and that the fishery is probably dependent on incoming year classes. These considerations clearly indicate that the population is overexploited.

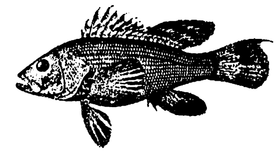
For further information

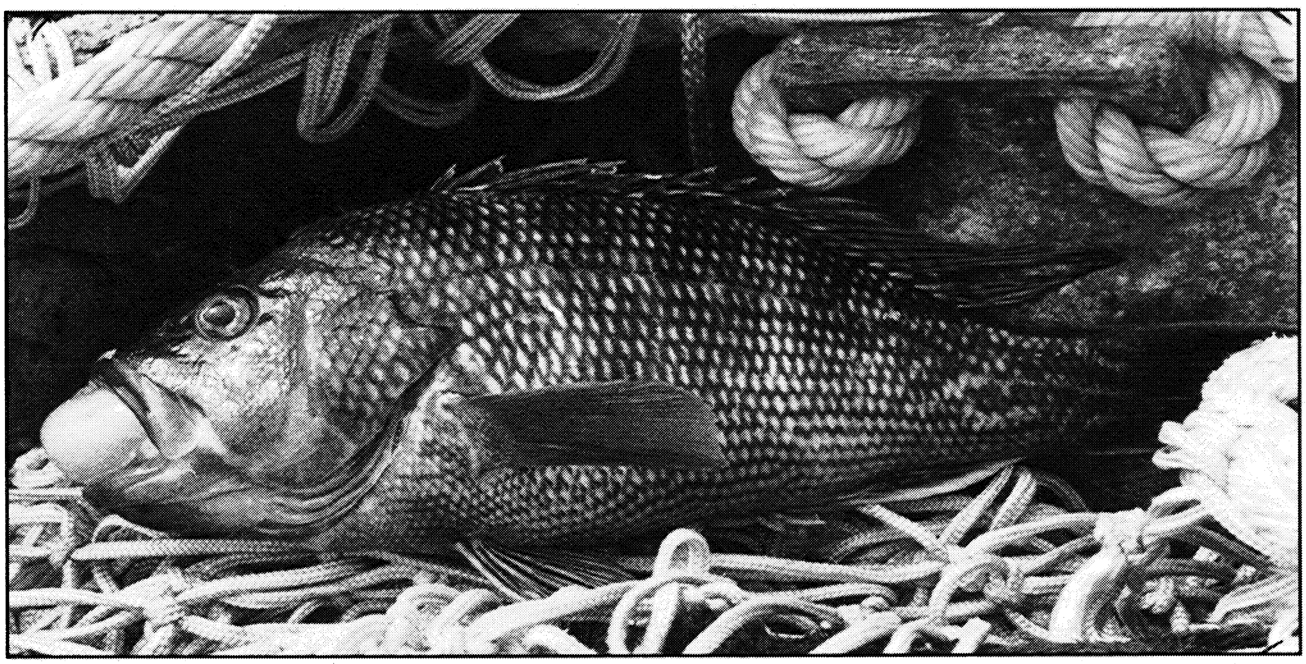
Mayo, R. K., 1982. An assessment of the scup, *Stenotomus chrysops* (L.), population in the Southern New England and Mid-Atlantic regions. Woods Hole, MA: NOAA/NMFS/NEFC. Lab. Ref. Doc. 82-46. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

Northeast Fisheries Center. 1989. Report of the 7th NEFC Stock Assessment Workshop. Woods Hole, MA: NOAA/NMFS/NEFC. Lab. Ref. Doc. 89-04. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

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. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

Black Sea Bass





NMFS photo by Brenda Figuerido

Black sea bass, *Centropristis striata*, occur off the northeastern United States along the entire Atlantic coast, and consist of two stocks north and 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 traps. Recreational fishing is as significant as commercial fishing. Currently there is no management outside state waters. Total catch decreased in 1992 to 2,575 mt, down from 3,200 mt in 1991.

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 1990, commercial landings have ranged from 1,100 to 1,900 mt, with average landings of 1,470 mt. Total landings have fluctuated without trend in the 1980s, punctuated by years with much higher recreational catches. Commercial landings in 1992 were 1,276 mt. The only reported catch by distant-water fleets was 1,500 mt in 1964.

Estimated recreational landings, occurring primarily in the middle Atlantic states, have ranged from 500 to 8,100 mt in the 1980s, with no apparent trend. (The high values for 1982 and 1986, 8,100 and 6,300 mt respectively, are due in part to sampling effects.) The estimated recreational landings have contributed 31 percent (1981) to 87 percent (1982) of the total nominal catch in the past ten years. Estimated recreational landings for 1992 from the Middle Atlantic and New England regions were 1,175 mt.

Standardized catch-per-unit-effort (CPUE, metric tons per days 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 steadily declined to the 1992 level of 0.57 mt per days fished. Data from the NEFSC spring offshore bottom trawl survey indicate an increase in abundance from 1970 (0.1 fish per tow) to 1977 (8.2 fish per tow), followed by a decline to 0.3 fish per tow by 1982. Indices since 1982 have averaged only 1.2 fish per tow. The 1992 index of 2.0 fish per tow represented an increase from 1991, although still well below

Black Sea Bass
Gulf of Maine-Middle Atlantic

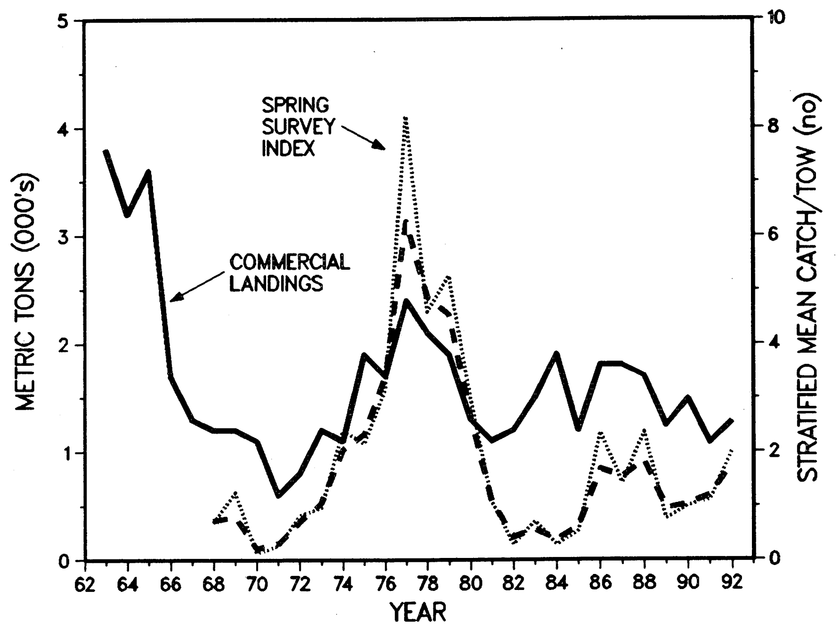


Table 15.1 Recreational and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	2.9[2]	2.3	0.7	1.5	6.3	0.9	1.8	1.6	1.4	2.1	1.3[1]
Commercial											
United States	1.4	1.5	1.9	1.2	1.8	1.8	1.7	1.2	1.5	1.1	1.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	4.3	3.8	2.6	2.7	8.1	2.7	3.5	2.8	2.9	3.2	2.6[1]

[1] Preliminary estimate
[2] 1979-1982

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

$M = 0.2$ $F_{0.1} = 0.11$ $F_{max} = 0.17$ $F_{1992} => F_{max}$

the index values 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 1992 appears to continue the recent trend of below average recruitment.

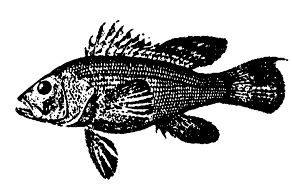
Size composition data from commercial landings indicate that black sea bass recruit fully to the trap and trawl fisheries by ages 2 and 3, respectively. The biologically optimum age at first harvest for black sea bass, based on yield per recruit analysis, is 6 years at F=0.3. High prerecruit indices from the NEFSC survey correspond to increased commercial landings two years later, but periods of higher landings (and CPUE) are brief. This suggests that the fishery tends to reduce incoming year classes rapidly. The assessment information is preliminary, but 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. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

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.



Ocean Pout

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.

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. Fishing in federal waters 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 nominal landings sharply declined in 1992 (from 1,400 to 500 mt).

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, 1992 landings dropped to 500 mt (-60 percent). Although a relatively strong 1987 year class recruited to the commercial fishery in 1990-91, landings in 1993 are expected to follow market demands. Landings from southern New England dominated the catch for the fifth consecutive year, accounting for 54 percent of the total 1992 U.S. harvest, reversing landing patterns observed in 1986-87 when the Cape Cod Bay fishery was dominant.

NMFS photo

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 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 historic high values in 1968-69 to lows of 300 mt and 1.6 kg per tow, respectively, in 1975. Between 1975 and 1985, survey indices increased to record high levels,

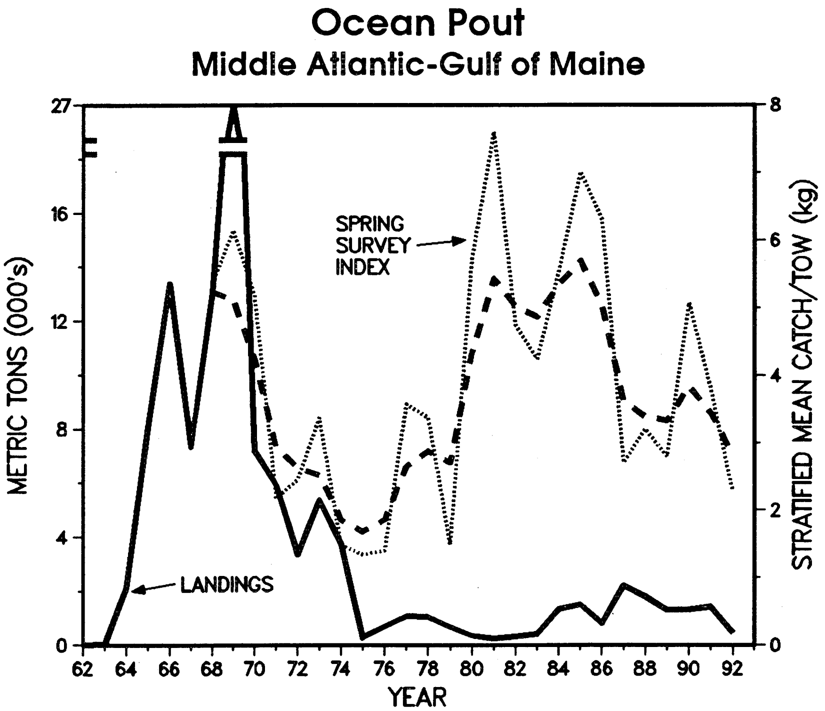


Table 16.1 Recreational and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.2	0.4	1.3	1.5	0.8	2.2	1.8	1.3	1.3	1.4	0.5
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	0.4	-	-	-	-	-	-	-	-	-	-
Total nominal catch	1.6	0.4	1.3	1.5	0.8	2.2	1.8	1.3	1.3	1.4	0.5

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	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1992} = Unknown

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

". . .due to declining market demands, 1992 landings dropped to 500 mt (-60 percent). Although a relatively strong 1987 year class recruited to the commercial fishery in 1990-91, landings in 1993 are expected to follow market demands."

peaking in 1981 and 1985. Subsequently, survey catch per tow indices have fluctuated about the long-term survey average; the spring 1992 index was 2.3 kg per tow.

The population appears to be fully exploited, and catches at the present level appear sustainable.

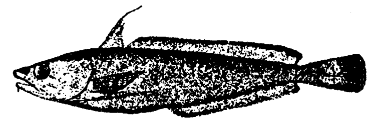
For further information

NEFC [Northeast Fisheries Science Center]. 1990. Eeport of the eleventh Stock Assessment Workshop (11th SAW), Fall 1990. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Ref. Doc.* 90-09. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

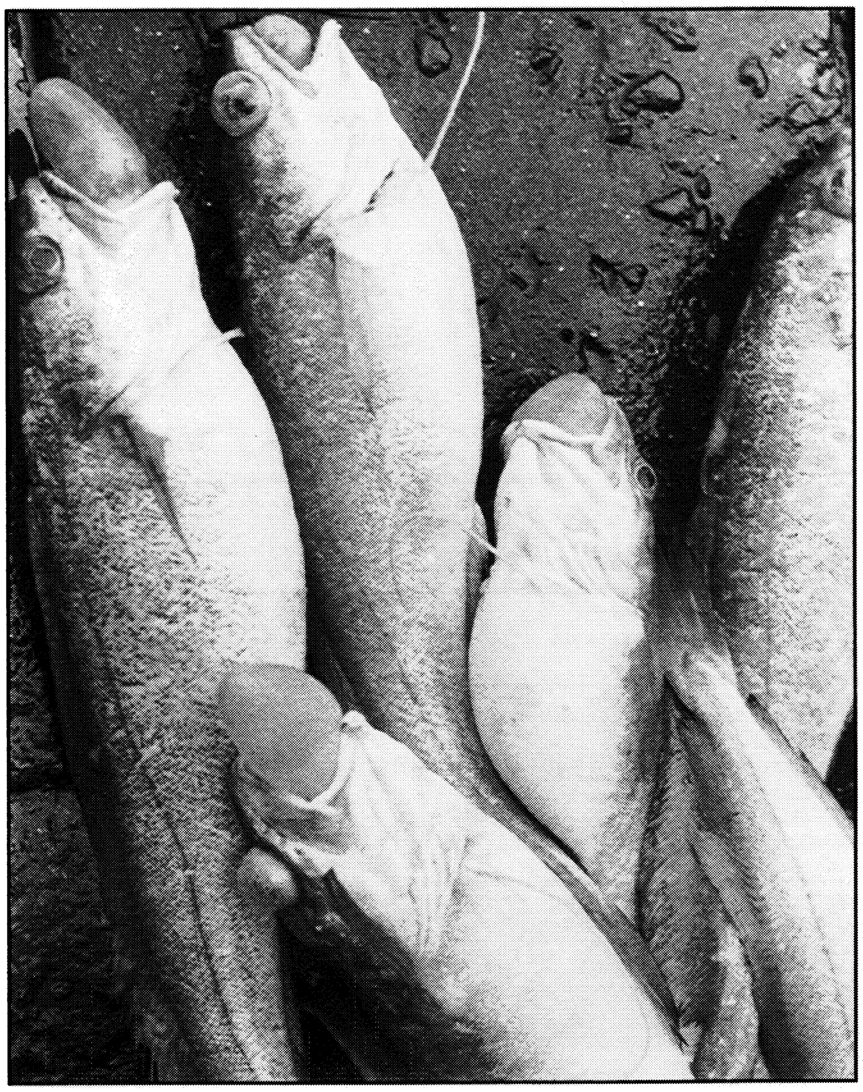
Olsen, Y. H., and Merriman, D. 1946. Studies on the marine resources of southern New England, IV: The biology and economic importance of the ocean pout, *Macrozoarces americanus* (Bloch and Schneider). *Bull. Bingham Oceanogr. Collec.* 9:1-184.

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.

White Hake



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 research vessel survey data indicate that the Gulf of Maine population is more or less discrete from populations further north and east. Depth distribution 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.



NMFS photo by Brenda Figuerido

In the Gulf of Maine region, spawning occurs in winter and spring, although the season and the extent of spawning is not clearly defined. 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.

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. Fishing is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan (FMP). Total landings increased by more than 50 percent in 1992 (9,600 mt) compared with 1991 (6,200 mt). Of the 10 major groundfish species covered by the Multispecies FMP, white hake was second only to cod in 1992 in quantity of landings from the Gulf of Maine.

The U.S. nominal catch has been taken primarily 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, U.S. vessels have accounted for more than 90 percent of the Gulf of Maine-Georges Bank white hake catch. Total nominal catch increased steadily from less than 1,000 mt during the late 1960s to 7,500 mt in 1984, declined to 5,500 mt by 1990, but increased to 6,200 mt in 1991 and to an historic high of 9,600 mt in 1992. The increase evident throughout the 1970s and early 1980s likely 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 individuals are difficult to distinguish from red hake, *Urophycis chuss*, resulting in an unknown degree of bias in reported nominal catches.

The NEFSC autumn survey biomass index has fluctuated without any consistent long-term trends since the early 1970s, although total landings tended to follow inter-annual fluctuations until the early 1980s. Except for an anomalously low index in 1982, indices for 1981 to 1992 have been quite stable at a level 30 to 40 percent below the 1970-1980 average although the smoothed index indicates an ap-

White Hake
Gulf of Maine-Georges Bank

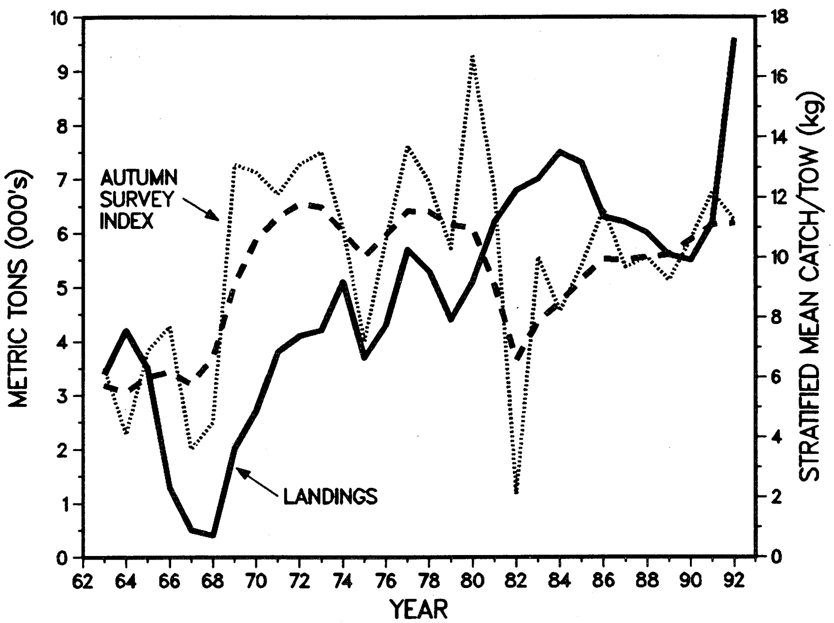


Table 17.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
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	6.2	6.5	6.4	5.3	5.5	5.4	5.0	5.0	5.6	8.4
Canada	0.3	0.8	1.0	0.9	1.0	0.7	0.6	0.6	0.5	0.6	1.2
Other	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-
Total nominal catch	5.0	7.0	7.5	7.3	6.3	6.2	6.0	5.6	5.5	6.2	9.6

Gulf of Maine - Georges Bank White Hake

Long-term potential catch	=	6,500 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	=	Index
Overfishing definition	=	25th percentile of NEFSC bottom trawl survey biomass index
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1991} = Unknown

"Given the stability in stock biomass since 1981, the mean 1981-1990 catch of 6,500 mt may be an appropriate estimate of the long-term potential catch."

parent steady increase since 1982. Catches declined between 1984 and 1990, but have increased during the past two years. Given the stability in stock biomass since 1981, the mean 1981-1990 catch of 6,500 mt may be an appropriate estimate of the long-term potential catch. Although total landings exceeded this level by about 50 percent in 1992, the population is still considered to be fully exploited based on recent levels of relative abundance. Continued harvesting at the 1992 level, however, is likely not sustainable and may lead to overexploitation of the stock.

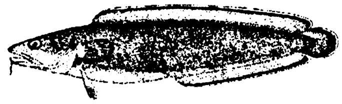
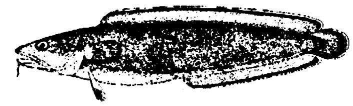
For further information

Burnett, J., S. H. Clark, and L. O'Brien. 1984. A preliminary assessment of white hake in the Gulf of Maine - Georges Bank area. Woods Hole, MA: NOAA/NMFS/NEFC. *Lab. Ref. Doc.* 84-31. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

Northeast Fisheries Center. 1986. Report of the Second NEFC Stock Assessment Workshop. *Woods Hole, MA: NOAA/NMFS/NEFC. Lab. Ref. Doc. 86-09.* Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

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. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543-1097.

Cusk

NMFS photo by Brenda Figuerido

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 80 cm (32 in.) and weights up to 4.5 kg (20 lb). Little is known about stock structure.

The principal fishing gears used to catch cusk are otter trawl, longline, and gill net. Recreational fishing is insignificant and foreign catches are minor. The fishery is not under management. Total catches in 1992 were 2,400 mt, 300 mt more than in 1991, and the highest annual total since 1985.

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. Since 1989, landings have been increasing. The majority of the U.S. catch has been taken from the Gulf of Maine while nearly all of the Canadian catch has been from Georges Bank. The 1992 U.S. catch was 1,600 mt and accounted for 67 percent of the total yield. Canadian landings in 1992 were 800 mt.

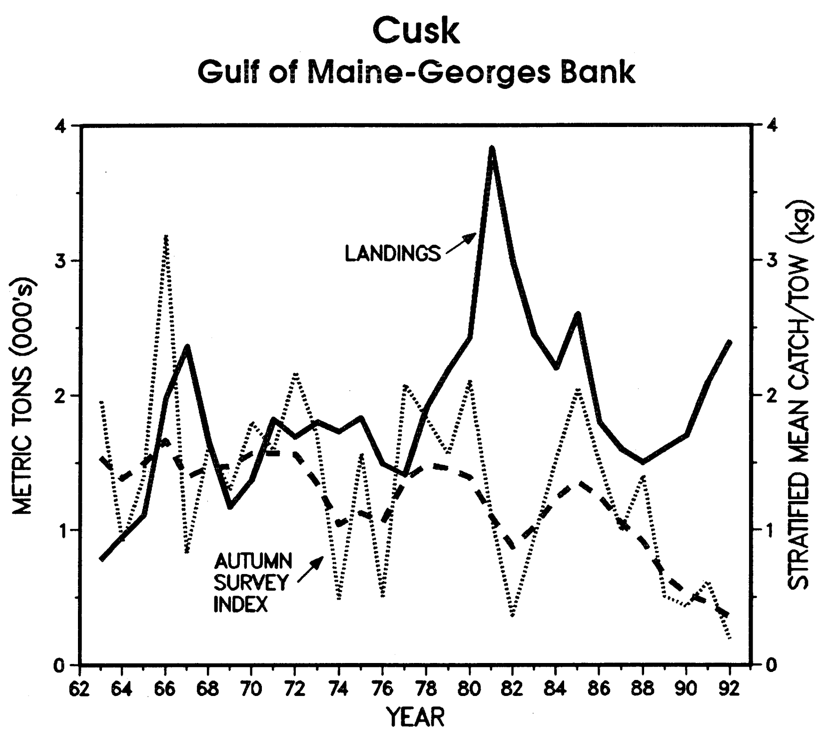
Historically, otter trawls have accounted for between 50 and 87 percent of the annual U.S. landings. In 1985-1986, longline landings of cusk markedly increased (to 23 percent of the total landings) as a result of a new auto-longline fishery. This fishery ceased operations in 1987 however, and longline gear accounted for only 5 percent of the total landings during 1987-1989. The fishery became active again in 1990-1991 and accounted for 17 percent of the landings, however, the fishery again ceased activity in 1992. During 1990-1992, line trawls and otter trawls accounted for 35 and 40 percent of the landings, respectively. Line trawls accounted for the majority of the landings in 1992 (53 percent).

The NEFSC autumn survey index has fluctuated considerably during the time series. The 1992 autumn index declined sharply from the 1991 value to a record low.

While annual landings have generally declined since 1981, survey indices of abundance have fluctuated without a consistent trend. The current level of assessment is too low to allow the status of the stock to be predicted with confidence, but continued declines in resource abundance are cause for concern.

For further information

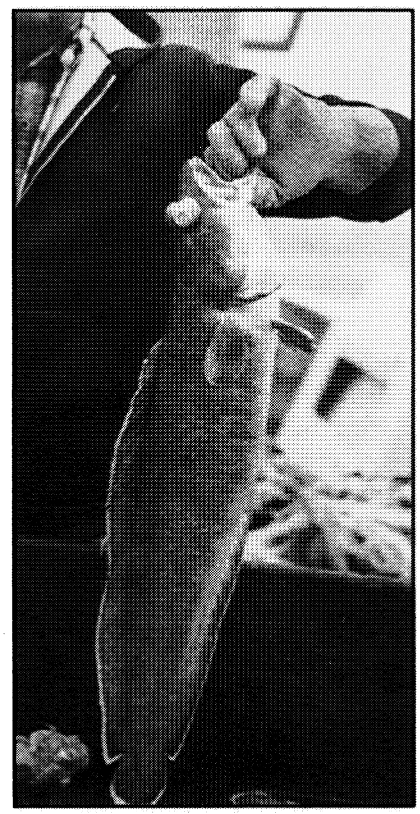
Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. *Fish. Bull., U.S.* 53.



"While annual landings have generally declined since 1981, survey indices of abundance have fluctuated without a consistent trend. The current level of assessment is too low to allow the status of the stock to be predicted with confidence."

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

Category	Year										
	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
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	1.4	1.8	1.7	2.3	1.8	1.4	1.1	0.9	1.2	1.5	1.6
Canada	0.7	0.6	0.5	0.3	0.1	0.3	0.4	0.7	0.5	0.6	0.8
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	2.1	2.4	2.2	2.6	1.9	1.7	1.5	1.6	1.7	2.1	2.4



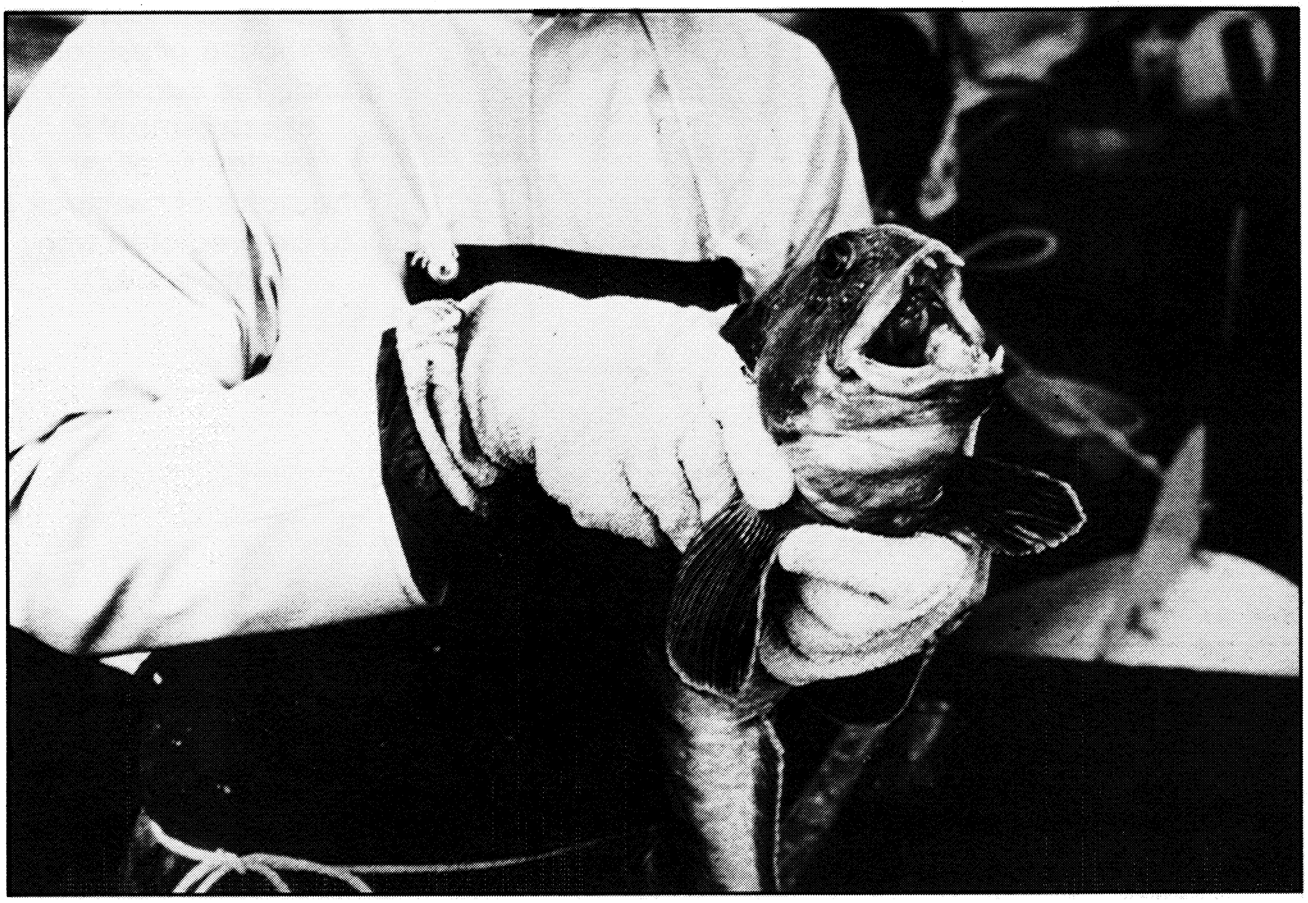
NMFS photo by Brenda Figuerido

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	=	Unknown
Size at 50% maturity	=	Unknown
Assessment level	=	Index
Overfishing definition	=	N/A
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1991} = Unknown

Atlantic Wolffish



NMFS photo by Brenda Figuerido

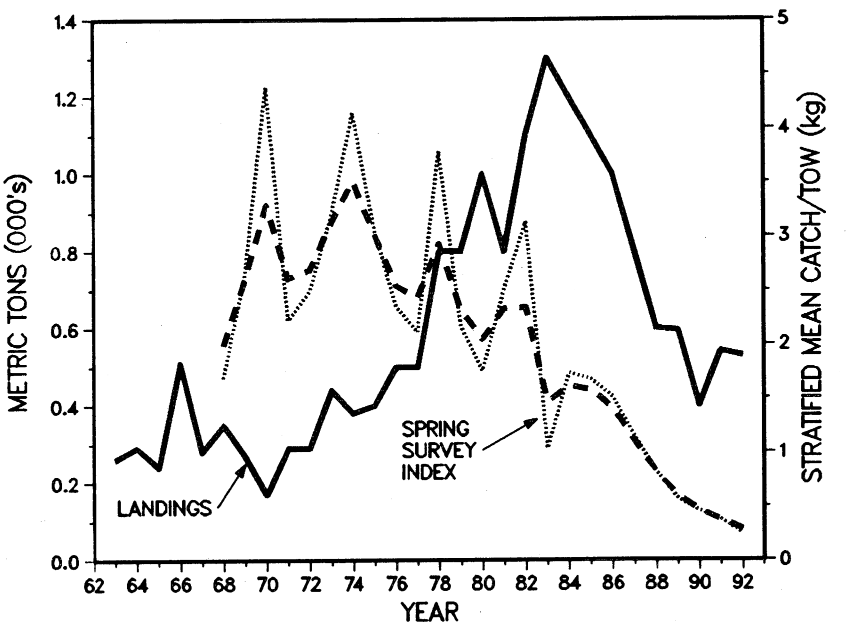
The wolffish or catfish, *Anarhichas lupus*, is a cold-water species of relatively minor importance in Gulf of Maine fisheries. Research vessel surveys conducted by the Northeast Fisheries Science Center indicate that populations on Georges Bank and in the western Gulf of Maine are discrete from wolffish 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 are significant shellfish predators.

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. There is no management. The total landings for 1990 were 500 mt, the lowest since the mid-1970s.

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 75 percent of the total Georges Bank-Gulf of Maine catch, with most of the remainder taken by Canadian fishermen. The total Georges Bank-Gulf of Maine nominal catch increased from 200 mt in 1970 to an average of around 1,000 mt since 1980. United States landings in 1990 were just under 400 mt, continuing the trend of a 100 to 200 mt decline per year since 1983. In 1991, the U.S. landings increased to almost 490 mt, but the Canadian take dropped to 55 mt. In 1992 the United States landings dropped again to about 465 mt while the Canadian portion rose slightly to around 65 mt. This total of about 530 mt is lower than any since the mid-1970s.

After fluctuating considerably from 1968 to 1982, the NEFSC spring survey index has shown a consistent downward trend in recent years and values of 0.37 kg per tow (1991) and 0.28 kg per tow (1992) are the lowest in the series. The average of the last five years, 0.42 kg per tow, is considerably less than the average of the previous years (2.3 kg per tow).

Atlantic Wolffish
Gulf of Maine-Georges Bank



"The decline in landings since 1983 and the longer term decline in the trawl survey indices indicate that recent levels of exploitation have reduced biomass substantially."

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

Category	Year										
	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
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	0.5	1.2	1.1	1.0	0.9	0.7	0.5	0.5	0.4	0.5	0.5
Canada	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.6	1.1	1.3	1.2	1.1	1.0	0.8	0.6	0.5	0.5	0.5

Gulf of Maine - Georges Bank
Atlantic Wolffish

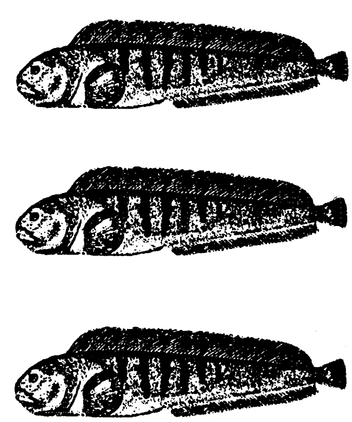
Long-term potential catch	=	<1,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	None
Status of exploitation	=	Overexploited
Age at 50% maturity	=	Unknown
Size at 50% maturity	=	Unknown
Assessment level	=	Index
Overfishing definition	=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

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1991} = Unknown

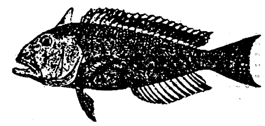
The decline in landings since 1983 and the longer term decline in the trawl survey indices indicate that recent levels of exploitation have reduced biomass substantially. Although an analytic assessment is not available, the stock is clearly overexploited and depleted.

For further information

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

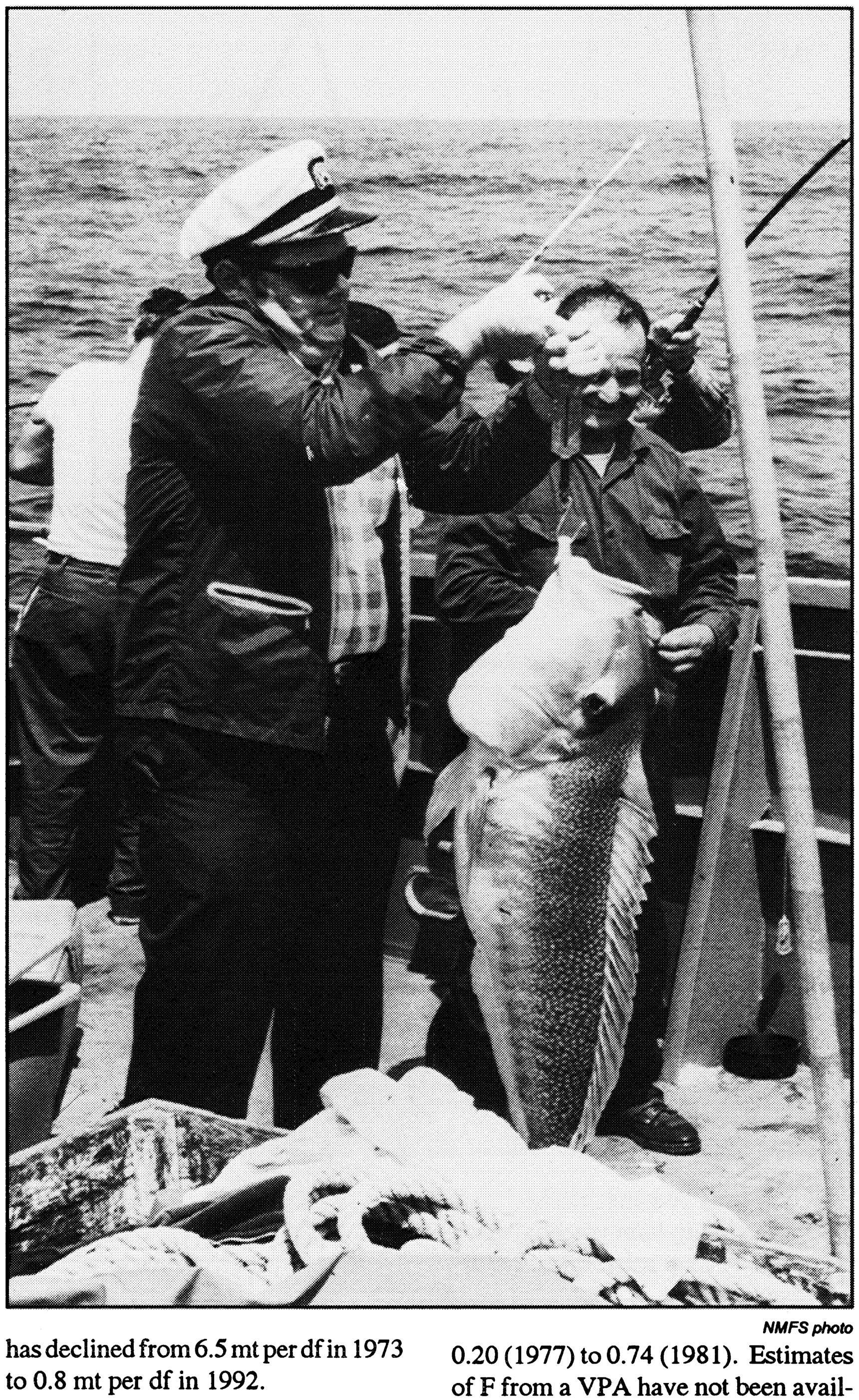


Tilefish



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 functionally mature by age 5 (50 cm or 20 in.).

Nominal catches were first recorded in 1915 (148 mt); 4,500 mt were taken in 1916, which is the largest annual catch to date, but only 5 mt were reported by 1920. Landings briefly increased to 1,000 to 1,500 mt during the early 1950s, followed by a decline to 30 mt in 1968-69. Most recently, catches increased to 3,800 mt in 1979 but have steadily declined to 1992 landings of 1,650 mt. Since the 1970s, the predominant gear type used in this fishery is longlines. A small recreational fishery developed during the late 1960s in New York and New Jersey with landings never exceeding 100 mt. Recent recreational catches are virtually nonexistent.



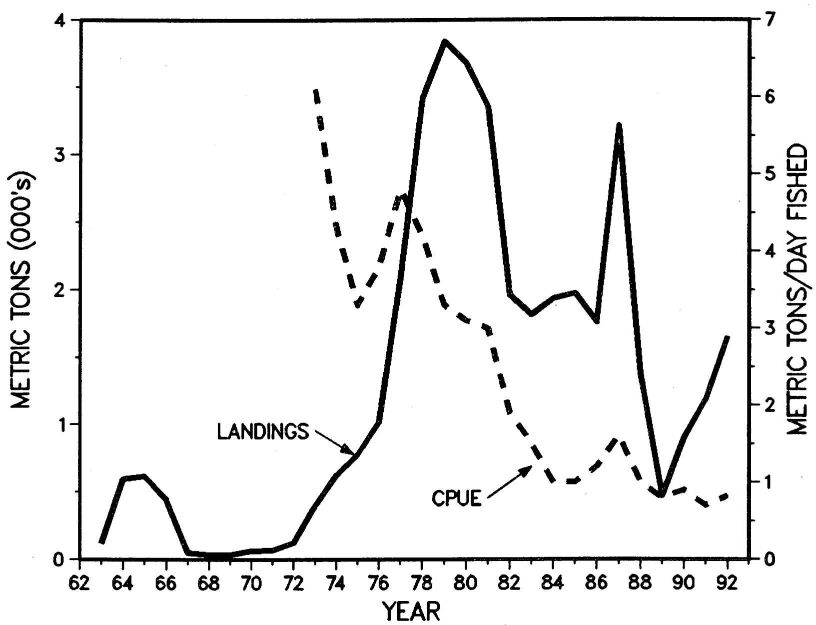
NMFS photo

Beginning in the early 1970s, a directed commercial tilefish fishery by longliners expanded rapidly from New Jersey and New York. Total fishing effort in standardized days fished (df, number of hours fished per set x number of sets of longline/24) increased from 57 df in 1973 to 1,948 in 1985. Following a brief decline in the late 1980s there has been a recent increase to 1,800 df in 1992. Subsequently, catch per unit effort (CPUE) has declined from 6.5 mt per df in 1973 to 0.8 mt per df in 1992.

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 a VPA have not been available since 1984, but the current level of F is estimated to be equal to or greater than the 1981 level (0.74). Long-term potential catch for tilefish estimated from a nonequilibrium surplus production model was about 1,200 mt.

Landings and CPUE data indicate

Tilefish
Georges Bank-Middle Atlantic



"The reduced CPUE since the early 1980s reflects significant stock decline and continued overexploitation."

that tilefish were heavily overexploited during the height of the longline fishery between 1977 and 1982. Fishing mortality exceeded the estimates of F_{max} by three times. Catches during this period were well above the long-term potential yield of the stock. This period was followed by steadily declining values in CPUE, and a lesser decline in both total landings and average size. There were also changes in the breeding structure of the population with decreases in the size per age of maturity in males. The reduced CPUE since the early 1980s reflects significant stock decline and continued overexploitation.

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

Category	Year										
	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
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	1.9	1.8	1.9	2.0	1.8	3.2	1.4	0.5	0.9	1.2	1.6
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	1.9	1.8	1.9	2.0	1.8	3.2	1.4	0.5	0.9	1.2	1.6

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

$M = 0.15$ $F_{0.1} = 0.17$ $F_{max} = 0.27$ $F_{1992} = \geq 0.74$

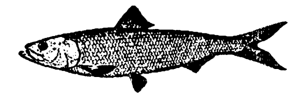
For further information

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.

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.

Atlantic Herring



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 further 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 the coastal fixed-gear fisheries (stop seines and weirs), which have greatly declined in recent years.

NMFS photo by Brenda Figuerido

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 the fishery-independent measures of abundance for herring are for fish originating from both spawning areas. As a consequence, the herring from the Gulf of Maine and from Georges Bank have been combined for assessment purposes 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 catches for the coastal stock complex have changed substantially over the past two decades. Catches averaged 88,839 mt during the years 1988 to 1992, whereas two decades ago they exceeded 300,000 mt. The change in catch is best understood by examining the changes in the regional fisheries that exploit the stock complex.

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 the catch of herring in Maine has been taken in mobile gear, compared with less than 50 percent during the 1970s. This shift in catches appears to be related to reduced availability of herring to the fixed-gear fisheries. 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.

Atlantic Herring
Coastal Stock Complex

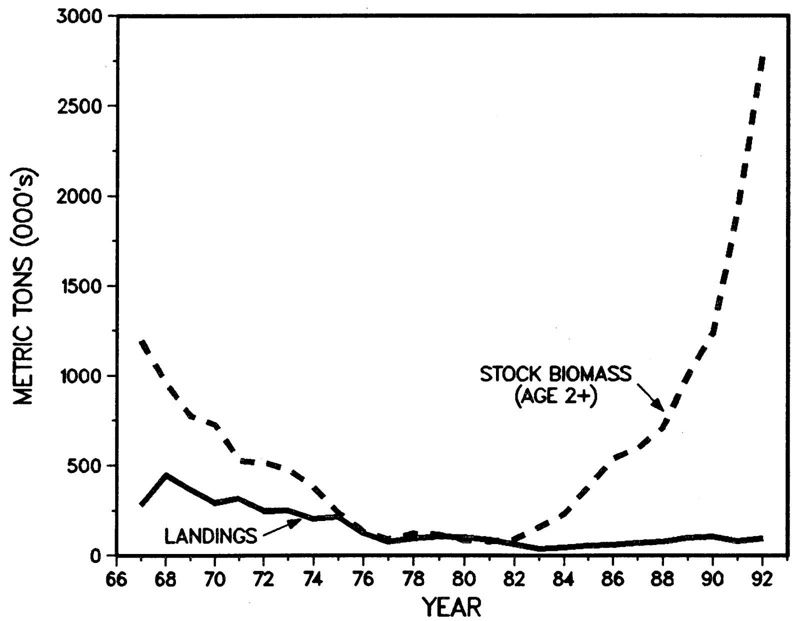


Table 21.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year										
	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	114.4	25.0	34.1	27.7	29.2	39.7	41.1	53.0	63.0	54.7	59.7
Canada	26.5	11.4	8.7	27.9	27.9	27.3	33.4	44.1	38.8	24.6	32.0
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch[1]	140.9	36.4	42.8	55.6	57.1	67.0	74.5	97.1	101.8	79.3	91.7

[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	=	Spawning Area Closure
Status of exploitation	=	Underexploited
Age at 50% maturity	=	3 years
Size at 50% maturity	=	26.0 cm (10.2 in.)
Assessment level	=	Age structured
Overfishing definition	=	None defined
Fishing mortality rate corresponding to overfishing definition	=	None defined

M = 0.20 **$F_{0.1}$ = 0.19** **F_{max} = 0.34** **F_{1991} = 0.04**

[1] Average age 2+ biomass at 20% MSP

The 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 pressure from the offshore fleets stopped and the stock began to rebuild. Today, the stock complex biomass appears to be exceeding precollapse levels, but caution must be exercised in interpreting these stock size estimates. Because there is no fishery in the offshore waters, 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 is not in question, but the exact level of stock size is 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.

A joint Atlantic States Marine Fisheries Commission 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

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 Sixteenth Northeast Regional Stock Assessment Workshop (16th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC.

Atlantic Mackerel

NMFS photo by Brenda Figuerido

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.

Mackerel are subjected to seasonal fisheries, both commercial and recreational, throughout most of their range. United States commercial catches have occurred mainly between January and May in southern New England and Mid-Atlantic coastal waters and between May and December in coastal Gulf of Maine waters. United States recreational catches occur mainly between April and October in areas of seasonal occurrence. Catches in Canadian waters off Nova Scotia and Newfoundland have typically been between May and November. Catches by other countries, principally during the intensive fishery conducted between 1968 and 1977, occurred mainly between December and April between Georges Bank and Cape Hatteras.

Mackerel in the Northwest Atlantic were managed by nationally-allocated catch quotas between 1973 and 1977 by the International Commission for Northwest Atlantic Fisheries. Since implementation of the Magnuson Fishery Conservation and Management Act on 1 March 1977, mackerel in U.S. waters have been managed by the National Marine Fisheries Service, initially under a preliminary management plan and since February 1980 under the Mid-Atlantic Fishery Management Council's Squid, Mackerel, Butterfish Fishery Management Plan. Management is based on total allowable catch limits, which have been increased over the 1980s.

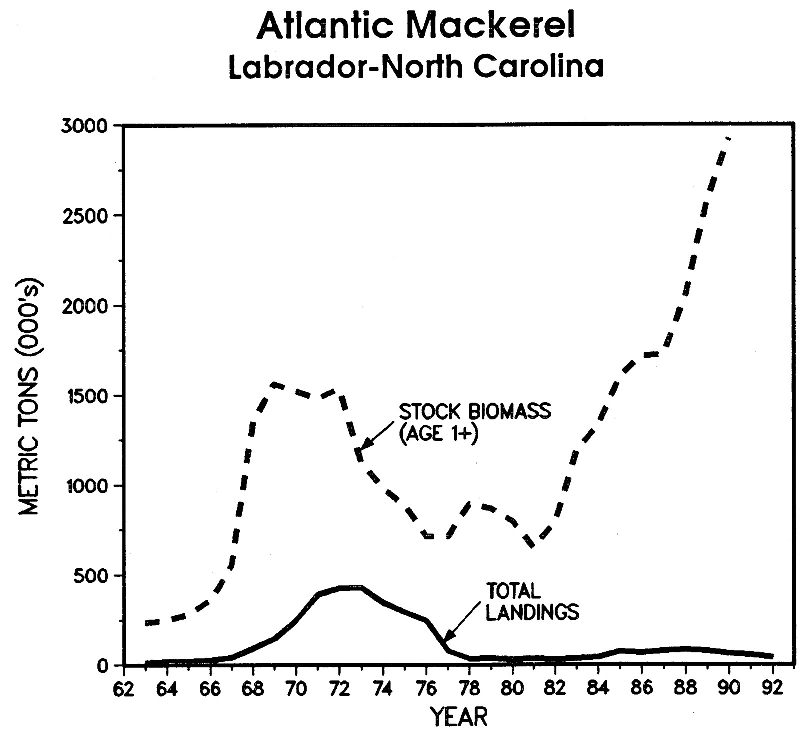
Mackerel landings increased dramatically beginning in the late 1960s, reaching a peak of roughly 400,000 mt in 1973. Landings subsequently declined to roughly 30,000 mt in the late 1970s, increased steadily from 1980 to 1988, and declined in 1989 and 1990. Total landings from this stock declined 9 percent in 1991 (60,590 to 55,238 mt). Increases in landings in the 1980s were due to larger U.S. and foreign joint venture fishing operations.

The United States accounted for 33 percent of the 1992 international catch on the Northwest Atlantic stock, including about 12,400 mt of commercial and 400 mt of recreational catch. The Canadian catch increased slightly from 22,186 mt in 1991 to 25,500 mt in 1992. The distant-water fleet catch dropped from 5,349 mt in 1991 to 0 in 1992 as TALFF was eliminated.

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 more than 2.0 million mt in 1990 and has remained stable. Spawning stock biomass (50 percent of age 2 fish and 100 percent of age 3 and older) increased from about 600,000 mt in 1982 to more than 2.0 million mt in 1990 and remained high in 1992.

Rebuilding of the mackerel stock has been aided by relatively low catches during 1980-1990 (average of 55,000 mt) as well as improved recruitment from the 1981 to 1982 and 1984 to 1988 year classes. The catch in 1993 - 1994 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 can sustain substantially more fishing, and is underexploited.



"The catch in 1993 - 1994 can be increased substantially, without adversely affecting spawning stock biomass."

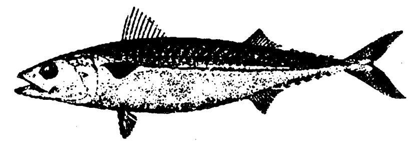


Table 22.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	4.6	3.3	2.6	3.3	3.9	5.6	4.2	2.3	2.0	2.0	0.4
Commercial											
United States	2.1	3.8	6.0	6.6	9.6	12.3	12.3	14.6	31.3	25.7	12.4
Canada	28.4	19.8	18.2	30.1	31.1	22.2	23.3	18.7	18.2	22.2	25.5
Other	152.2	6.0	15.0	32.4	25.4	35.1	42.9	36.8	9.1	5.3	-
Total nominal catch	187.3	32.9	41.8	73.2	70.0	75.2	82.7	72.4	60.6	55.2	38.3
Optimum yield	N/A	30.0	101.7	83.6	225.3	154.6	106.0	74.0	83.0	114.0	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	=	Squid, Mackerel, 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	=	0.27

M = 0.20 **$F_{0.1}$ = 0.27** **F_{max} = 0.96** **F_{1992} = <0.05**

[1] Assuming constant recruitment at level of geometric mean of 1961-1984 year classes and fishing mortality at $F_{0.1}$

For further information

Anderson, E.D. 1984. Status of the Northwest Atlantic mackerel stock-1984. Woods Hole, MA: NOAA/NMFS/NEFC. *Lab. Ref. Doc.* 85-03. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

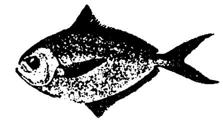
Overholtz, W.J., and B.L. Perry. 1985. Update of the status ofethe Northwest Atlantic mackerel stock for 1985. Woods Hole, MA: NOAA/NMFS/NEFC. *Lab. Ref. Doc.* 85-13. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

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. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

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. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

Butterfish



NMFS photos by Brenda Figuerido

Atlantic butterfish (*Peprilus triacanthus*) range from Newfoundland to Florida and are found in commercially exploitable concentrations between Cape Hatteras and Southern New England. For management purposes, the butterfish population in waters north of Cape Hatteras is assumed to constitute a unit stock. This stock migrates inshore and northward during the summer and offshore and southward during the winter in response to seasonal changes in water temperature on the shelf. Spawning takes place chiefly during the summer months and peaks in July. Juvenile butterfish begin recruiting to the spawning stock at the end of their first year. Although the maximum recorded age for this species is 6 years, few fish older than 3 years are observed.

Butterfish have been landed by domestic fishermen since the 1800s. From 1920 to 1962, the annual harvest averaged 3,500 mt. Foreign catches began in the 1960s, and from 1968 to 1976, landings of butterfish increased to a peak of 19,500 mt in 1973 and averaged 11,700 mt annually. Butterfish landings have dropped since 1976; from 1977 to 1986, landings averaged 6,300 mt, and from 1987 to 1991 landings averaged 2,900 mt.

Domestic butterfish landings totaled 2,700 mt in 1992. Landings increased by 25 percent from 2,200 mt during 1991. The spatial and temporal distribution of butterfish landings in 1992 was similar to that of recent years with the majority of butterfish landings occurring in Southern New England and Mid-Atlantic Bight waters.

Butterfish are managed by the Mid-Atlantic Fishery Management Council (MAFMC) under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. For 1992, the maximum optimum yield and the allowable biological catch for butterfish was 16,000 mt and the domestic allowable harvest was 10,000 mt (MAFMC 1992). These regulations are in effect for 1993 and 1994 as well (MAFMC 1992).

The catch per tow index (total weight for all ages) from the NEFSC 1992 autumn bottom trawl survey decreased by 15 percent, while the 1992 age 1^+ index (14.1 age-1 and older fish per tow) decreased by 42 percent from 1991. Above average prerecruit indices over the past five years, however, suggest that butterfish reproduction remains strong in the Northwest Atlantic.

Butterfish landings have averaged less than 30 percent of the domestic allowable harvest of 10,000 mt since 1987 and are well below historical yields. Japanese demand for Atlantic butterfish exports has decreased in recent years (MAFMC 1992), and this has probably had a negative impact on Atlantic butterfish landings. Since 1987, domestic landings per unit effort (LPUE) have also dropped considerably, even though fishing effort has remained relatively stable.

Butterfish
Gulf of Maine-Middle Atlantic

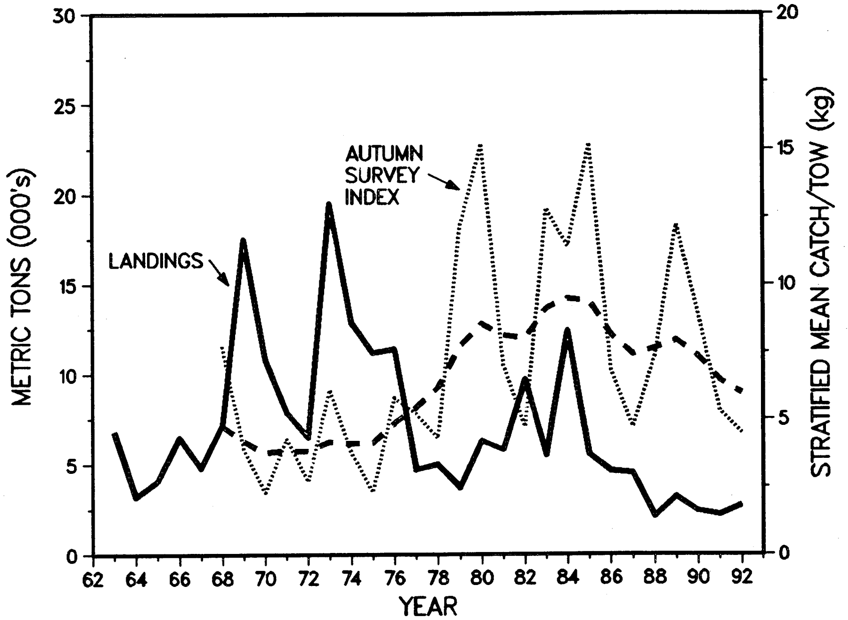


Table 23.1 Recreational and commercial catches (thousand metric tons)

Category	Year										
	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	3.3	4.9	12.0	4.7	4.4	4.5	2.1	3.2	2.4	2.2	2.7
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	5.5	0.6	0.4	0.8	0.2	0.0	0.0	<0.1	<0.1	0.0	-
Total nominal catch	8.8	5.5	12.4	5.5	4.6	4.5	2.1	3.2	2.4	2.2	2.7
Total allowable catch	-	11.0	11.0	<16.0	<16.0	<16.0	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	=	Squid, Mackerel, 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_{1992} = Unknown

"Data collected by domestic fishery observers from 1989 to 1992 suggest that substantial quantities of butterfish were discarded and that most fishing mortality is attributable to discarding."

While research survey data indicate that abundance of butterfish prerecruits has remained high, survival to older ages has decreased. One mechanism to account for reduced survival and decreased landings and LPUE would be an increase in butterfish mortality due to discarding at sea. Data collected by domestic fishery observers from 1989 to 1992 suggest that substantial quantities of butterfish were discarded and that most fishing mortality is attributable to discarding. Overall, it appears that the butterfish stock could support landings at the domestic allowable harvest level of 10,000 mt, but such an increase seems unlikely unless market demand improves and discard mortality is reduced.

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]. 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.

Bluefish

NMFS photo by Brenda Figuerido

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).

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. The principal commercial fishing gear used to catch bluefish is the otter trawl. Recreational fishing is very important with catches far exceeding commercial catches. Most of the recreational catch of bluefish is taken in the Middle Atlantic states (New York to Virginia).

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 20 percent from 1991 to 1992 (27,300 to 21,800 mt). Commercial landings peaked in 1981 at 7,500 mt. Commercial landings decreased 23 percent in 1992, from 6,200 to 4,800 mt, and accounted for about 22 percent of the total catch.

The recreational component of the fishery, which has historically constituted 80 to 90 percent of the total catch, peaked in 1980 at nearly 70,000 mt. The 1992 recreational catch of 17,000 mt was a decrease of 19 percent from the previous year (21,100 mt), and accounted for about 78 percent of the total catch. An index of recreational fishing effort for bluefish increased from 1981 (21 million bluefish trips) to an estimated 38 million bluefish trips in 1988, then declined to about 30 million trips in 1989-1990, and increased to about 34 million trips in 1992. Coastwide, recreational catch per bluefish trip by weight and numbers peaked in 1981 at 2.7 kg per trip (1.5 fish per trip), and has since decreased steadily, declining to 0.5 kg per trip (0.4 fish per trip) in 1992.

Current stock assessment information is insufficient to allow a quantitative determination of the status of

Bluefish
Atlantic Coast

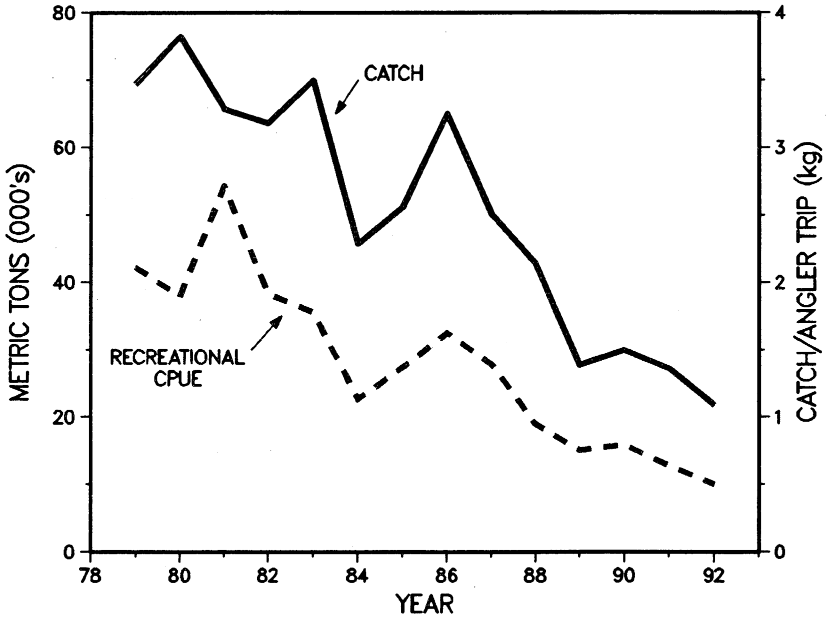


Table 24.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	62.1[1]	62.9	39.3	45.0	59.4	43.5	35.7	23.0	23.7	21.1	17.0
Commercial											
United States	5.2	7.2	5.4	6.1	6.7	6.6	7.2	4.7	6.2	6.2	4.8
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	67.3	70.1	44.7	51.1	66.1	50.1	42.9	27.7	29.9	27.3	21.8

[1] Mean for 1979-82

Atlantic Coast
Bluefish

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Bluefish FMP
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	1 year
Size at 50% maturity	=	35 cm (13.8 in.)
Assessment level	=	Index
Overfishing definition	=	F_{MSY}
Fishing mortality rate corresponding to overfishing definition	=	0.35-0.40

$M = 0.35$ $F_{0.1} = 0.18$ $F_{max} = 0.27$ F_{1992} = >Unknown

"The 1992 recreational catch of 17,000 mt was a decrease of 19 percent from the previous year (21,100 mt), and accounted for about 78 percent of the total catch."

exploitation for bluefish. Indices of juvenile bluefish abundance suggest that a strong year class recruited to the stock in 1989, and contributed significantly to the fishery during 1990-1992. However, trends in recreational catches and the index of abundance based on recreational catch and effort data indicate that bluefish abundance has decreased substantially during the past decade, and that the stock is fully exploited.

For further information

NEFC [Northeast Fisheries Center]. 1988. Report of the 5th NEFC Stock Assessment Workshop (5th SAW). Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Woods Hole Lab. Ref. Doc.*87-12. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

NEFC [Northeast Fisheries Center]. 1988. Report of the 6th NEFC Stock Assessment Workshop (6th SAW). Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Woods Hole Lab. Ref. Doc.*87-12. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

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. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

Spiny Dogfish

Spiny dogfish, *Squalus acanthias*, are distributed in the western North Atlantic from Georgia to Newfoundland. During spring and autumn, they are found along the 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, the 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.

The principal commercial fishing gears used for catching dogfish are otter trawls and sink gill nets. Dogfish are frequently caught as bycatch during groundfish operations and discarded. Recreational fishing and foreign fishing are insignificant. At present, there is no fishery management plan, but one will be implemented within two years. Landings declined slightly in 1992 (from 11,500 to 11,100 mt).

Reported international nominal catches peaked at about 21,000 mt in 1972 and declined sharply from 1975 to 1978. Distant-water fleets consistently accounted for virtually all of the reported catches. Domestic catches since 1979 have fluctuated between 2,600 and 6,900 mt, with no trend. Landings in 1991 remained relatively high and landings in 1992 are expected to remain at these high levels due to the strong demand in the European market, attributable to declines in European dogfish stocks.

Photo by Brenda Figuerido

Minimum biomass estimates of spiny dogfish based on NEFSC spring bottom trawl survey catches increased slightly from 1991 estimates of 642,000 to 662,000 mt in 1992, 128 percent more than the 1968-1989 geometric average of 291,000 mt. Minimum biomass estimates during the decade (1980-89) have generally been higher than values observed between 1968 and 1979. The 1992 estimate is 35 percent more than the 1980-89 geometric average.

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, at certain times of the year, smaller individuals, consisting of both mature and immature males as well as immature females, are taken as bycatch and discarded. Since this species bears live young, a directed fishery on mature females may significantly impact spawning potential. The potential for rapid overexploitation of sharks has been observed in U.S. West Coast and European fisheries. This results from low growth and fecundity rates, schooling of large mature individuals by sex, and direct stock recruitment relationships.

A conservative estimate of the maximum sustainable yield for the species is between 40,000 and 60,000 mt, based on European studies (Holden 1968), which suggest that no more than 20 percent of the minimum biomass can be harvested annually. Under this harvest scenario, about 90,000 mt (20 percent of the 1980-1990 average) could be taken annually from the present population.

Assuming that the 1992 minimum biomass estimate is correct (0.7 million mt), then about 128,000 mt could be landed from the stock. The low levels of current landings belie the increasing stock size in recent years. Increases in dogfish and skate abundance, coupled with decreases in abundance of many demersal species, have resulted in the NEFSC trawl survey catches by weight on Georges Bank,

Spiny Dogfish
Gulf of Maine-Middle Atlantic

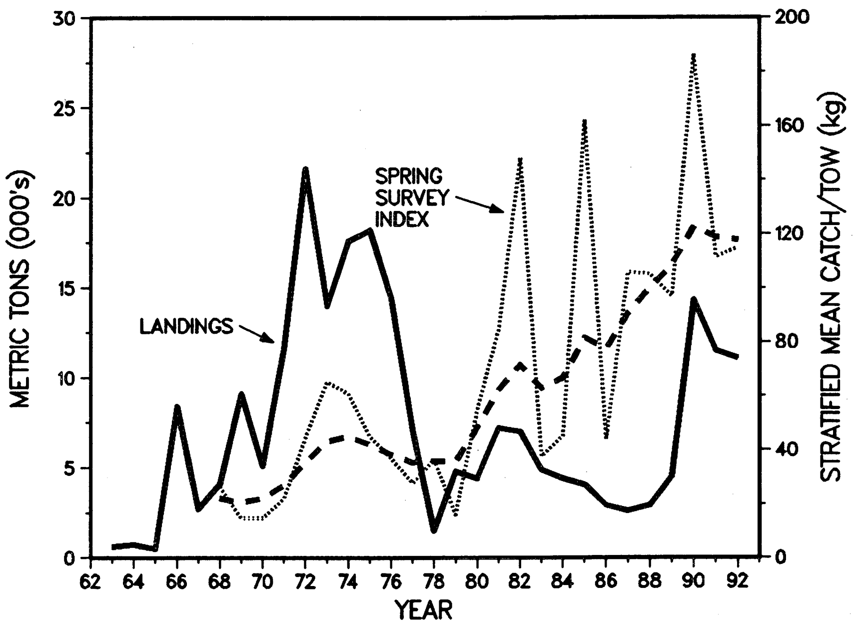


Table 25.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	4.7	4.9	4.4	4.0	2.6	2.6	2.9	4.4	14.3	11.5	11.1
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	6.2	-	-	-	0.1	-	<0.1	<0.1	-	-	-
Total nominal catch	10.9	4.9	4.4	4.0	2.7	2.6	2.9	4.4	14.3	11.5	11.1

Gulf of Maine-Middle Atlantic
Spiny Dogfish

Long-term potential catch	=	40,000 - 60,000 mt
SSB for long-term potential catch	=	300-450,000 mt
Importance of recreational fishery	=	Insignificant
Management	=	None
Status of exploitation	=	Underexploited
Age at 50% maturity	=	6 years, males 12 years, females
Size at 50% maturity	=	60.1 cm (23 in.), males 80.7 cm (32 in.), females
Assessment level	=	Index
Overfishing definition	=	N/A
Fishing mortality rate corresponding to overfishing definition	=	N/A

M = 0.05 **$F_{0.1}$ = 0.10** **F_{max} = 0.39** **$F_{1991} < F_{0.1}$**

"The potential for rapid overexploitation of sharks . . . results from low growth and fecundity rates, schooling of large mature individuals by sex, and direct stock recruitment relationships."

for example, changing from roughly 25 percent dogfish and skates in 1963 to nearly 75 percent of these species in recent years. Such large increases in relative biomass of very low-valued species has raised concerns about possible biological interactions of elasmobranch species with more highly valued gadoid and flounder stocks.

For further information

Grosslein, M.D. 1974. A first approximation of MSY for spiny dogfish in Subareas 5 and 6 and Division 4. *ICNAF* [International Commission for the Northwest Atlantic Fisheries] *Res. Doc.* 74/30.

Holden, M.J. 1968. The rational exploitation of the Scottish-Norwegian stocks of spurdogs (*Squalus acanthias* L.). *Ministry of Agriculture, Fisheries and Food, Fishery Investment Series II 25(8):1-27.*

Nammack, M. F. 1982. Life history and management of spiny dogfish, *Squalus acanthias*, off the northeastern United States. Williamsburg, VA: College of William and Mary. Master's thesis.

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. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

Slauson, T. P. 1982. Growth, maturation, and fecundity of the spiny dogfish, *Squalus acanthias*, in the northwestern Atlantic. Stony Brook, NY: State University of New York at Stony Brook. Master's thesis.

Skates

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 12,300 mt in 1992, which is a 9 percent increase over the 11,200 mt landed in 1991. 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. In 1981 reported skate landings bottomed out at 538 mt, and have since increased steadily. The increase in domestic landings is 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.

NMFS photo by Brenda Figuerido

Survey abundance indices for skates (again all species combined) are expressed as the minimum population estimate from area-swept calculations and smoothed to reflect trends in the data. Over the time series from 1968 to 1992, smoothed survey indices for skates showed three distinct trends in the data. During the first half of the time series, 1968 through 1979, abundance indices have shown a slight but steadily declining trend in the data, reaching a series low of 81,000 mt in 1979. 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, falling to 135,000 mt in 1992, but remains 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

Skates
Gulf of Maine - Middle Atlantic

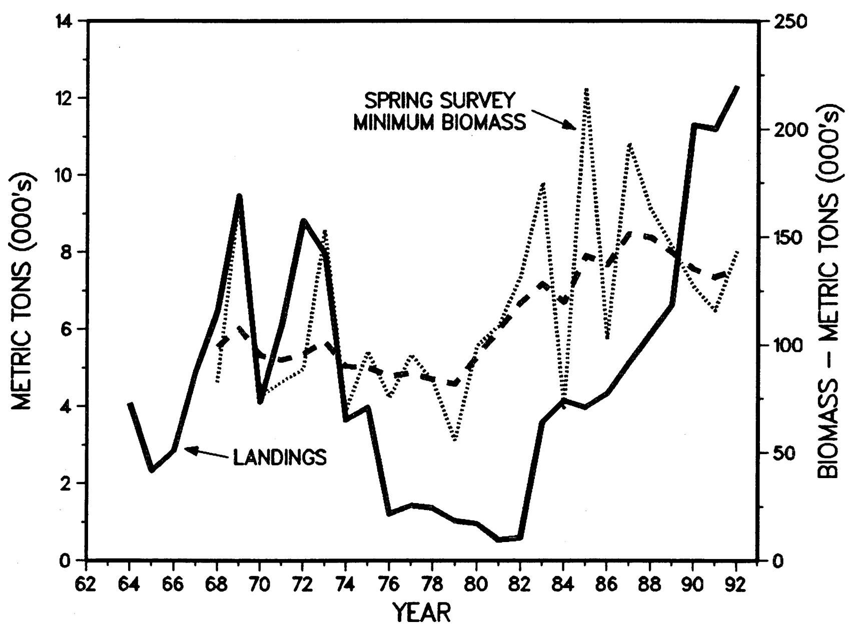


Table 26.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year										
	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	2.9	3.6	4.1	4.0	4.2	5.1	5.9	6.6	11.3	11.2	12.3
Canada	<0.1	-	-	<0.1	-	<0.1	<0.1	-	-	-	-
Other	4.5	-	-	-	0.1	-	-	-	-	-	-
Total nominal catch	7.4	3.6	4.1	4.0	4.3	5.1	5.9	6.6	11.3	11.2	12.3

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 **$F_{0.1}$ = 0.49** **F_{max} = 1.0** **F_{1991} = <F_{max}**

[1]Pertains to little skate

"The increase in domestic landings is partially in response to the increased demand for lobster bait, and, more significantly, to the increased export market for skate wings."

these species can be maintained. Skates have a limited reproductive capacity, and the stocks may be easily collapsed through extensive 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, although the aggregate population abundance indices may be increasing, particularly vulnerable species (*e.g.*, barndoor skate) may 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.

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. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

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.

Short-Finned Squid

NMFS photo by Brenda Figuerido

The short-finned squid (*Illex illecebrosus*) is a pelagic cephalopod that ranges from Florida to Labrador in the Western Atlantic. Within its range of commercial exploitation from Cape Hatteras to Newfoundland, the *Illex* population is assumed to constitute a unit stock. *Illex* 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 (Rowell and Trites 1985), and the Gulf Stream is thought to be an important transport mechanism for larvae and juveniles. *Illex* are essentially an annual species. Recent research on their age and growth indicates a lifespan of less than one year (Dawe *et al.* 1985). Despite this short lifespan, *Illex* grow rapidly and can attain lengths of 35 cm (14 in.) in dorsal-mantle length, although most individuals harvested in the commercial fishery are between 10 and 28 cm (4 to 11 in.) long.

The domestic *Illex* fishery began in the 1800s, and from 1928 to 1966, annual squid landings from Maine to North Carolina (including *Loligo pealei*) averaged roughly 2,000 mt. Directed foreign fishing for *Illex* in the U.S. EEZ began in 1972 and was curtailed in 1982. From 1972 to 1982, *Illex* landings from Cape Hatteras to the Gulf of Maine averaged 19,000 mt. During 1983 to 1992, *Illex* landings have averaged 9,400 mt, or roughly half of the yields experienced between 1972 and 1982.

Illex landings in 1992 were a record 17,827 mt and had an ex-vessel value of $9.7 million for an average price of $0.54 per kg ($0.25 per lb). In comparison with 1991, landings and value increased by 49 and 40 percent, while average price decreased by 7 percent. The spatial pattern of *Illex* landings in 1992 was similar to that of recent years, with the vast majority of landings coming from Mid-Atlantic Bight waters.

Illex are managed by the Mid-Atlantic Fishery Management Council under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. In 1992, the maximum optimum yield, the allowable biological catch, and the domestic allowable harvest were 30,000 mt (MAFMC 1991). For 1993 and 1994, similar regulations are in effect (MAFMC 1992).

The stratified mean number per tow of all sizes of *Illex* squid obtained in the NEFSC autumn bottom trawl survey provides a relative index of total stock abundance and subsequent availability to the commercial fishery. For 1992, this index was slightly below its long-term average (1967-1991), but was more than three times above its mean level during the mid-1980s (1982-1986), when relative stock abundance and commercial landings per unit of effort were low. Further, the 1992 autumn prerecruit (≤10 cm dorsal-mantle length) index was 175 percent above its long-term average and was the third highest prerecruit index observed since 1967, suggesting that the relative abundance of juvenile *Illex* was above average in 1992.

Overall, the outlook for the domestic *Illex* fishery in 1993 is promising. Although landings in 1992 were

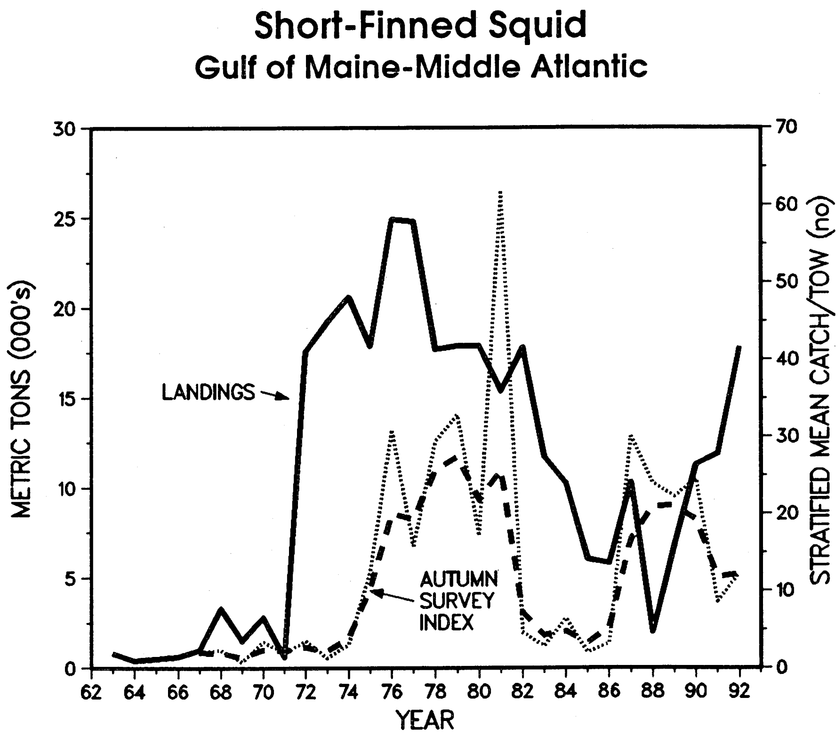


Table 27.1 Recreational and commercial catches (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.1	9.9	9.5	5.0	5.2	10.3	2.0	6.8	11.7	11.9	17.8
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	18.2	1.8	0.7	1.1	0.2	-	<0.1	-	-	-	-
Total catch	19.3	11.7	10.2	6.1	5.4	10.3	2.0	6.8	11.7	11.9	17.8
Total allowable catch	-	30.0	30.0	30.0	25.0	22.5	22.5	17.0	15.0	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	=	Squid, Mackerel 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} = N/A F_{1992} = Unknown

at record levels, they were still below the average level of landings during 1972 to 1982. It is possible that landings in 1993 will surpass 1992 landings since relative abundance, as measured by research survey indices, has remained near average levels. However, availability of *Illex* to the domestic fishery and the research survey varies annually, in part because the U.S. EEZ is near the edge of the stock's distribution. Thus it is difficult to predict whether *Illex* landings will increase again in 1993, even though the *Illex* resource is presently under-exploited relative to its long-term potential yields.

For further information

Dawe, E.G., R.K. O'Dor, P.H. Odense, and G.V. Hurley. 1985. Validation and application of an ageing technique for short-finned squid (*Illex illecebrosus*). *J. Northw. Atl. Fish. Sci.* 6:107-116.

Mid-Atlantic Fishery Management Council. 1991. 1992 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.

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

Rowell, T., and R. Trites. 1985. Distribution of larval and juvenile *Illex* in the Blake Plateau region. *Vie Milieu.* 35(3):149-161.

Long-Finned Squid

Long-finned squid (*Loligo pealei*) are distributed in shelf and slope waters extending from Newfoundland, Canada to the Gulf of Venezuela. Within its range of commercial exploitation from Southern Georges Bank to Cape Hatteras, the *Loligo* population is assumed to constitute a unit stock. North of Cape Hatteras, *Loligo* 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 on the age and growth of *Loligo* indicates they have a lifespan of less than one year. Despite this short lifespan, *Loligo* grow rapidly and can attain lengths of more than 40 cm (16 in.) in dorsal-mantle length, although most individuals harvested in the commercial fishery are between 9 and 30 cm (3.5 in. to 12 in.) long.

NMFS photos by Brenda Figuerido

The *Loligo* fishery in the Northwest Atlantic 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 *Loligo* developed in 1967, and foreign fishing fleets exploited *Loligo* 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, and annual domestic landings have averaged 17,800 mt during 1987 to 1992.

The *Loligo* stock is managed by the Mid-Atlantic Fishery Management Council under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. In 1992, the maximum optimum yield was 44,000 mt, the allowable biological catch was 37,000 mt and the domestic allowable harvest was 34,000 mt (MAFMC 1991). For 1993 and 1994, allowable biological catch and domestic allowable harvest have been increased to 44,000 mt (MAFMC 1992).

Loligo landings totaled 18,172 mt in 1992 with an ex-vessel value of $23.342 million and an average price of $1.28 per kg ($.58 per lb). In comparison with 1991, total landings decreased by 6 percent while total value and average price increased by 3 percent and 10 percent. The spatial pattern of the *Loligo* fishery in 1992 was similar to that of recent years with the majority of landings coming from Southern New England and Mid-Atlantic Bight waters.

Indices of the relative abundance of *Loligo* taken from the NEFSC autumn bottom trawl survey indicate that stock biomass was below average and that stock numbers were above average in 1992. In particular, the mean weight per tow of *Loligo* was 35 percent below its long-term average, and the mean number of prerecruits ($\leq$8 cm in dorsal-mantle length) per tow in the autumn of 1992 was 235 percent above its long-term average and was the highest level observed during 1967 to 1992. In contrast, the mean number of recruits (>8 cm in dorsal-mantle length) per tow taken in the 1992 autumn survey was near the lowest level observed during 1967 to 1992.

Overall, total *Loligo* landings declined slightly in 1992 in response to the below-average level of stock biomass. The small-vessel inshore fishery for *Loligo* in 1992 had the lowest level of landings per unit of effort (LPUE) during the 1982 to 1992 period, and it appears that small vessel effort decreased in response to poor landings success. In contrast, LPUE in the large vessel fishery remained stable during 1992 as effort for this component of the fishery increased to near record levels.

The record autumn 1992 *Loligo* prerecruit index indicates that a large cohort would be available for harvest in the offshore winter fishery in 1993. Although research survey indices are

Long-Finned Squid
Gulf of Maine-Middle Atlantic

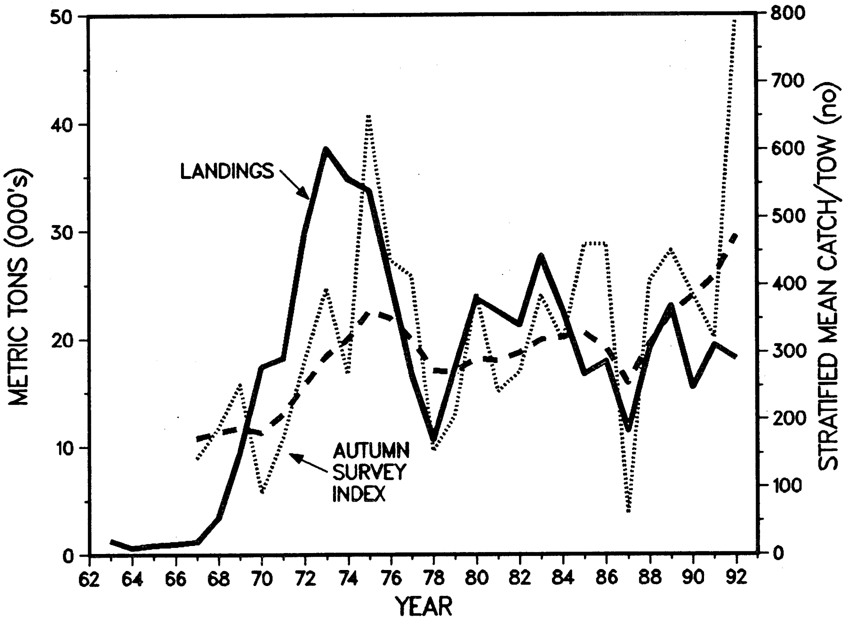


Table 28.1 Recreational and commercial catches (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	2.5	15.9	11.6	10.2	13.3	11.5	19.1	23.0	15.5	19.4	18.2
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	22.3	11.7	11.0	6.5	4.6	<0.1	<0.1	<0.1	0.0	0.0	-
Total catch	24.8	27.6	22.6	16.7	17.9	11.5	19.1	23.0	15.5	19.4	18.2
Allowable biological catch	-	44.0	44.0	33.0	37.0	37.0	37.0	37.0	37.0	37.0	44.0

Gulf of Maine-Middle Atlantic
Long-Finned Squid

Long-term potential catch	=	44,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Squid, Mackerel and Butterfish FMP
Status of exploitation	=	Underexploited
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

$M \geq 1.0$ $F_{0.1}$ = Unknown F_{max} = N/A F_{1992}=Unknown

"Overall, above-average landings during the first quarter of 1993, combined with the record prerecruit index in the autumn of 1992, suggest that *Loligo* landings are likely to increase in 1993."

not yet available to track this cohort, preliminary *Loligo* landings from January 1, 1993 through April 30, 1993 (13,300 mt) were 67 percent above 1992 levels and roughly 20 percent above 1989 levels, when the highest level of domestic landings occurred (23,000 mt). Overall, above-average landings during the first quarter of 1993, combined with the record prerecruit index in the autumn of 1992, suggest that *Loligo* landings are likely to increase in 1993.

For further information

Mid-Atlantic Fishery Management Council. 1991. 1992 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.

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.

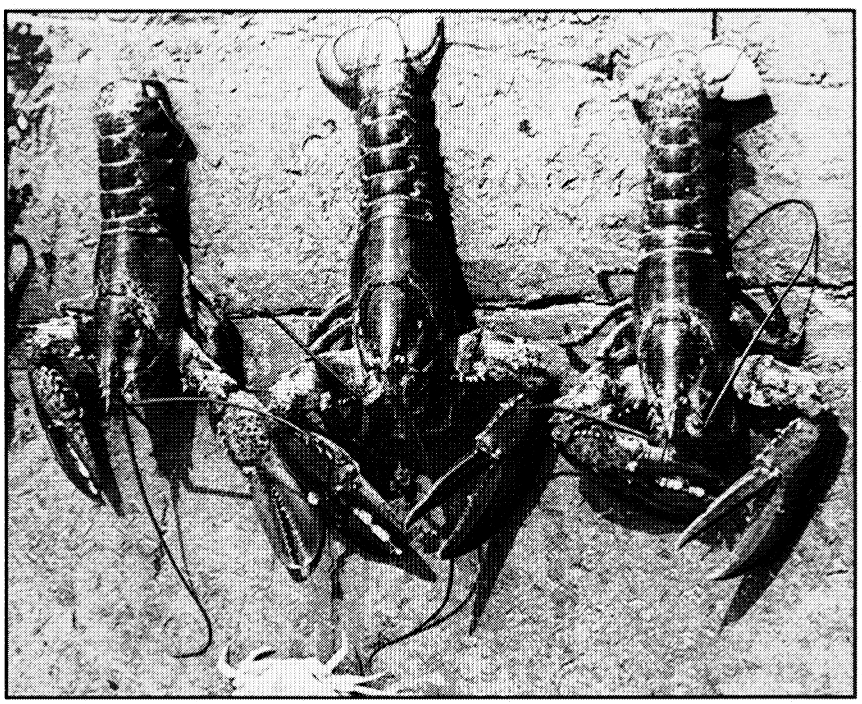
NEFSC [Northeast Fisheries Science Center]. 1992. Report of the Fourteenth Northeast Regional Stock Assessment Workshop (14th SAW). Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 92-07. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

American Lobster

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 and less abundant in more southerly areas. 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, with some evidence that 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 and the 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 size. A significant proportion of the lobsters caught in inshore 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



NMFS photo

American Lobster

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Minor
Management	=	FMP/ASMFC
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

"Overall, the American lobster resource is considered overexploited."

managed under the New England Fishery Management Council's Lobster Fishery Management Plan, and within 3 mi of shore under various state regulations. The primary regulatory measure is carapace length (CL). Total landings increased 15 percent from 1989 to 1990 (from 24,000 to 27,600 mt). In 1991, total U.S. landings rose again to 29,100 mt (slightly more than 5 percent from 1990). United States landings in 1992 dropped almost everywhere throughout the range of the resource (from 8 to 25 percent regionally). Overall, about 25,300 mt (a 13 percent decrease) of lobsters were landed in the U.S. fishery. Similar declines in landings were seen in Canada.

American Lobster
Gulf of Maine-Middle Atlantic

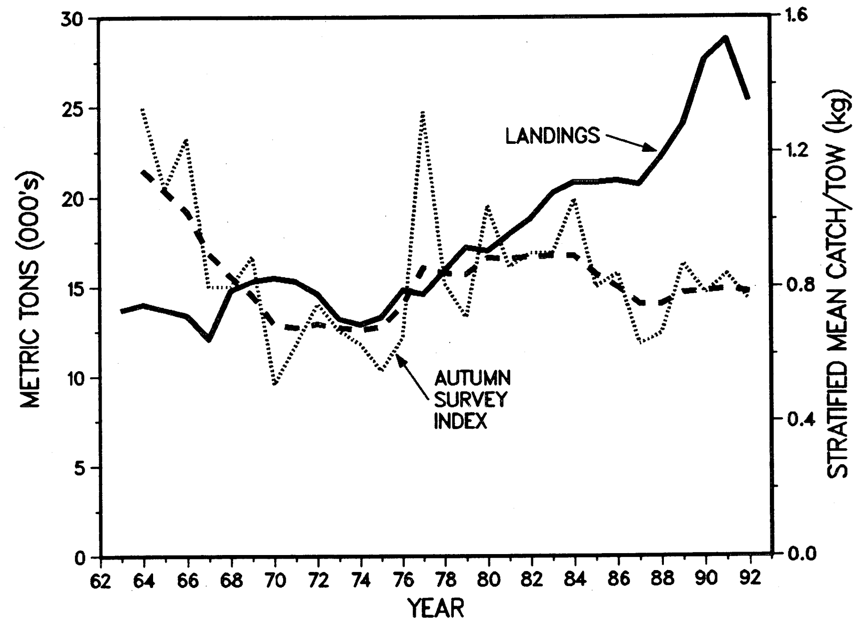


Table 29.1 Commercial and recreational landings (thousand metric tons), live weight). Landings statistics have been revised to reflect unreported catches.

Category	Year										
	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational[1]	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States											
Offshore[2]	2.6	2.4	4.2	2.6	3.4	3.3	3.0	3.3	5.0	4.7	4.4
Inshore[3]	12.7	17.6	16.4	18.0	17.8	17.3	19.2	20.7	22.6	24.0	20.9
Canada											
Georges Bank	0.2	0.2	0.2	0.2	<0.1	<0.1	<0.1	<0.1	0.1	0.2	0.2
Total nominal catch	15.5	20.2	20.8	20.8	20.9	20.7	22.2	24.0	27.7	28.9	25.5

[1] Recreational catches unknown
[2] Includes trawl and offshore trap catches
[3] Inshore trap catches

Inshore Fishery

Nominal landings in the U.S. inshore fishery remained relatively stable from 1965 to 1975, ranging from 10,300 to 12,200 mt, averaging 11,100 mt. From 1978 to 1990, the catch has risen steadily from 12,900 mt to a record 22,600 mt in 1990, an increase of about 75 percent. The landings for 1990 were some 9 percent higher than in the previous year, which was a record year as well. In 1991, the inshore landings rose another 6 percent to 24,000 mt, continuing the string of record-setting years. This increase can be attributed in part to an increase in abundance of lobsters, but also in large part to a continuing trend in increase in effort, especially in the number of pots fished. Some of this effort increase may be in response to recent increases in minimum size limits. Fishermen, trying to cover short-term losses due to the new size limits, appear to be fishing more pots in the inshore areas, as well as expanding the areas fished. However, in 1992, inshore landings decreased to 20,971 mt (-13 percent). This decrease was seen throughout the U.S. portion of the resource. In Canada, the Scotia-Fundy region saw a decrease in 1992 of around 20 percent. 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).

Offshore Fishery

Prior to 1950, lobsters were primarily taken offshore as incidental trawl catches in the 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 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 have risen from a decline in the late 1970s and early 1980s to an average of around 3,000 mt, but have never composed more than 20 percent of the total U.S. landings. In 1990, the offshore landings rose to just under 5,000 mt, the highest on record, representing an increase of about 50 percent over the previous year. The contribution of the offshore fishery to overall landings in 1990 was about 19 percent of the total. In 1991, the offshore component of the landings dropped slightly to around 4,700 mt (16 percent of the total), and in 1992 landings dropped further to 4,359 mt (an 8 percent decrease) representing 17 percent of the total U.S. landings.

Survey Indices

The NEFSC autumn survey biomass index declined steadily from 1.15 kg per tow in 1964 to 0.68 kg per tow in 1971. From 1971 to 1976, this index averaged 0.69 kg per tow, and increased to an average of 0.87 kg per tow from 1977 to 1984. In 1986, the autumn index dropped to 0.8 kg per tow, and to 0.75 in 1987 and 1988. A slight but steady rise in the index from 1989 to 1991 brought this value up to 0.78, slightly below the average of 0.8 for the previous 20-year period. In 1992, this index dropped again to 0.76. 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 until recent years when a further decline is indicated.

Recent Assessments

The increases in the offshore landings in the past decade and the continued intense inshore fishery have raised the question of the relationship between animals in these two areas. If consistent recruitment in the coastal areas depends on high abundance of spawning lobsters offshore, then recent decreases in the abundance caused by the development of the offshore trap fishery may result in reduced inshore catches in future years. It would be prudent to view lobsters from both areas as a whole resource.

Work is currently underway to develop means of tying these areas together. This year (1993) the NEFSC-sponsored Stock Assessment Review Committee (SARC) Invertebrate Subcommittee worked to address these issues. 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.

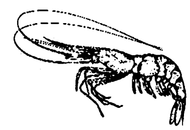
While all three areas are important, the Gulf of Maine represents approximately 71 percent of the landings. Major strides were made this year in defining this region and the lobster resource within it. The fishery is dominated by inshore pots and is managed based on a minimum size of 83 mm (3.25 in.) CL throughout, plus a maximum size (127 mm, 5 in. CL) and some level of v-notching protection for females in the state of Maine. Landings in the Gulf of Maine were around 13,000 mt in the early 1980s and dropped slightly to around 12,000 mt until 1989. In 1989 landings rose to more than 16,500 mt and increased to 20,500 mt in 1991. In 1992, however, they dropped off to 18,600 mt. Catch per unit effort (based on data from Maine and Massachusetts) for this time period show similar trends with a drop in 1992. Since the overfishing definition adopted by the New England Fishery Management Council refers only to females (it is based on egg production), work has focused on them. The NEFSC autumn survey abundance indices for female lobsters, both prerecruits (those about to molt into legal size), and fully recruited (those already legal sized) show the same pattern, with increases relative abundance from 1983 to 1991, and a substantial decline in 1992. Whether these declines in 1992 are due to an actual decrease in population size or to the availability of the lobsters (1992 was a relatively cold year, thus the lobsters may not have been moving around as much and therefore may have been harder to catch) is still to be determined. In 1992, landings declined relative to 1991 in all three assessment areas. Gulf of Maine landings fell by 9 percent, to around 18,600 mt. Georges Bank and South Offshore landings dropped to 2,783 mt, a 35 percent decrease. This is around the level of the late 1970s. In the area of Southern Cape Cod to Long Island Sound Inshore, landings dropped by 9 percent to around 3,900 mt after a decade of increases.

Assessment results indicate that the Gulf of Maine and 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) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. NEFSC Ref. Doc. 93-06. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.



Northern Shrimp

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. Historical trends in abundance also appear to have been strongly influenced by temperature, with above normal temperatures being associated with poor recruitment. This stock collapsed during the mid-1970s, but abundance has since increased considerably.

Northern shrimp are 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 (late winter at age 4). Females may survive to spawn in subsequent years, although natural mortality appears to increase sharply following first hatching.

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. Fishing was allowed during the full 183 day time frame from the 1986 fishing season (December 1985 through May 1986) through the 1991 season. The 1992 and 1993 fishing seasons were reduced somewhat in response to assessment evidence for declining abundance and recruitment.

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. Total effort on this stock (number of trips) has risen steadily from 1,100 trips in 1980 to 12,300 trips during the 1987 fishing season; effort during the 1988-1990 fishing seasons was relatively constant, at an average of about 9,400 trips. For the 1991 and 1992 fishing seasons, effort declined somewhat (8,000 and 8,300 trips, respectively).

Nominal catches peaked at 12,800 mt in 1969, averaged approximately 11,000 mt during 1970-72, and then declined precipitously during the mid- to late 1970s. Landings subsequently increased steadily from 300 mt in 1980 to 5,000 mt in 1987, and then decreased to an average of 3,300 mt for 1988 and 1989. Landings for 1990 totaled approximately 4,400 mt, reflecting recruitment of the strong 1987 year class; but for 1991 and 1992 landings declined to 3,400 mt. Preliminary data for the 1993 fishing season indicate a total of approximately 2,000 mt.

Since 1983, the primary source of

Northern Shrimp
Gulf of Maine

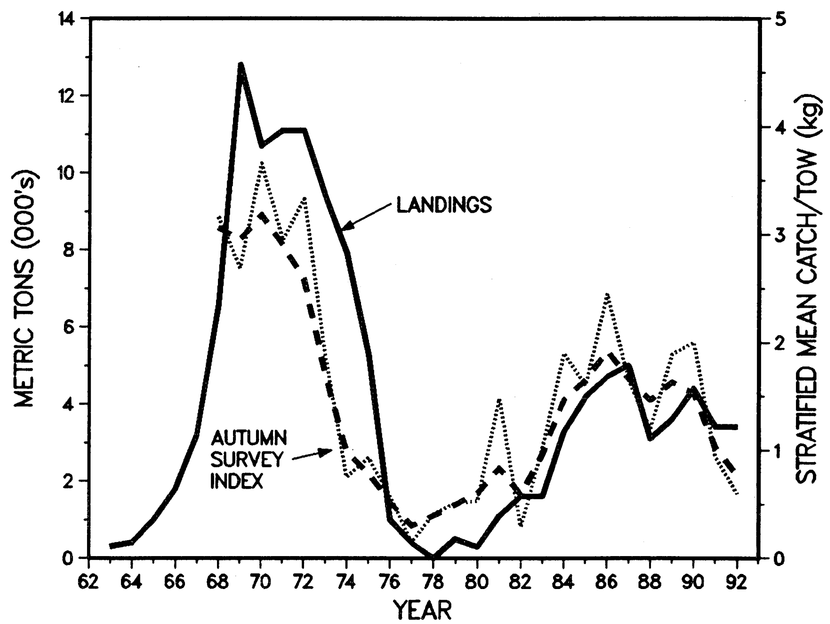


Table 30.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	3.5	1.6	3.3	4.2	4.7	5.0	3.1	3.6	4.4	3.4	3.4
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.5	1.6	3.3	4.2	4.7	5.0	3.1	3.6	4.4	3.4	3.4

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	=	2 years
Size at 50% maturity	=	9 cm (3.5 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_{1992} = 0.4**

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 *R/V Gloria Michelle*. This survey has detected two strong year classes, one produced in 1982 and a second produced in 1987; other year classes in the time series have been considerably weaker. Summer survey index values peaked in 1985-86 and then declined in 1987, reflecting increased natural and fishing mortality on the 1982 year class. Catch per tow then increased again with recruitment of the 1987 year class; weight per tow indices for 1990 were among the highest observed in the time series. Trends for the NEFSC autumn survey index have been similar. Both indices declined in 1991 and 1992, reflecting decreased abundance.

The 1987 year class has now passed through the fishery and subsequent year classes appear to be much weaker. Consequently, stock biomass and landings are expected to decline further during 1994.

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. 1992. Assessment report for Gulf of Maine northern shrimp, 1992. Report to the Northern Shrimp Section of the Atlantic States Marine Fisheries Commission, October 1992. Washington, D.C.: Atlantic States Marine Fisheries Commission.

Northern Shrimp Technical Committee. Unpublished. Cruise results: Gulf of Maine northern shrimp survey, August 3-13, 1992. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Resource Surveys Investigation, Woods Hole, MA 02543.

Surfclam

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 is insignificant. The EEZ fishery is managed under the Surfclam-Ocean Quahog Fishery Management Plan (FMP) of the Mid-Atlantic Fishery Management Council. The primary management measure is a total allowable catch (TAC) limit. From 1991 to 1992, landings from EEZ and state waters increased 9 percent (from 30,000 to 32,700 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.

Regulation of the fishery has proceeded with a principal objective being to rebuild depleted stocks. This was accomplished under Amendments 1 through 7 of the Surfclam-Ocean Quahog FMP. Under Amendment 8, an ITQ (individual transferable quota) system was established in 1990, whereby the annual landing quota was allocated disproportionately among the vessels participating in the fishery, based on a combination of performance history and vessel size. This system is intended to address economic inefficiencies that resulted from the intensive regulatory scheme used to rebuild the depleted stocks. Attendant with the adoption of the ITQ scheme, the

Surfclams

"Research vessel survey data collected through 1992 indicated adequate surfclam resource 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."

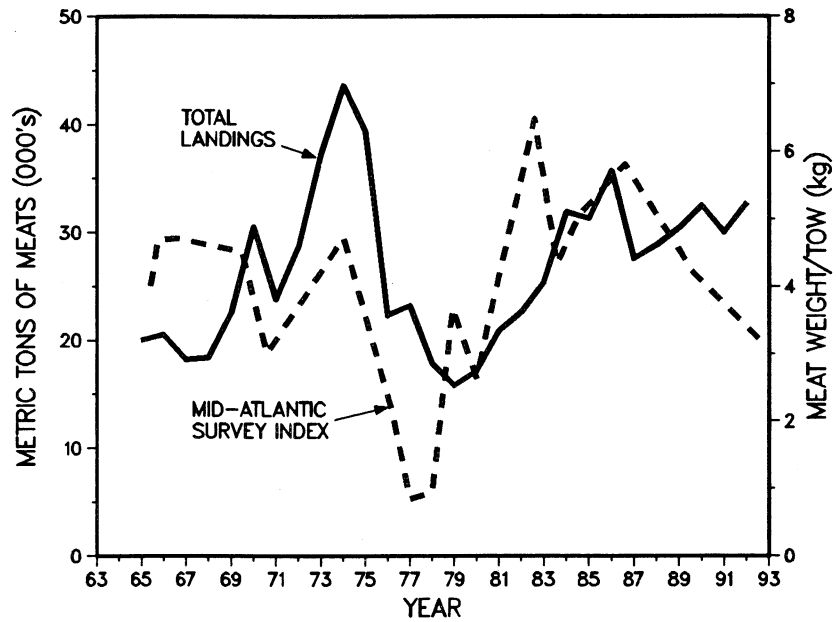


Table 31.1 Recreational catches and commercial landings (thousand metric tons, meats)

Category	Year 1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States											
EEZ	20.7	20.5	24.8	23.7	24.9	22.1	23.9	22.3	24.0	20.6	21.7
State waters	5.5	4.9	7.2	9.2	10.8	5.4	4.9	8.1	8.5	9.4	11.0
Canada	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	26.2	25.4	32.0	32.9	35.7	27.5	28.8	30.4	32.6	30.0	32.7
Total allowable EEZ catch	-	18.9	24.3	24.3	24.3	24.3	24.3	25.2	24.3	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
Age at 50% maturity	=	2 years
Size at 50% maturity	=	5 cm (2.0 in.) shell length
Assessment level	=	Index
Overfishing definition	=	Optimum yields between 14,300 mt and 22,400 mt
Fishing mortality rate corresponding to overfishing definition	=	0.1

$M = 0.05$ $F_{0.1} = 0.11$ $F_{max} = 0.46$ $F_{1992} = 0.1$

restrictions on hours and days of the week fished and a moratorium on vessel construction were dropped. In their place, trading of vessel allocations is intended to reduce vessel overcapitalization and result in a 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) and to 59 in 1992 (-21 percent). Two management areas, New England and Mid-Atlantic, were formerly identified in the FMP, but have been combined in Amendment #8 of the FMP. A single annual quota (24,300 mt of meats in 1992) applies to all management areas. Currently, the Georges Bank region remains 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 during 1973-75. Average catches in these three years of 40,100 mt (meats) were 50 percent greater than the 1965-1977 average of 27,000 mt. The southern Virginia-North Carolina fishery collapsed during 1976; most vessels returned to more northern ports. During 1989, most of the Middle Atlantic landings were taken off New Jersey, with the remainder taken off the Delmarva Peninsula and south. Total EEZ landings in 1992 were 21,700 mt, representing a 5 percent increase from the previous year's total of 20,600 mt.

Biomass indices from research vessel surveys generally parallel trends in landings statistics from various portions of the management area. 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 to harvestable size of this single year class off northern New Jersey resulted in an increasing proportion of total Mid-Atlantic catches from that area. 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 the 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 continued at relatively high levels until the return of the fleet from southern Virginia-North Carolina during 1976. Concentration of the offshore fishery in Delmarva waters between 1976 and 1980 resulted in declining stocks of commercial sizes. Recent surveys indicate that the abundance of the 1977 year class has remained high but is declining. These clam have grown at substantially slower rates than the 1976 year class off New Jersey, perhaps in response to the very high density of surfclams off Delmarva.

Research vessel survey data collected through 1992 indicated adequate surfclam resource 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 1992 (5,400 mt to 11,000 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.

The 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 in the New Jersey area off Atlantic City has reduced biomass in that area. Nevertheless, substantial 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 in the absence of strong year classes spawned since 1977.

For further information

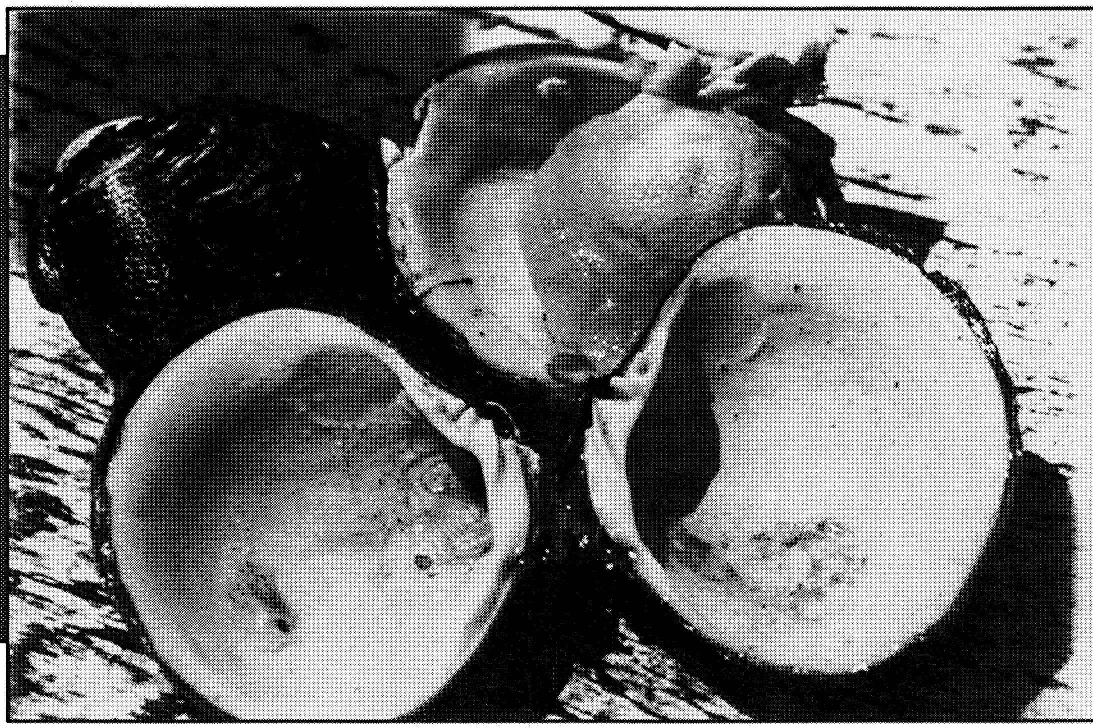
Murawski, S.A. 1989. Assessment updates for middle Atlantic, southern New England, and Georges Bank surf clam populations. Report of the 9th NEFC Stock Assessment Workshop (9th SAW), Working Paper #4. WodsHole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 89-08.

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 Fifteenth Northeast Regional Stock Assessment Workshop (15th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-06.

Ocean Quahog



NMFS photo

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 similar in Gulf of Maine and 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 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 (24,000 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 be-

"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."

New England-Middle Atlantic
Ocean Quahogs

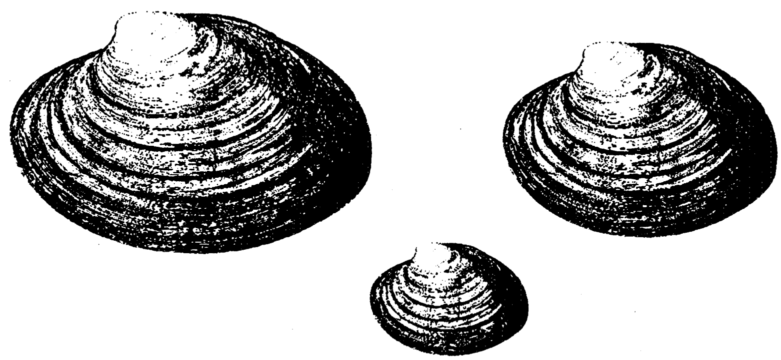
Long-term potential catch	=	24,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Surf Clam and Ocean Quahog FMP
Status of exploitation	=	Fully Exploited in some areas
Age at 50% Maturity	=	8 years, males 11 years, females
Size at 50% maturity	=	50 mm (2.0 in.) shell length
Assessment level	=	Index
Overfishing definition	=	Optimum yields between 18,100 and 27,200 mt
Fishing mortality rate corresponding to overfishing definition	=	<1.0

M = 0.01-0.10 **$F_{0.1}$ = Unknown** **F_{max} = 0.03-0.05** **F_{1992} = <0.1**

tween 1976 and 1979, from 2,500 to 15,800 mt of meats per year. Landings in 1992 (22,500) were near the record high level observed in 1985. Most of the landings are currently derived from the EEZ waters of the Mid-Atlantic Bight, with some EEZ landings from off Maine, and an inshore fishery (state waters) off Rhode Island. 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 off Delmarva, 13 percent off New Jersey, 22 percent off Long Island, 30 percent off Southern New England, and 28 percent on Georges Bank.

Trends in fishery performance from 1979 to 1992 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 con-



NMFS photo

Ocean Quahog

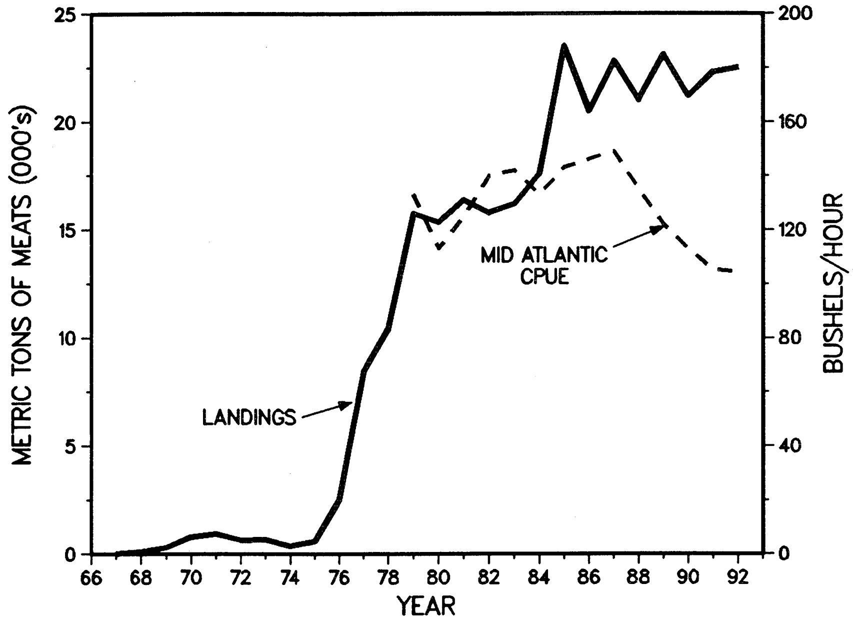


Table 32.1 Recreational catches and commercial landings (thousand metric tons, meats)

Category	Year										
	[1]1976-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States											
EEZ	11.2	15.2	16.4	23.6	19.7	22.2	20.6	22.9	21.1	22.2	22.5
State	0.5	0.7	1.2	<0.1	0.8	0.0	0.4	0.2	0.1	0.1	<0.1
Canada	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	11.2	15.9	17.6	23.6	20.4	22.8	21.0	23.1	21.2	22.3	22.5
Total allowable FCZ	-	18.1	18.1	27.2	27.2	27.2	27.2	23.6	24.0	24.0	24.0

[1]1976 was the beginning of the FCZ fishery

tinue 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, Southern New Jersey, and on Georges Bank, landings considerably greater than the current levels are not warranted due to the extremely slow growth rate and poor annual recruitment observed in these areas. 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. Large number of ocean quahog currently exist on Georges Bank, but the resource has been subject to fishery closure because paralytic shellfish poisoning toxins are present in that region. The Gulf of Maine fishery for ocean quahog is not currently subjected to the ITQ restrictions in force in the Middle Atlantic Bight. Rather, an experimental fishery has been designated for the purpose of gathering information on the abundance, distribution, and biological characteristics of the resource in EEZ waters along the Maine coast.

For further information

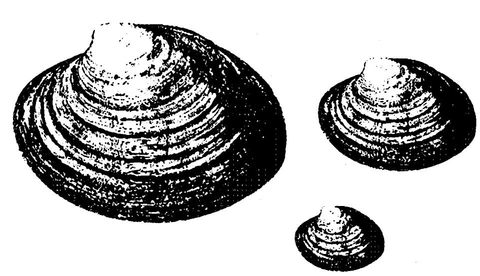
Murawski, S.A., F.M. Serchuk, J.S. Idoine, and J.W. Ropes. 1990. Population and fishery dynamics of ocean quahog, *Arctica islandica*, in the Middle Atlantic Bight. *In* Report of the 10th NEFC Stock Asssessment Workshop (SAW 10). Woods Hole, MA: NOAA/NMF/NEFSC. *NEFSC Ref. Doc.* 90-07, Working Paper #10. Available from: NOAA/NMFS, Northeast Fisheries Science Center, Woods Hole, MA 02543.

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.

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.

NEFC [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. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

NEFSC [Northeast Fisheries Science Center]. 1993. Report of the Fifteenth Northeast Regional Stock Assessment Workshop (15th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 93-06. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.



Sea Scallop

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 percent 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 due to their presumed low fecundity. 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 the New England Fishery Management Council's Fishery Management Plan for the Atlantic Sea Scallop Fishery. Total (United States and Canada) landings in 1992 were 20,300 mt (meat weight), a moderate decline from the 22,600 mt landed in 1991.

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	=	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	=	$F_{5\%} = 0.71$

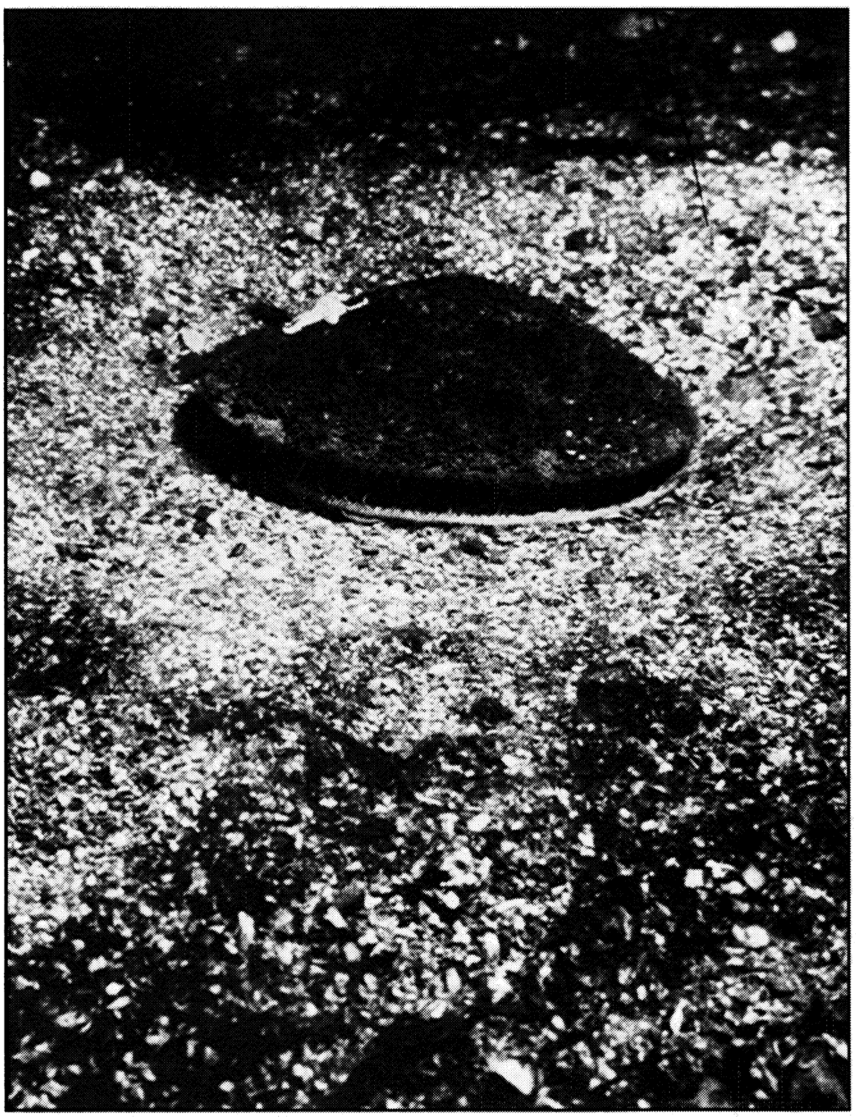
M = 0.10 **$F_{0.1} = 0.12$** **$F_{max} = 0.23$** **$F_{5\%} = 0.71$** **$F_{1991} = 1.5$ to 1.8**

Sea Scallops

Table 33.1 Recreational and commercial landings (thousand metric tons, meat weight)

Category	Year										
	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U. S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
Gulf of Maine											
United States	0.6	0.9	0.7	0.4	0.3	0.4	0.5	0.6	0.6	0.6	0.7
Canada	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	0.1	0.0	<0.1	<0.1
Total	0.6	1.0	0.8	0.5	0.3	0.4	0.6	0.6	0.6	0.6	0.7
Georges Bank											
United States[1]	3.9	4.6	3.2	3.0	4.6	4.9	6.1	5.8	10.1	9.4	8.5
Canada	7.6	2.8	2.0	3.8	4.7	6.8	4.4	4.7	5.2	5.8	6.1
Total	11.5	7.4	5.2	6.1	9.3	11.7	10.5	10.5	15.3	15.2	14.6
Mid-Atlantic											
United States	4.0	3.2	3.8	3.3	3.8	7.9	6.5	8.3	6.6	7.0	5.0
Total nominal catch	16.1	11.6	9.8	10.6	13.4	20.0	17.6	19.4	22.6	22.8	20.3

[1] For United States, Georges Bank landings include Southern New England



NMFS photo

"Commercial fishing effort increased substantially from 1988 to 1990, and continued in 1991 and 1992 at record levels for this resource area."

Gulf of Maine

Nominal landings in 1992 from the Gulf of Maine were 722 mt, 19 percent higher than in 1991. More than 80 percent of the catch was from state territorial waters (less than 3 nmi from shore) indicating continued dependence of the fishery on inshore scallop beds. Commercial fishing effort increased substantially from 1988 to 1990, and continued in 1991 and 1992 at record levels for this resource area.

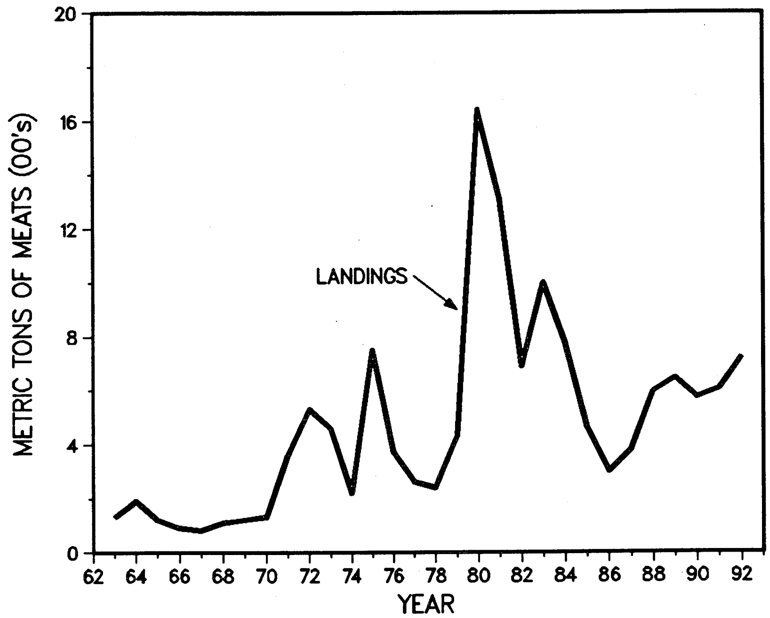
Georges Bank

Total (United States and Canada) nominal landings from Georges Bank continued at near record levels. In 1992 landings were 14,600 mt, showing a small decline from 1991 when landings were 15,200 mt. Of the 1992 total, U.S. landings accounted for 58 percent (8,500 mt) while Canadian landings accounted for 42 percent (6,100 mt). The 1992 U.S. catch was 10 percent lower than in 1991, while Canadian landings increased by 5 percent during this time. As in the Gulf of Maine, commercial fishing effort increased greatly from 1988 to 1990, and has continued at record levels in the Georges Bank region for the past three years. Commercial catch per unit effort (CPUE) declined by approximately 8 percent in 1992, continuing the decline observed in 1991.

Indices from the 1992 U.S. sea scallop research vessel survey indicate that the scallop resource in the U.S. portion of Georges Bank remains at high levels of biomass and abundance. In the South Channel region of the

"Fishing effort on Georges Bank is at record high levels and far exceeds what the resource can sustain in the long run."

Sea Scallops
Gulf of Maine

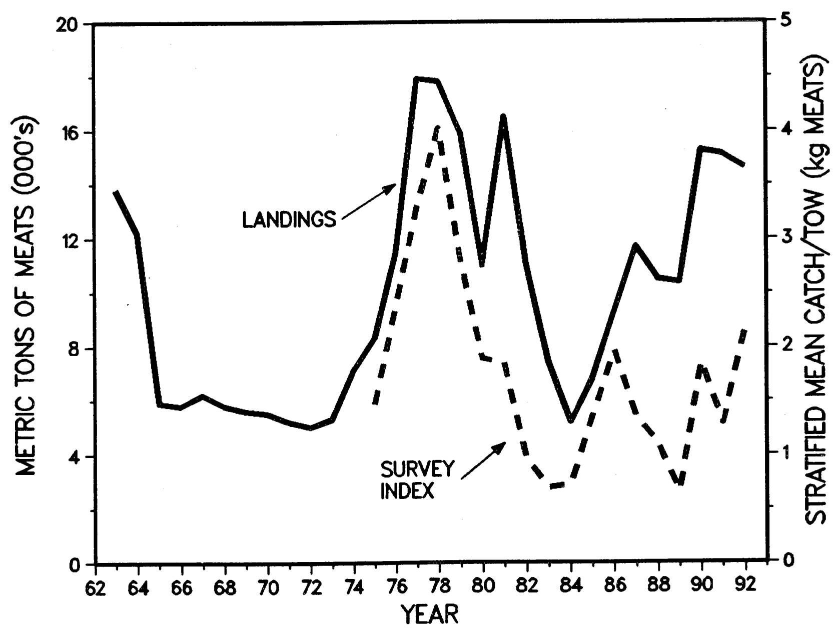


bank, all indices of abundance and biomass increased sharply in 1992, marking the third consecutive year of increased abundance. In the southeastern part of the bank, a substantial increase over the 1991 survey index was also observed in 1992. Biomass indices for the U.S. northern edge and peak regions, however, decreased by about 40 percent from 1991 to 1992.

Indices of prerecruit abundance (scallops smaller than 72 mm shell height) were relatively high in the South Channel, indicating that the abundance of recruited scallops may increase during the upcoming year. However, the effect this year class will have on harvest depends on its size distribution and the relative abundance of larger scallops available to comply with meat count restrictions. Prerecruit indices in the southeast part of the Georges Bank region were near average, suggesting that fishable biomass should be maintained at similar levels to the past several years. In the U.S. portion of the northern edge and peak of the bank, prerecruit indices dropped sharply in 1992, indicating that stock abundance and fishable biomass may decline. The U.S. Georges Bank scallop resource is still dominated by small scallops. During the 1992 survey, 53 percent of the scallops caught in the 1992 survey had meat counts in excess of 80 meat count.

Fishing effort on Georges Bank is at record high levels and far exceeds what the resource can sustain in the long run. Current fishing mortality in the southeast part of Georges Bank is estimated to be F=0.6. In the South Channel region, which is the larger area, current fishing mortality is estimated to be F=1.9. For the two areas

Sea Scallops
Georges Bank



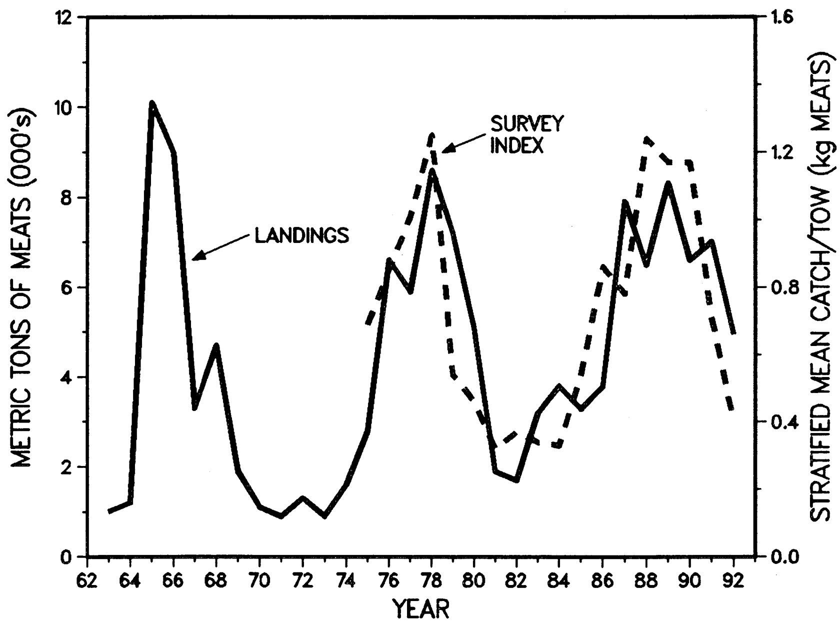
"Given the low abundance of scallops in the Mid-Atlantic resource, landings from this region are expected to continue to decline in 1993."

combined, fishing mortality is much higher than F_{max} (F=0.23) and about double that resulting in overfishing as provisionally defined by the New England Fishery Management Council. At this high fishing mortality rate, the fishery is highly 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.

Middle Atlantic

Total nominal catch in 1992 was 5,000 mt, a substantial decline from the 7,000 mt landed in 1991. Most of the Mid-Atlantic catch (57 percent) continued to come from the New York Bight region (2,800 mt), but landings in this region showed the sharpest decline from 1991 landings (4,700 mt). In the Delmarva region, landings fell from 2,200 mt in 1991 to 1,600 mt in 1992. In contrast, landings increased in the Virginia/North Carolina area from 100 mt in 1991 to nearly 600 mt in 1992. Fishing effort during 1992 continued to be very high in the Mid-Atlantic region with over 17,000 days fished in the dredge fishery. Commercial CPUE decreased by about 20 percent in 1992, continuing the trend in declining CPUE observed since 1989 in the Mid-Atlantic region.

Sea Scallops
Middle Atlantic



Abundance and biomass indices from the 1992 U.S. sea scallop survey indicate that scallop abundance in the Mid-Atlantic continues to decline from the record high levels of the late 1980s. Indices of abundance for prerecruits and harvestable-size scallops declined in all regions from 1991 to 1992. The pattern of above average recruitment observed in the Mid-Atlantic region in the 1985-89 surveys (1982-86 cohorts) has not continued with respect to the 1988 and 1989 cohorts. The Mid-Atlantic area is no longer dominated by small scallops. During the 1992 survey, 43 percent of the scallops caught in this area were greater than 80 meat count.

Given the low abundance of scallops in the Mid-Atlantic resource, landings from this region are expected to continue to decline in 1993. If fishing effort remains at the current high level, commercial CPUE is also expected to decline in 1993. Fishing mortality in this region appears to have increased over time, following trends in fishing effort. Fishing mortality in the Delmarva region is estimated to be 1.6, approximately double the fishing mortality in the provisional overfishing definition of the New England Fishery Management Council.

For further information

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. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

Wigley, S.E. and F.M. Serchuk. 1991. Current resource conditions in USA Georges Bank and Mid-Atlantic sea scallop populations: Results of the 1991 NMFS sea scallop research vessel survey. In Report of the Thirteenth Regional Stock Assessment Workshop (13th SAW), Fall 1992. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 92-02. Available from: NOAA/NMFS/NEFSC, Woods Hole, MA 02543.

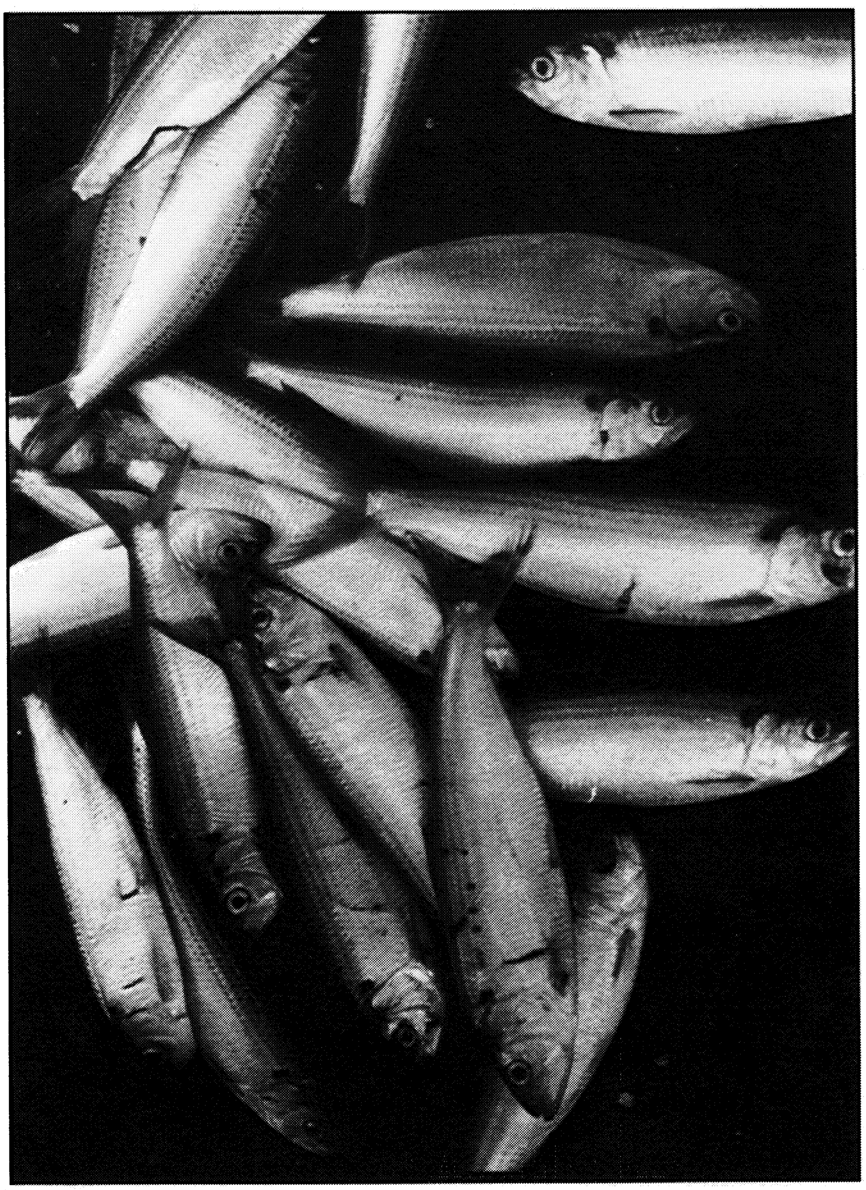
Serchuk, F.M. and S.E. Wigley. 1992. Status of the sea scallop fisheries off the Northeastern United States, 1991. NEFSC [Northeast Fisheries Science Center]. 1992. Report of the Thirteenth Regional Stock Assessment Workshop (13th SAW), Fall 1992. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 92-02.

River Herring

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 is farther north, from Labrador to South Carolina. In coastal rivers where the ranges overlap, the fisheries for the two 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. In 1969, the nominal catch began a downward trend until the mid- to late 1970s, and averaged 4,000 to 5,000 mt until the late 1980s. Total landings north of Cape Hatteras, N.C. have since declined to 670 mt in 1992. North Carolina, Virginia, and Maine are the only states with substantial commercial fisheries, accounting for approximately 90 percent of total landings.



NMFS photo by Brenda Figuerido

In response to the observed decline in nominal catch and the lack of a coastwide increase in stock biomass, the Atlantic States Marine Fisheries Commission prepared a comprehensive coastwide management plan for shad and river herring with the participation of all coastal states between Maine and Florida. Bycatch of river herring in the foreign directed fisheries is managed under the Mid-Atlantic Fishery Management Council's Squid, Mackerel, and Butterfish Fishery Management Plan. 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 equal among all rivers. Several river herring stocks along the East Coast are still being exploited at more than optimal levels and some potential spawn-

"The dramatic decline in landings since the mid-1960s reflects substantial declines in resource abundance since that time."

ing 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 Special Report #19. Available from: Atlantic States Marine Fisheries Commission, 1776 Massachusetts Ave., N.W., Ste. 600, Washington, D.C. 20036.

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 special report #18. Available from: Atlantic States Marine Fisheries Commission, 1776 Massachusetts Ave., N.W., Ste. 600, Washington, D.C. 20036.

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. Available from: Atlantic States Marine Fisheries Commission, 1776 Massachusetts Ave., N.W., Ste. 600, Washington, D.C. 20036.

River Herring
Gulf of Maine-Middle Atlantic

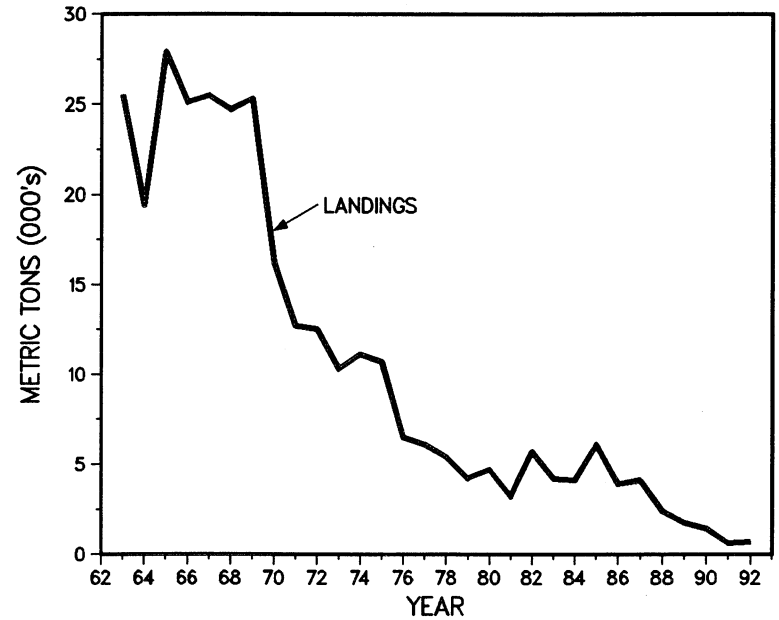


Table 34.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	7.9	4.2	4.1	6.1	3.9	4.1	2.4	1.8	1.4	0.6	0.7
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	5.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total nominal catch	12.9	4.2	4.1	6.1	3.9	4.1	2.4	1.8	1.4	0.6	0.7

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; Squid, Mackerel, 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_{1992} = Variable

American Shad

Photo by Brenda Figuerido

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 rivers. Following their downstream migration, shad migrate north along the coast to Canada where they feed during the summer. A southward migration occurs 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 stock. American shad have been the subject of intensive exploitation for their flesh and roe with nominal commercial catch along the Atlantic coast exceeding 22,000 mt in 1896. The principal fishing gear currently used for American shad is the gill net. Commercial catch reported north of Cape Hatteras, N.C. during the 1980s has been the lowest on record, averaging 1,000 mt annually since 1980. Landings during 1992 declined to 653 mt. Recreational fishing may be significant, but no estimates of landings are available.

Excessive fishing has been blamed for stock declines in the Hudson and Connecticut Rivers, as well as rivers in Maryland, North Carolina, and Florida. Dams along the Susquehanna River led to an almost complete disappearance of what was once a major fishery. Pollution in the lower Delaware was 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 involving habitat improvement, fish passageways, and stocking programs have resulted in improved returns to some river systems, particularly the Delaware, Connecticut, and Susquehanna Rivers.

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 Ameri-

American Shad
Gulf of Maine-Middle Atlantic

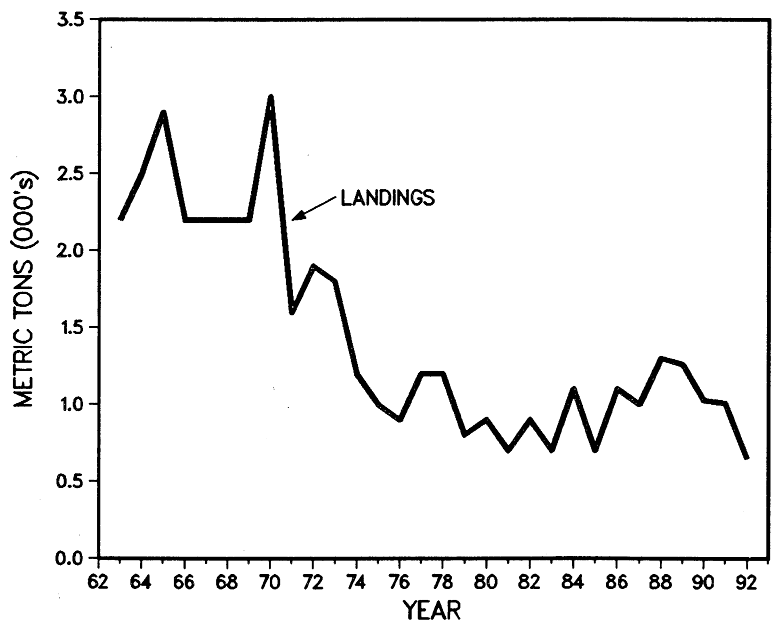


Table 35.1 Recreational catches and commercial landings (thousand metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.2	0.7	1.1	0.7	1.1	0.9	1.3	1.3	1.0	1.0	0.7
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	1.2	0.7	1.1	0.7	1.1	0.9	1.3	1.3	1.0	1.0	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	=	Individual states
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_{1992} = Variable

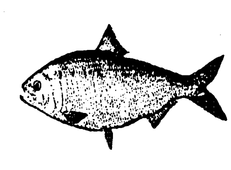
"Restoration efforts involving habitat improvement, fish passageways, and stocking programs have resulted in improved returns to some river systems, particularly the Delaware, Connecticut, and Susquehanna Rivers."

can shad contribute an unknown degree of exploitation to certain river systems. The assessment information is insufficient to confidently determine the status of individual or aggregated stocks.

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 Spec. Rpt. No. 15. Available from: Atlantic States Marine Fisheries Commission, 1776 Massachusetts Ave., N.W., Ste. 600, Washington, DC 20036.

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. Available from: Atlantic States Marine Fisheries Commission, 1776 Massachusetts Ave., N.W., Ste. 600, Washington, DC 20036.



Striped Bass

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 in mid-February in Florida and 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 migration: an upriver spawning migration from late winter to early spring, and a coastal migration that is apparently not associated with spawning activity. Coastal migrations may be quite extensive; striped bass tagged in Chesapeake Bay have been captured 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 of the fish.

Atlantic coastal fisheries for striped bass rely primarily on production from stocks spawning in the Hudson River and in tributaries of the Chesapeake Bay. The Chesapeake stock 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. The decline in abundance of the Chesapeake Bay stock probably was due

NMFS photo by Brenda Figuerido

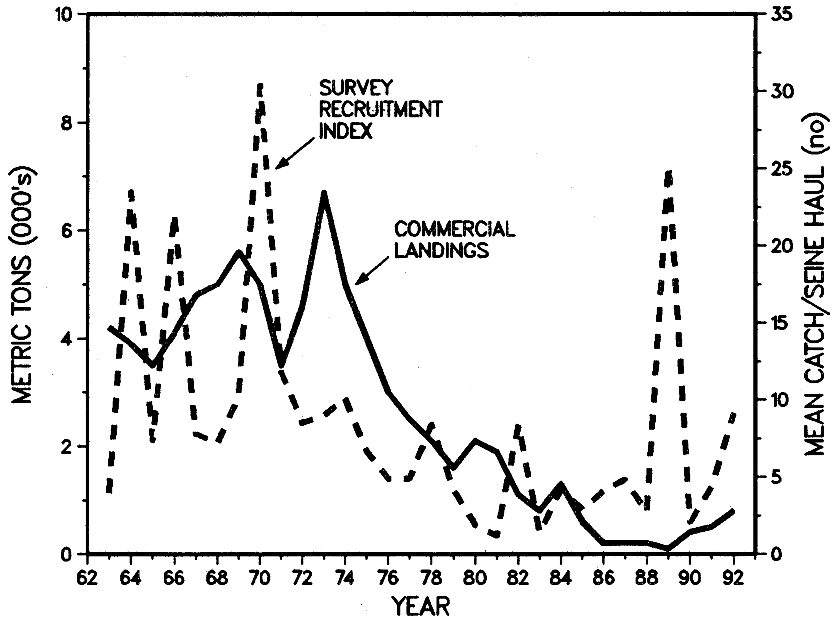
Gulf of Maine - Middle Atlantic Striped Bass

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 fully recovered)

M = 0.15 **$F_{0.1}$ = not calculated** **F_{max} = 0.5** **F_{1990} = 0.23**

[1]Moderate exploitation began in 1990

Striped Bass
Gulf of Maine-Middle Atlantic



" During 1992, an estimated 4.2 million striped bass were caught by recreational anglers; 90 percent of these were released alive."

Table 36.1 Recreational harvest and commercial landings (thousand metric tons)

Category	Year 1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	1.5[1]	1.2	0.5	0.8	0.4	0.4	0.6	0.3	1.2	1.6	2.2
Commercial											
United States	2.8	0.8	1.3	0.6	0.2	0.2	0.2	0.1	0.4	0.5	0.8
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	4.3	2.0	1.8	1.4	0.6	0.6	0.8	0.4	1.6	2.1	3.0

[1] 79-82 (survey not conducted prior to 1979)

primarily to overfishing, however poor water quality in spawning and nursery habitats likely also contributed.

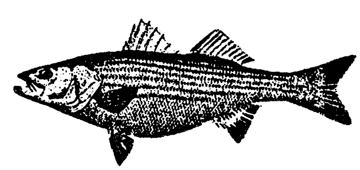
During the mid-1980s, stringent management measures were adopted by the states from Virginia to Maine to attempt to rebuild the Chesapeake stocks. These measures, aimed at protecting the 1982 and subsequent year classes until females could spawn at least once, have been effective in increasing spawning 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 tributaries to the Chesapeake Bay have been at or near record 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 second highest on record, and exceeded management criteria for relaxing fishery regulations in 1990. The 1992 index, though not exceptional, was near the long-term average.

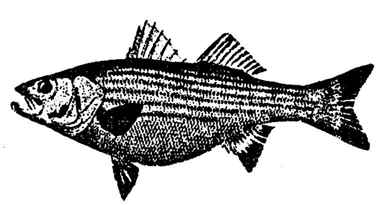
Recreational landings of striped bass often equal or exceed commercial landings. In 1992, estimated recreational harvest (2,200 mt) was nearly 3 times commercial landings. During 1992, an estimated 4.2 million striped bass were caught by recreational anglers; 90 percent of these were released alive.

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. 1992. Emergency striped bass research study. Report for 1990. Washington, DC: U.S. Department of the Interior, U.S. Department of Commerce. Available from: NMFS F/CM3, 1335 East-West Highway, Silver Spring, MD 20910.





Atlantic Salmon

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 mature 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.

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, including Nova Scotia, Newfoundland, Labrador, and West Greenland, that commercial gill net 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 stocks.

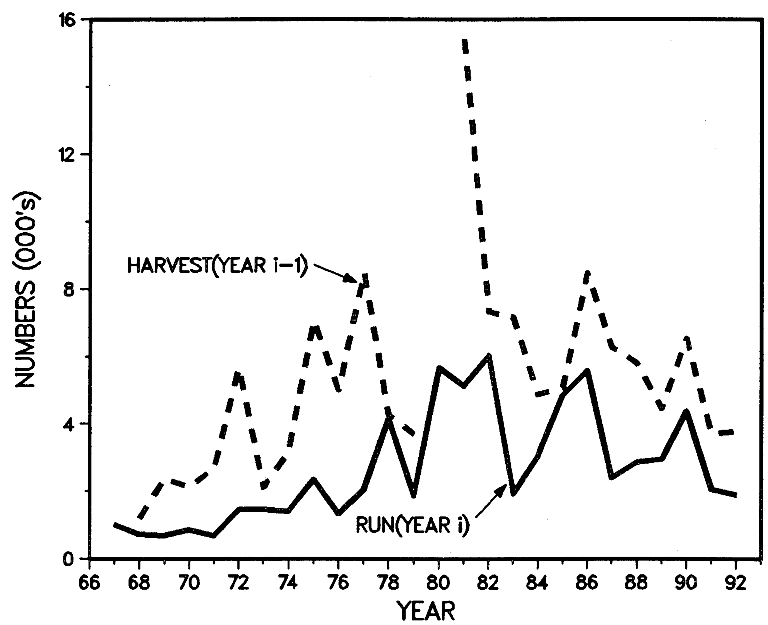
NMFS Photo by Brenda Figuerido

Home water fisheries are limited to an angling fishery in Maine only. Angler landings have averaged approximately 350 salmon in recent years, which resulted in an exploitation rate of approximately 10 percent of the run to Maine Rivers. 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 gill net 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 percent in recent years and at approximately 80 percent for the 2 sea-winter component. These levels of exploitation 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 States is a member. The Greenland fishery is managed with a quota system that has been in place since 1976. With concerns over stock status in mind, a multi-year quota agreement beginning in 1993 was agreed which provides a framework for quota setting based on a forecast model of salmon abundance. The 1993 quota has been set at 213 mt and was designed to result in a 50 percent increase in spawning escapement to North America rivers. Subsequent to the governmental negotiated quota agreement, a private initiative was successful in purchasing the 1993

Atlantic Salmon



"With concerns over stock status in mind, a multi-year quota agreement beginning in 1993 was agreed which provides a framework for quota setting based on a forecast model of salmon abundance."

Table 37.1 Recreational catches and commercial landings (numbers)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	615	355	639	958	1091	424	400	1007	1414	477	600
Commercial[1]											
United States	-		-	-	-	-	-	-	-	-	-
Canada	2592	3401	2657	4575	1104	1161	590	1722	780	1425	
Greenland	2963	976	1697	2939	4070	4175	3463	3797	1525	1871	
Total nominal catch	6170	4732	4993	8472	6265	5760	4453	6526	3719	3773	600

[1] Carlin tag harvest estimates

quota with the exception of a small fishery for local use.

The Canadian fishery has been managed with 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 1993 by an amount consistent with the reduction in licensed effort in that part of the Province.

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_{1991} = 0.6**

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.

Sturgeon

Sturgeon
East Coast

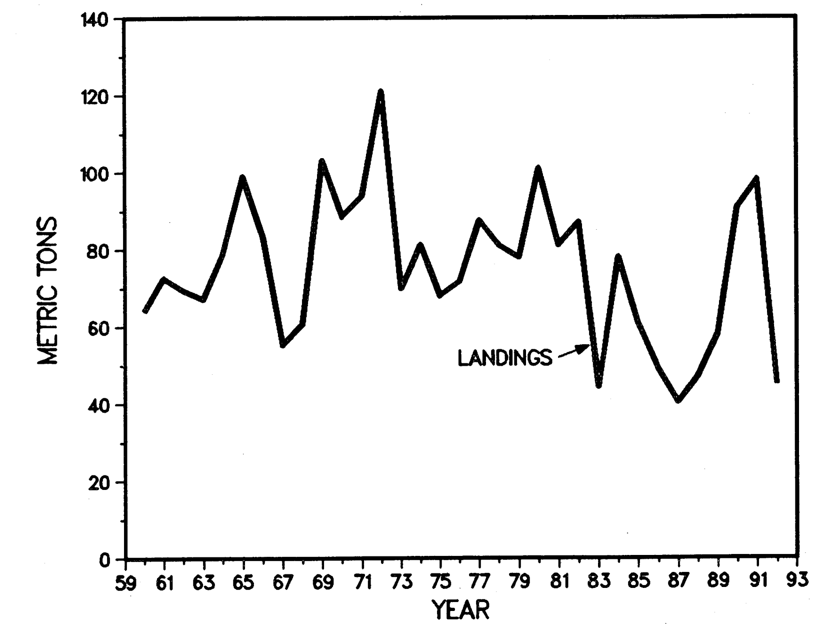


Table 38.1 Recreational catches and commercial landings (metric tons)

Category	1972-82 Average	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	84	45	78	61	49	41	47	58	91	98	45
Canada	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	84	45	78	61	49	41	47	58	91	98	45

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 has a more northerly distribution, being recorded in the Canadian Province of Labrador, whereas the shortnose sturgeon ranges only to the Province of New Brunswick.

Sturgeon once supported a substantial commercial fishery, but, 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 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.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. These two factors combine to make them vulnerable to over-exploitation. Juveniles and adults are benthic (or bottom) feeders, consuming a variety of crustaceans, bivalves, and worm prey. As adults, shortnose sturgeon are smaller than Atlantic sturgeon reaching a body length of approximately 100 cm (40 in.) whereas the Atlantic sturgeon can be twice that length. Both species begin their spawning migration to freshwater during late winter to early summer. The migration occurs latter in the year at higher latitudes, and where the species cooccur, 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 are still undocumented for the rarer shortnose sturgeon. Tagging studies have demonstrated Atlantic sturgeon can make considerable oceanic migrations 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

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, prohibited under the ESA
Fishing mortality rate corresponding to overfishing definition	=	None defined

$M = 0.12$ $F_{0.1}$ = Unknown F_{max} = Unknown F_{1991} = 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 yrs
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_{1991} = Unknown

and a large proportion of the landings are bycatch. Around the turn 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 over-exploited, catches declined dramatically to only incidental landings during the period 1900 to 1950. Some fishing activity in the Carolinas area 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.

Management for sturgeons is in the form of an Atlantic States Marine Fisheries Commission (ASMFC) plan for the Atlantic sturgeon and a recovery plan under the Endangered Species Act for the shortnose sturgeon. The

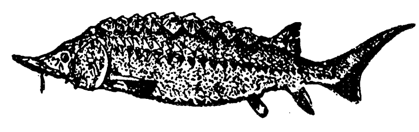
"Recent increases in landings are due to increased catches in developing ocean fisheries in New York and New Jersey. There is no significant sport fishery for sturgeon."

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. There are minimum size limits (7 ft), harvest restrictions, and closed season in some states. Recent harvest reductions are believed to reflect the influence of these new management measures. 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

Harbor porpoise, *Phocoena phocoena*, is one of the smallest cetaceans, reaching only 5 ft and about 140 lb. Sexual maturity is reached between 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 (Read 1990). This is one of the shortest-lived of all cetaceans, with a maximum longevity in the range of 12 to 15 years.

Harbor porpoise are found in waters from North Carolina to Labrador. The geographical distribution and simultaneous timing of reproduction in widely separated geographical areas suggests that there are four populations in the western North Atlantic Ocean: western Greenland, Newfoundland-Labrador, Gulf of St. Lawrence, and Gulf of Maine (Gaskin 1984). The limited genetic research done thus far could not separate the putative populations (NEFSC Marine Mammal Investigation 1992).

Seasonal movements and the degree of mixing between putative populations is largely unknown. To determine the seasonal distribution of harbor porpoise in the Gulf of Maine region, the Marine Mammals Investigation of the NMFS has conducted aerial and shipboard line transect surveys in the region from the Gulf of Maine to Florida during October 1991, December 1992, February 1993 and April 1993. There are large numbers of porpoises in U.S. waters of the Gulf of Maine - lower Bay of Fundy region in the summer, and nearly none in the same region in the winter. The winter distribution is largely unknown except that some porpoises have been found stranded on beaches from New York to North Carolina in the winter and spring (Polacheck *et al.* 1992). There is little information concerning the distribution of harbor porpoises in the Canadian waters off Nova Scotia and Newfoundland and within the Gulf of St. Lawrence.

Estimates of harbor porpoise abundance are available for the summer population in the Gulf of Maine and Bay of Fundy region. A comprehensive shipboard survey was conducted by NMFS in the Gulf of Maine during July and August 1991 with a replicate survey done in July and August 1992. The NMFS surveys covered the known summer range of harbor porpoise in the Gulf of Maine and Bay of Fundy. Line transect methods were used to estimate harbor porpoise density. The various components of this methodology were reviewed in detail, with particular attention paid to the possible introduction of bias and potential means of reducing the magnitude of variance associated with the density point estimate. The best available estimates of population size based on summer survey work is 37,500 (95 percent CI 26,700 to 86,400) animals for 1991 and 67,500 (95 percent CI 32,900 to 104,600) animals for 1992. These values are not significantly different, and a pooled estimate is 47,200 (95 percent CI 39,500 to 70,600).

Fisheries Interaction

Estimating total mortality caused by commercial fisheries on the Gulf of Maine harbor porpoise population is a difficult task. The largest incidental catches are made by the groundfish gill net fisheries (NEFSC Marine Mammal Investigation 1992) where porpoise become entangled, presumably as they forage near the bottom (Read and Gaskin 1988). The NEFSC Sea Sampling Program has collected data on fishing activity and marine mammal interactions since June 1989 using trained observers aboard randomly selected fishing vessels. The current level of observer coverage is approximately 10 percent of the total estimated fishing effort (NEFSC Marine Mammal Investigation 1992). To estimate total incidental mortality, the observed incidental catch rate must be applied to some measure of total fishing effort. Unfortunately, no direct measure of total effort exists, so indirect measures have been used, such as tons of fish landed and number of fishing trips recorded by NMFS port agents (Bisack 1992). Estimation is further complicated by the seasonal migration of harbor porpoise in the Gulf of Maine and the seasonal changes in patterns of fishing effort. The estimated bycatch has varied from 2,300 to 900 over the past three years (Table 1). Although some informal mail and telephone surveys have been conducted in Canada, there are no comprehensive estimates available for other regions of the Northwest Atlantic.

The ratios of estimates of bycatch to estimates of abundance have been used to estimate the biological significance of the by-catch (NEFSC Marine Mammal Investigation 1992). Using the three annual estimates of bycatch (Table 1) and the pooled estimate of abundance (47,200), these ratios appear to have declined from 1990 to 1992 (Table 1). The 1992 ratio is significantly lower than the 1990 and 1991 ratios (Smith *et al.* 1993).

To fully understand the biological significance of bycatch of this species in eastern North America will require additional information on (1) population structure and movements throughout eastern North America, (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. Repeating 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. Resolving some of these uncertainties are issues of high priority.

For further information

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.

Gaskin, D.E. 1984. The harbour porpoise *Phocoena phocoena* (L.): regional populations, status, and information on direct and indirect catches. *Rep. Int. Whal. Commn.* 34:569-586.

NEFSC Marine Mammal Investigation. 1992. Harbor porpoise in eastern North America: status and research needs. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 92-06.

Palka, D. 1993. (In press). Abundance estimates of the Gulf of Maine harbor porpoise. *Rep. Int. Whal. Commn.*

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 harbor porpoises by gill nets. *J. Wildl. Manage.* 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.

Table 39.1. Estimated bycatch and ratio of bycatch to pooled weighted abundance with standard error

Year	Bycatch	SE	Ratio (%)	SE
1990	2400	470	5.1	1.38
1991	1700	340	3.6	0.97
1992	900	120	1.9	0.43

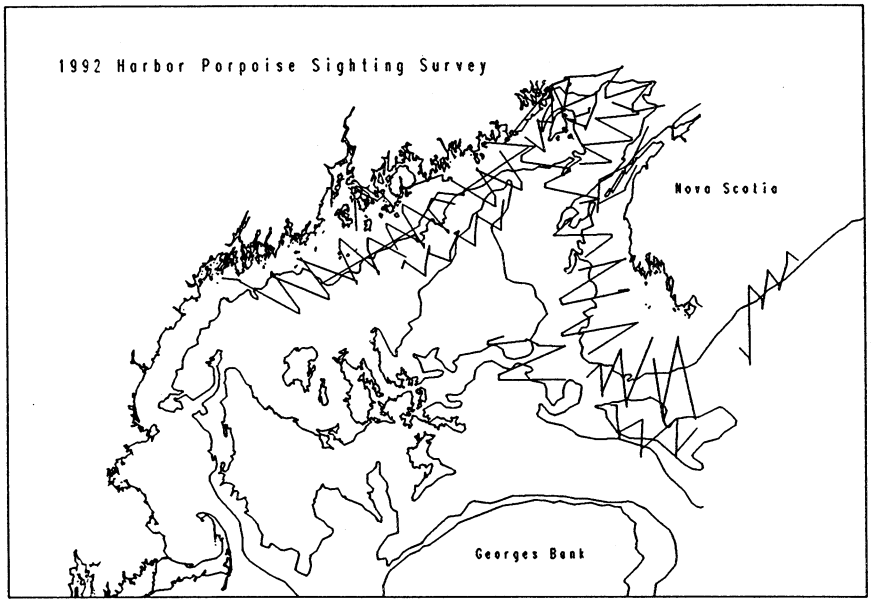


Figure 39. 1. Map of area of operation for 1992 harbor porpoise survey showing transect lines.

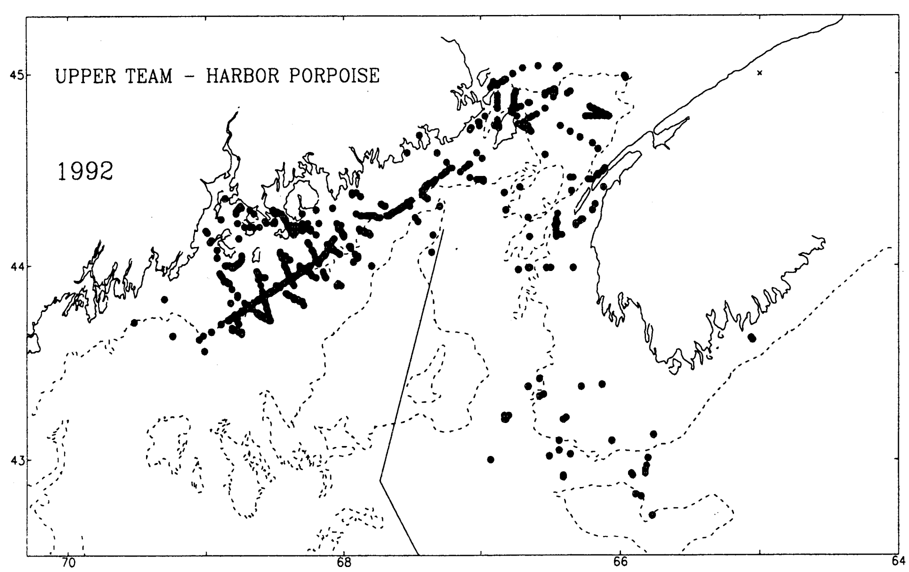


Figure 39.2. Map of area of operation for 1992 harbor porpoise survey showing harbor porpoise sightings recorded by one of two teams which was located in the upper crow's nest of the R/V *Abel-J*.

Common Name Index

Scientific Name Index