NOAA Technical Memorandum NMFS-NE-115

Status of Fishery Resources off the Northeastern United States for 1998

U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Northeast Fisheries Science Center
Woods Hole, Massachusetts

September 1998

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Status of Fishery Resources off the Northeastern United States for 1998

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September 1998

Note on Species Names

The NMFS Northeast Region's policy on the use of species names in all technical communications is generally to follow the American Fisheries Society's (AFS) lists of scientific and common names for fishes (*i.e.*, Robins *et al.* 1991)[a], mollusks (*i.e.*, Turgeon *et al.* 1998)[b], and decapod crustaceans (*i.e.*, Williams *et al.* 1989)[c], and to follow the American Society of Mammalogists' list of scientific and common names for marine mammals (*i.e.*, Wilson and Reeder 1993)[d]. Exceptions to this policy occur when there are subsequent compelling revisions in the classifications of species, resulting in changes in the names of species (*e.g.*, Cooper and Chapleau 1998)[e].

[a]Robins, C.R. (chair); Bailey, R.M.; Bond, C.E.; Brooker, J.R.; Lachner, E.A.; Lea, R.N.; Scott, W.B. 1991. Common and scientific names of fishes from the United States and Canada. 5th ed. *Amer. Fish. Soc. Spec. Publ.* 20; 183 p.

[b]Turgeon, D.D. (chair); Quinn, J.F., Jr.; Bogan, A.E.; Coan, E.V.; Hochberg, F.G.; Lyons, W.G.; Mikkelsen, P.M.; Neves, R.J.; Roper, C.F.E.; Rosenberg, G.; Roth, B.; Scheltema, A.; Thompson, F.G.; Vecchione, M.; Williams, J.D. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. 2nd ed. *Amer. Fish. Soc. Spec. Publ.* 26; 526 p.

[c]Williams, A.B. (chair); Abele, L.G.; Felder, D.L.; Hobbs, H.H., Jr.; Manning, R.B.; McLaughlin, P.A.; Pérez Farfante, I. 1989. Common and scientific names of aquatic invertebrates from the United States and Canada: decapod crustaceans. *Amer. Fish. Soc. Spec. Publ.* 17; 77 p.

[d]Wilson, D.E.; Reeder, D.M. 1993. Mammal species of the world: a taxonomic and geographic reference. Washington, DC: Smithsonian Institution Press; 1206 p.

[e]Cooper, J.A.; Chapleau, F. 1998. Monophyly and interrelationships of the family Pleuronectidae (Pleuronectiformes), with a revised classification. *Fish. Bull. (U.S.)* 96:686-726.

Acknowledgments

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Introduction

The Resource Evaluation and Assessment Division of the Northeast Fisheries Science Center (NEFSC), National Marine Fisheries Service (NMFS), with headquarters in Woods Hole, Massachusetts, regularly updates assessments of finfish and shellfish resources off the northeastern coast of the United States and presents information as needed to administrators, managers, the fishing industry, and the general public. Some of these assessments are prepared exclusively by NEFSC scientists; many others are prepared jointly with researchers at other federal and state agencies and academic institutions. This report summarizes the status of selected finfish and shellfish resources off the northeastern coast of the United States from Cape Hatteras to Nova Scotia based on information available through Spring of 1998.

Night watch net mending, R/V *Albatross IV*

NOAA Fisheries NEFSC Photo by Brenda Figuerido

This report includes review chapters on fishery landings and economic trends, aggregate resource trends, and the status of key fishery resources. The Fishery Landings Trends section provides summary overviews since publication of the last "Status of the Fishery Resources" document; specifically, final commercial and recreational landings data for 1994-1996 and preliminary data for 1997. The Fishery Economic Trends chapter provides information on fishing activity and fishery economics in the Northeast including fleet size and characteristics and economic returns. The Aggregate Resource Trends section provides an overview of trends in abundance for major finfish assemblages on the northeast shelf, together with an overview of resource status. A special topics chapter is added this year highlighting the groundfish fishery vessel buyout program in the northeast, which removed 79 vessels from the severely overcapitalized New England fleet. Finally, the Species Synopses section includes information about the status of 51 stocks of finfish and shellfish, and harbor porpoise.

The species and stocks described in the Species Synopses section can be logically grouped into eight categories: principal groundfish, flounders, other groundfish, principal pelagics, other finfish, invertebrates, anadromous fish, and marine mammals (harbor porpoise). The region occupied by these stocks (including areas in Canadian waters occupied by resources exploited by both the U.S. and Canada) is shown in Figure 1. Such "trans-boundary stocks" include stocks such as Georges Bank cod, which are found on both sides of the international boundary line on eastern Georges Bank, and highly migratory stocks such as Atlantic mackerel which move seasonally between U.S. and Canadian waters. There are several other species of commercial and recreational importance that are not included in this report, such as bluefin and yellowfin tuna, swordfish, red crab, sand lance, sea urchin, menhaden, pelagic sharks, and inshore shellfish (including softshell and hard

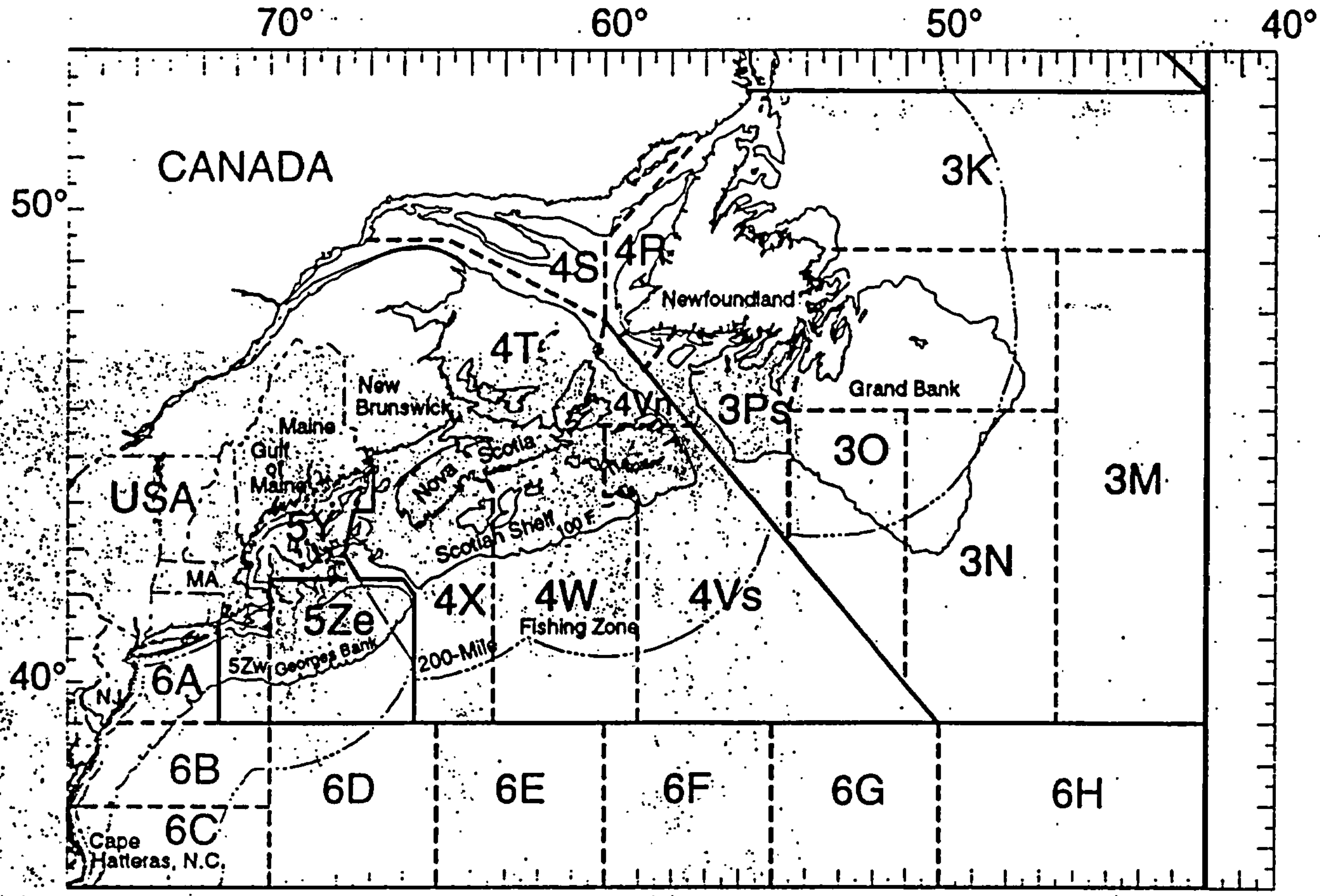


Figure 1. The Northwest Atlantic, including Northwest Atlantic Fisheries Organization (NAFO) subareas and divisions and other features mentioned in this report.

clams, oysters, and blue mussels). Some of these are migratory species that are present off the northeastern U.S. only seasonally, while others are resident primarily or exclusively within state waters and are routinely assessed and managed by state agencies.

OVERVIEW OF ASSESSMENT APPROACHES

Depending on the nature of the fishery, the type and amount of data available, and the information required for management, assessments may be generated in several different ways. The simplest approach involves use of commercial landings and fishing effort data and/or research vessel survey data to generate indices of abundance. (As research vessel surveys are performed using small mesh gear to sample juvenile fish and invertebrates, survey data are also used to develop indices of incoming recruitment.) A second approach is to utilize commercial landings and effort data and/or information on population size and productivity to determine relationships between effort and yield; this is referred to as a surplus-production or surplus-yield model (Figure 2A). Yield and spawning stock biomass-per-recruit curves may also be developed based on biological parameters (growth and natural mortality rates, maturation, etc.) generated from biological sampling or other sources of information (Figure 2B). The most complex (and useful) assessments can be performed when size and age composition of the catch and the population can be determined reliably through sampling of commercial and recreational catches at sea and at dockside and through sampling of research vessel survey catches at sea. This allows development of more detailed analytic (size or age structured) assessments such as virtual population analysis or VPA which provide information on stock size, recruitment and fishing mortality and exploitation patterns over time. Such assessments may incorporate relationships between spawning stock size and recruitment (stock-recruitment models) which provide a basis for benchmark advice on management options. These models may account for changes in environmental conditions.

The type of assessment performed depends on the complexity of the information needed. For intensively fished stocks requiring detailed information on trends in stock size, recruitment and fishing mortality, analytic assessments are generally required. For moderately exploited fisheries where management

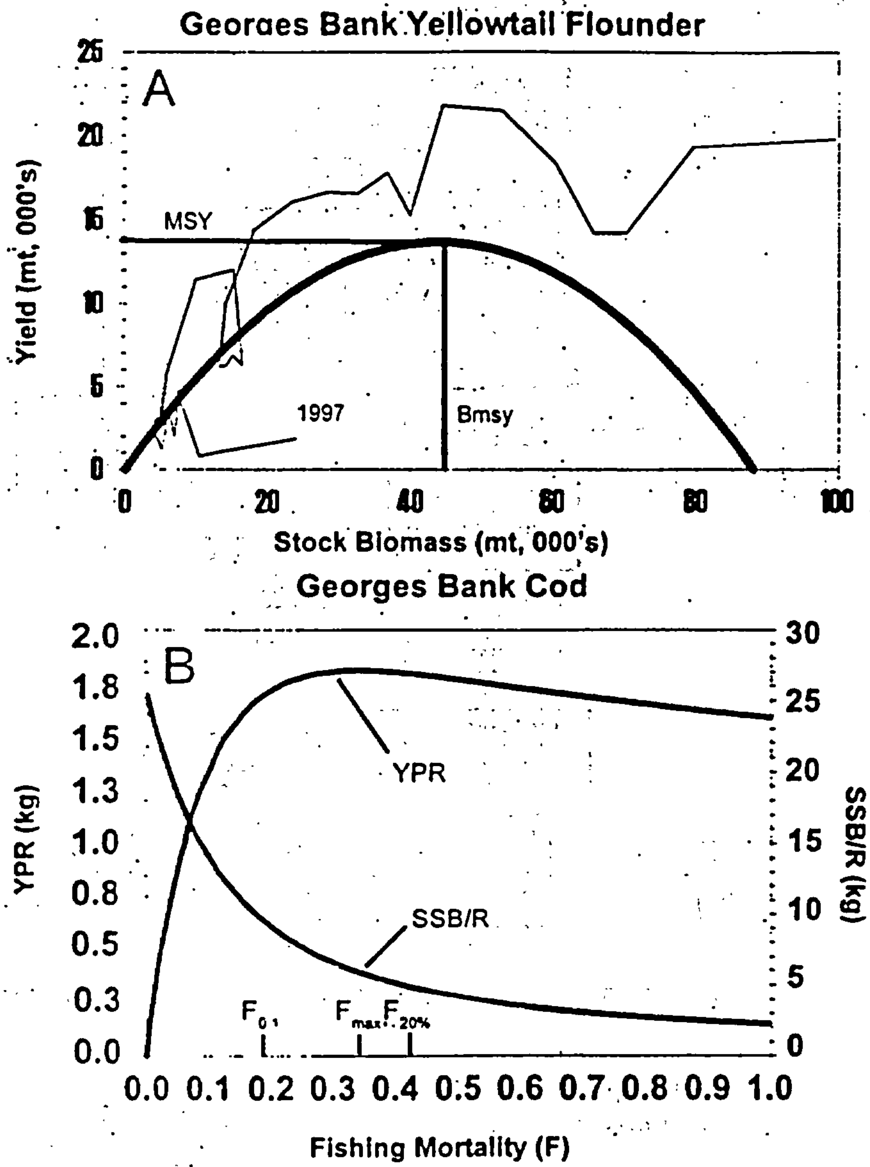


Figure 2. (A) Surplus production model yield curve for Georges Bank yellowtail flounder, and (B) yield-per-recruit and spawning stock biomass-per-recruit curves for Georges Bank cod, including biological reference points.

is less intensive, surplus-production or index-based methods may be adequate. In any case, the process obviously depends upon the type and amount of data available; while analytic assessments are the most useful and informative, adequate supporting information is available only for a relatively few northeast stocks. The improvement of "fishery-dependent" data collection programs (landings and effort data by area, and biological sampling of commercial and recreational catches at sea and at dockside) and "fishery-independent" data collection in research vessel surveys has been and continues to be a high priority of the National Marine Fisheries Service. Also, much remains to be learned about the biology of many species; the biological information which is available (*e.g.*, growth and maturation rates) requires continual updating in many cases since biological parameters may vary significantly with exploitation and environmental changes. For the present, there are great differences in availability of different types of information for the many species of interest in this region, and thus assessment work for different species will follow different pathways. As management needs continue to intensify, so will the need for improved fishery-dependent and fishery-independent data collection.

KINDS OF ASSESSMENTS

The assessments presented in this report can be roughly grouped in order of increasing complexity into the following categories, each one including features of simpler levels. Types are as follows:

INDEX: assessment involves development of an index of stock size from research vessel survey data (mean catch per tow) or from fishery catch-per-unit-of-effort (CPUE) data.

SURPLUS PRODUCTION: assessment models relationships between yield and fishing effort. Models are based on simple biological rules of increase and decrease and allow useful analyses with relatively little data, but cannot be readily adapted to account for detailed biological or fishery-related information.

YIELD PER RECRUIT: assessment provides evaluations of yield as a function of fishing mortality and age at entry to the fishery, incorporating information on biological parameters (growth and natural mortality rates). Spawning stock biomass per recruit calculations are analogous in that they use such information along with maturation data to model trends in spawning biomass.

AGE/SIZE STRUCTURED: assessment includes analysis of the observed size or age composition of the catch (*e.g.*, virtual population analysis, modified DeLury analysis) and biological information (size and weight at age, maturation rates) to provide estimates of fishing mortality and total and spawning stock size (numbers and weight) over time. Resulting estimates can be combined with estimates of incoming recruitment from research vessel surveys or other sources to make predictions of catch and stock size in upcoming years in relation to fishing mortality. They also provide data for a wide variety of more sophisticated analyses e.g. recruitment in relation to spawning stock size or multispecies modeling.

Figure 3 provides an outline of the sequence in which catch and survey data, in the lower right and left boxes respectively, can be used to provide assessment advice. For example, an INDEX level assessment involves information generated by following either the rightmost or leftmost vertical arrows, depending on whether commercial or survey data are available. A SURPLUS PRODUCTION type. assessment would require landings and effort data from the fishery (lower right-hand box in the figure) while YIELD PER RECRUIT analyses are dependent on detailed biological information (biological data.) AGE/SIZE STRUCTURED assessments would require information represented in the middle column of boxes in Figure 3.

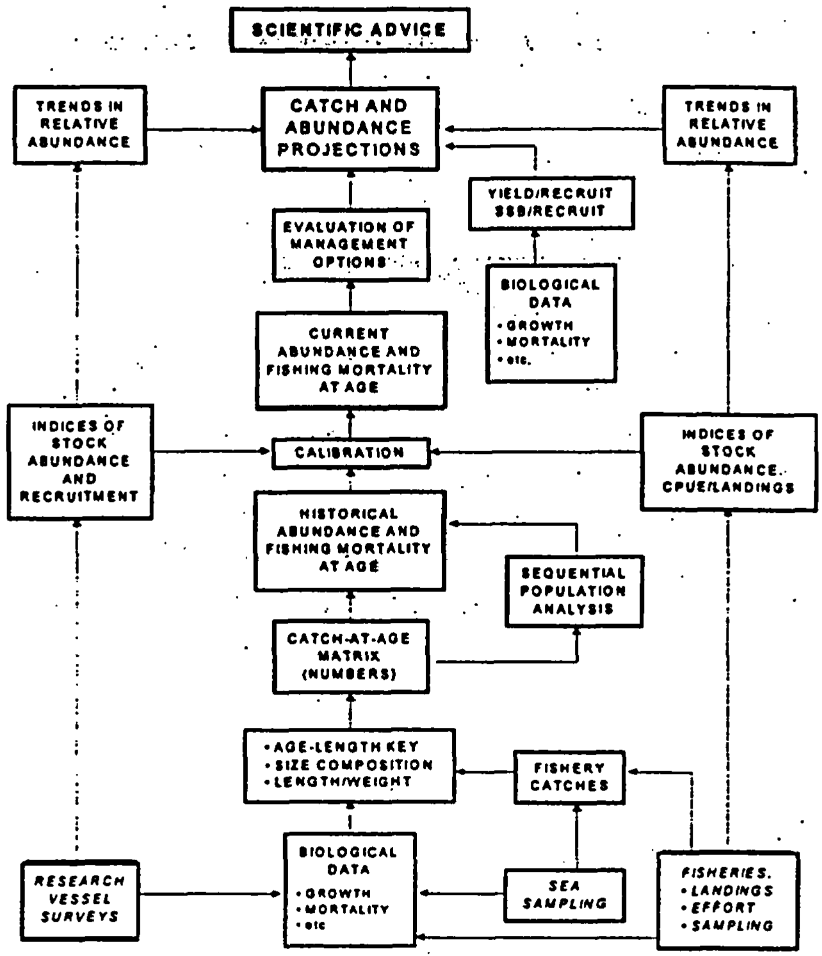


Figure 3. Diagram of alternative pathways by which fishery-dependent and fishery-independent data are used to provide assessment advice.

Increasing the level of complexity of an assessment requires a substantial additional commitment of resources to develop and maintain it at its more complex level. Conversely, the level and information content of an assessment can decrease relatively quickly if sufficient resources are not allocated to it.

The assessments in this report consider each species as a separate entity, with no consideration of species interactions. However, there are significant biological (predator/prey) as well as technological (bycatch) interactions for northeastern U.S. fishery resources, and a large part of the Center's research program is dedicated to modeling the effects of these interactions. The results of these studies are not presented here. The significance of the mixed-species nature of the northeast trawl fisheries is illustrated in the section entitled Aggregate Resources Trends. There, aggregate research trawl survey and commercial trawl data are presented illustrating major trends in abundance and catches. The approaches used, however, are illustrative of overall trends and do not address species interactions and other complexities of multispecies fishery resources.

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 and the Mid-Atlantic Fishery Management Councils. Fisheries occurring primarily in state waters are managed by the individual states or through Interstate Agreements made under the auspices of the Atlantic States Marine Fisheries Commission (ASMFC). Current management plans are listed in Table 1.

PATHWAYS OF ASSESSMENT ADVICE

Stock assessments and related analyses and documentation are sometimes provided directly to the Councils through Scientific and Statistical Committee meetings or to ASMFC via section meetings. Increasingly, however, managers are depending upon the Northeast Regional Stock Assessment Workshop (SAW) process for assessment advice.

The SAW originated in 1985 as a vehicle for in-house or local peer review of stock assessments and related research. As the condition of fishery resources in the Northeast de-

Table 1. Federal, joint and interstate fishery management plans currently in place or under development for species-stocks mentioned in this report.

Plan	Jurisdiction	Organization Responsible	Year Implemented	Last Amendment	Amendment Number
1. Northeast Multispecies	Federal	NEFMC	1986	1997	8[1]
2. Atlantic Sea Scallop	Federal	NEFMC	1982	1997	6[1]
3. American Lobster	Interstate	ASMFC	1979	1997	3
	Federal	NEFMC	1983	1997	6[1]
4. Atlantic Surfclam and Ocean Quahog	Federal	MAFMC	1977	1996	10[1]
5. Atlantic Mackerel, Squid, and Butterfish	Federal	MAFMC	1978	1996	6[1]
6. Summer Flounder, Scup, and Black Sea Bass	Joint	MAFMC/ASMFC	1988	1997	10[1]
7. Bluefish	Joint	MAFMC/ASMFC	1989		
8. Atlantic Herring	Federal	US Dept of Commerce	1995		
	Interstate	ASMFC	1993		
	Federal	NEFMC		Under Development	
9. Northern Shrimp	Interstate	ASMFC	1986		
10. Striped Bass	Interstate	ASMFC	1981	1995	5
11. Tilefish	Federal	MAFMC		Under Development	
12. Atlantic Salmon	Federal	NEFMC	1987		
13. Winter Flounder	Interstate	ASMFC	1989	1992	1
14. Dogfish	Federal	MAFMC/NEFMC		Under Development	
15. Atlantic Sturgeon	Interstate	ASMFC	1990		
16. Shad and River Herring	Interstate	ASMFC	1985		
17. Goosefish	Federal	NEFMC/MAFMC		Under Development	

[1] New Amendment in process

teriorated and pressure for assessment and management advice intensified, the SAW evolved into an intensive biannual review process involving four components: a Steering Committee to oversee the process and determine priorities; working groups responsible for completion of stock assessments and working papers; a Stock Assessment Review Committee (SARC) that reviews assessments and prepares management advice; and a Public Review Workshop that presents SARC reports and advice at fishery management council meetings. SARC membership is structured to include experts from the NEFSC and other NMFS Centers, the Councils and ASMFC, state agencies and academic institutions, and Canada; and all SAW-related meetings and workshops are open to participation by industry representatives and other interested parties. The SAW has been very effective in generating high quality assessment advice while enhancing the credibility of this advice through intensive peer review and participation by fisheries scientists, industry and the general public.

DEFINITION OF TECHNICAL TERMS

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

Assessment level: Categories of the level of complexity of each assessment included in this document are as given above (INDEX, SURPLUS-PRODUCTION, YIELD PER RECRUIT, and AGE/SIZE STRUCTURED). The latter may include projections of future catch and stock sizes or modeling of relationships between recruitment and spawning stock size.

Biological reference points: Benchmarks such as fishing mortality rates that may provide acceptable protection against growth overfishing and/or recruitment overfishing for a particular stock. They are usually calculated from yield-per-recruit curves, spawning stock biomass-per-recruit curves and stock-recruitment data. Examples are $F_{0.1}$, F_{max} and $F_{20\%}$.

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

Exploitation rate: The proportion of a population at the beginning of a given time period that is caught during that time period (usually expressed on a yearly basis). For example, if 720,000 fish were caught during the year from a population of 1 million fish alive at the beginning of the year, the annual exploitation rate (or annual fishing mortality rate) would be 0.72. Note that this rate cannot exceed unity; obviously, more fish cannot die than were originally present.

Fishing mortality rate (F): That part of the total mortality rate applying to a fish population that is caused by fishing. Fishing mortality is usually expressed as an instantaneous rate, as discussed under **Mortality rates**, and can range to values exceeding unity, such as 2.0 or higher.

F_{max}: The fishing mortality rate that results in the maximum level of yield-per-recruit. This is the point that defines growth overfishing.

F_{med}: The fishing mortality rate at which recruitment balances removals over time, as estimated from stock-recruitment data.

$F_{0.1}$: 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).

$F_{20\%}$: The fishing mortality rate at which spawning per recruit (usually using spawning biomass per recruit as a proxy) is reduced to 20% of the unfished level. Other levels may be used depending on biological characteristics of the target species and/or management objectives.

Growth overfishing: The rate of fishing, as indicated by a yield-per-recruit curve, greater than that at which the loss in weight from total mortality equals 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, such as maximum yield from surplus production models or average observed catches over a period of years.

Maturation: Reported in this document wherever possible as median length or age at maturity (L_{50} or A_{50}) as determined from length and age-specific maturation ogives.

Mortality rates: The rates at which fish die from fishing and/or natural causes. Mortality rates can be described in several ways.

One conceptually simple approach is to express mortality on an annual basis, *i.e.*, A, the annual mortality rate, expressed as a proportion (5% or 0.05 per year). This is the fraction of the population alive at the beginning of the year which dies during the year. The survivors may be represented by (1-A) = S, the annual survival rate.

In exploited populations, however, it is important to account for both fishing and natural mortality. This can pose complex problems for three reasons: we generally have little information on natural mortality; population changes tend to be exponential; and also, different components tend to be multiplicative, that is, in any given period of time, individuals that die from natural causes would otherwise be killed by fishing and vice versa.

For these reasons, biologists tend to work with <u>instantaneous</u> rates, in which time intervals are sufficiently short so as to allow separation of the primary components as instantaneous fishing mortality (F) and instantaneous natural mortality (M). Together the two are equivalent to instantaneous total mortality (Z), *i.e.* Z = F+M.

The necessary mathematics are based on a logarithmic scale which relates well to biological processes (since they tend to be exponential); and effects which are multiplicative in nature become additive on a logarithmic scale.

The concept of instantaneous rates can be illustrated by a simple example. Imagine a year of a fish's life to be divided into a large number (n) of equal time intervals, and Z/n is the number dying within that interval. If n = 1,000 and Z = 1.0, then during the first time interval 1/1000 = 0.1% of the population dies. For a population of 1,000,000 fish, 1000 would die, leaving 999,000 survivors. In the next time interval 0.1% of 999,000 fish, or 999 fish die, leaving 998,001 survivors, and so on. Repeated 1,000 times, we would have:

$$1{,}000{,}000\,(1-0.0010)^{1000}$$

$$= 367{,}695 \text{ survivors}$$

Or, we may use the relation:

$$S = e^{-Z} = 0.3679\,(1{,}000{,}000)$$

$$= 367{,}879 \text{ survivors}$$

where e is the base of natural logarithms (2.71828).

The calculation provides the same approximate result. Note that the annual mortality rate A = 1 - S, hence, 1-0.3679 or 0.6321 or 63% in our example. Again, A can never exceed unity, although F and Z can, for heavily exploited stocks.

Using instantanous rates to deal with different sources of mortality over time can be illustrated as follows. Assume a population at the beginning of a year consists of 1,000 fish, and that during the year it is subjected to an instantaneous fishing mortality rate of F=0.5, while instantaneous natural mortality (M) = 0.2. The instantaneous total mortality rate (Z) is equal to (F+M) = 0.7. Removals by fishing are calculated by applying the annual exploitation rate:

$$\frac{F}{Z}(1-e^{-Z}) = \frac{0.5}{0.7}(1-e^{-0.7})$$

$$= 0.3596$$

During the year, 0.3596(1000) = 360 fish are caught, and:

$$S = e^{-0.7}$$

$$= 0.4966(1000)$$

$$= 497 \text{ fish survive}$$

The difference from the original number of 1,000 fish (1,000-360-497), or 143 fish, is the number dying from natural causes. The additive property of instantaneous rates allows us to obtain approximately the same result for natural mortality, *i.e.*,

$$\frac{M}{Z}(1-e^{-Z}) = \frac{0.2}{0.7}(1-e^{-0.7})$$

$$= 0.1438,$$

or, 144 fish

In the absence of fishing this number would be:

$$A = (1-e^{-0.2})\,1000$$

$$= 0.1813(1000)$$

$$= 181 \text{ fish}$$

with 819 fish surviving to the beginning of the following year. If the process is continued for another year, the catch in the exploited population would be 179 fish, 71 fish would die from natural causes, and 247 fish would survive, while in the unfished population 149 fish would die, leaving 670 survivors. Continued for 10 years the exploited population would be essentially eliminated (1 surviving fish) whereas 14% of the unfished population (135 fish) would survive.

This example uses an annual exploitation rate (36%) for the exploited population that is somewhat high but was sustained historically by some Northeast stocks. For some heavily fished stocks (scallops, yellowtail flounder) exploitation rates have in some years exceeded 80 percent. The corresponding instantaneous fishing and total mortality rates were F > 2.0 and Z > 2.2. The number of yellowtail alive after 5 years from a year class of 1,000,000 fish would be

$$1{,}000{,}000\,[e^{-2.2\times 5}] = 17 \text{ fish!}$$

Natural mortality rate (M): That part of a fish population's total mortality caused by factors other than fishing, usually expressed as an instantaneous rate. Commonly, all sources of M are considered together since they usually account for much less than fishing mortality.

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

Overfishing definition: Objective and measurable guideline(s) for a given stock defining the point at which the stock reaches an overfished condition; required for each fishery management plan under National Standard 1 guidelines (50 CFR Part 600) for the Magnuson-Stevens Fishery Conservation and Management Act. This may be expressed in terms of a minimum level of spawning biomass; maximum level of fishing mortality, or some other measureable standard designed to ensure maintenance of the stock's productive capacity.

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

Recruitment: The amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area. The number of fish that grow to become vulnerable to the fishing gear in a given year would be the recruitment to the fishable population in that year. The term is also used in referring to the number of fish reaching a certain age or size.

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

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

Spawning stock biomass-per-recruit (SSB/R): The expected lifetime contribution to the spawning stock biomass for a recruit of a specific age (*e.g.*, per age 2 individual). For a given exploitation pattern, rate of growth, and natural mortality, an expected equilibrium value of SSB/R can be calculated for each level of F. A useful reference point is the level of SSB/R that would be realized if there were no fishing. This is a maximum value for SSB/R, and can be compared to levels of SSB/R generated under different rates of fishing. For example, the maximum SSB/R for Georges Bank haddock is approximately 9 kg for a recruit at age 1.

Status of exploitation: In this report, the terms underexploited, fully exploited, and overexploited. These describe the effects of current fishing effort on each stock, and are based on the best judgement of the assessment scientist responsible.

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

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

Vessel class: Commercial fishing vessels are classified according to their gross registered tons (grt) of displacement. Vessels displacing less than 5 tons were not routinely monitored prior to the new mandatory reporting system implemented in the Northeast in 1994, and were referred to as undertonnage. The current classification scheme is as follows:

Vessel Class	GRT
1	<5
2	5 - 50
3	51 - 150
4	151+

Virtual population analysis (or cohort analysis): An analysis of the catches from a given year class over its life in the fishery. If 10 fish from the 1968 year class were caught each year for 10 successive years from 1970 to 1979 (age 2 to age 11), then 100 fish would have been caught from the 1968 year class during its life in the fishery. Since 10 fish were caught during 1979, then 10 fish must have been alive at the beginning of that year. At the beginning of 1978, there must have been at least 20 fish alive because 10 were caught in 1978 and 10 more were caught in 1979. Working backward by year, one can be virtually certain that at least 100 fish were alive at the beginning of 1970.

A virtual population analysis goes a step further and calculates the number of fish that must have been alive if some fish also died from causes other than fishing. For example, if in addition to the 10 fish caught per year in the fishery, the instantaneous natural mortality rate was also known, then a virtual population analysis calculates the number that must have been alive each year to produce a catch of 10 fish each year plus those that died from natural causes.

If one knows the fishing mortality rate during the last year for which catch data are available (in this case, 1979), then the exact abundance of the year class can be determined in each and every year. Even when an approximate fishing mortality rate is used in the last year (1979), a precise estimate of the abundance can usually be determined for the stock in years prior to the most recent one or two (*e.g.*, for 1970-1976 or 1977 in the example).

Accuracy depends on the rate of population decline and the correctness of the starting value of the fishing mortality rate (in the most recent year). This technique is used extensively in fishery assessments, since the conditions for its use are so common: many fisheries are heavily exploited, annual catches for a year class can generally be determined, natural mortality rate is known within a fairly small range and is low compared with the fishing mortality rate.

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

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

For further information

Gabriel, W.L., M.P. Sissenwine, and W.J. Overholtz. 1989. Analysis of spawning stock biomass per recruit: an example for Georges Bank haddock. N. Am. J. Fish. Mgmt. 9: 383-391.

Gulland, J.A. 1983. Fish stock assessment, a manual of basic methods. John Wiley & Sons, Inc., New York. 223 p.

Gulland, J.A., ed. 1988. Fish population dynamics. John Wiley & Sons, Inc., New York. 422 p.

Hillborn, R. and C.J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics & uncertainty. Chapman and Hall, London, 570 p.

O'Brien, L., J. Burnett, and R.K. Mayo. 1993. Maturation of 19 species of finfish off the northeast coast of the United States, 1985-1990. NOAA [National Oceanic and Atmospheric Administration] Tech. Rept. NMFS 113, 66 p.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Canada 191, 382 p.

Rosenberg, A., convener. 1994. Scientific review of definitions of overfishing in U.S. fishery management plans. NOAA [National Oceanic and Atmospheric Administration] Tech. Memo. NMFS-F/SPO-17, 205 p.

Fishery Landings Trends

Commercial and recreational fishing off the northeastern U.S. coast provides a significant portion of total U.S. landings. Total U.S. commercial landings in 1996 were estimated at more than 4.3 million metric tons (mt), of which approximately 17 percent came from the Northeast. U.S. recreational landings were estimated to exceed 94,000 mt (excluding Alaska, Hawaii, and Pacific Coast salmon). Aggregate statistics for U.S. fisheries are detailed in *Fisheries of the United States. 1996.*

Prior to 1994, fishery statistics were collected in the Northeast under a voluntary reporting system. Landings and price data were collected by NMFS port agents and state personnel at the point of first sale through dealer reports or "weighout receipts". This information was complemented by interviews of vessel captains by NMFS port agents at dockside, to collect detailed data on fishing effort, gear used and areas fished; and a monthly canvas to collect landings data at secondary ports. In June of 1994, voluntary reporting was replaced by a mandatory reporting system in which dealer reports were retained, and dockside interviews were replaced by a logbook reporting system. This system is now used in all fisheries subject to federal fishery management plans or FMPs (except the American lobster and Atlantic herring fisheries). Further, many vessels that fish for lobster and herring are permitted under one or more of the remaining federal FMPs, and are therefore subject to mandatory reporting. Recreational fishermen are surveyed both in the field as they complete fishing trips and through telephone calls to households. These independent components, along with census data, produce estimates of recreational catch, effort, and participation.

Table 2 provides commercial (domestic and foreign) and recreational landings data for 36 of the 39 species, or species groups, reviewed in this document (Atlantic salmon and sturgeons excluded). "Foreign" landings include Canadian and distant-water fleet catches outside of the U.S. EEZ for transboundary stocks fished by the U.S., such as Canadian landings of groundfish and scallops from eastern Georges Bank, and Atlantic mackerel from off Nova Scotia and Newfoundland. They also include catches made by U.S. vessels during internal waters processing (IWP) operations in state waters, which are transferred to foreign vessels and later landed in foreign ports. It is logical to group these species into several assemblages: principal groundfish, flounders, other groundfish, principal pelagics, other pelagics, anadromous fish, and invertebrates.

For these assemblages, landings totalled 485,600 mt in 1996, an increase of 61,900 mt (15%) from 1995 (Table 2). Of these landings, 13% were from foreign, 81% from domestic commercial, and 6% from domestic recreational fishing. The 1996 increase was primarily due to a substantial rise in U.S. commercial landings of Atlantic herring and to a lesser extent, Atlantic mackerel. Preliminary figures for 1997 indicate a total of 466,200 mt (17% foreign, 78% domestic commercial, and 5% domestic recreational). The 1994-1995 average was 433,000 mt.

Principal groundfish (Atlantic cod, haddock, redfish, silver hake, red hake, and pollock) and flounders (yellowtail, summer flounder, American plaice, witch and winter flounder, and windowpane) have together accounted for less than 20% of the total landings by weight since 1994 (16% in 1996). Principal pelagics (Atlantic herring and Atlantic mackerel) and invertebrates (squids, American lobster, northern shrimp, surfclams, ocean quahogs, and sea scallops) accounted for 30% and 31%, respectively, of the 1994-1997 total (32% and 29% in 1996). Other groundfish (goosefish, scup, black sea bass, ocean pout, white hake, cusk, Atlantic wolffish, tilefish, spiny dogfish, and skates) accounted for 16% of the 1994-1997 total (17% for 1996). See Table 2.

Total foreign landings of species and stocks within these assemblages have fluctuated in recent years without a clear trend. U.S. commercial landings have increased somewhat, primarily due to increased landings of principal pelagics, which have offset declines for principal groundfish and invertebrates (Table 2).

For more Information

NMFS [National Marine Fisheries Service]. 1997. Fisheries of the United States, 1996. *Current Fishery Statistics* No. 9600. USDOC/NOAA/NMFS, Silver Spring, MD.

Table 2. Total landings of selected assessment species groups off the northeastern United States; from domestic and foreign commercial fishing, and from recreational fishing, 1994 and 1995 (1,000 mt)

Species	Commercial Foreign		Commercial U.S.		Recreational		Total	
	1994	1995	1994	1995	1994	1995	1994	1995
Principal Groundfish								
Atlantic cod	5.3	1.1	17.8	13.7	4.1	3.9	27.2	18.7
Haddock	2.4	2.1	0.3	0.4	<0.1	<0.1	2.7	2.5
Redfish	<0.1	<0.1	0.4	0.4	0.0	0.0	0.4	0.4
Silver hake	0.0	0.0	16.1	14.7	<0.1	<0.1	16.1	14.7
Red hake	0.0	0.0	1.7	1.6	<0.1	<0.1	1.7	1.6
Pollock	15.2	9.9	3.8	3.4	0.2	0.3	19.2	13.6
Subtotal	22.9	13.1	40.1	34.2	4.3	4.2	67.3	51.5
Flounders								
Yellowtail flounder	2.1	0.5	3.1	1.9	0.0	0.0	5.2	2.4
Summer flounder	0.0	0.0	6.6	7.0	4.1	2.5	10.7	9.5
American plaice	<0.1	0.0	5.1	4.7	0.0	0.0	5.1	4.7
Witch flounder	<0.1	<0.1	2.7	2.2	0.0	0.0	2.7	2.2
Winter flounder	<0.1	<0.1	3.6	4.0	0.6	0.7	4.2	4.7
Windowpane	0.0	0.0	0.5	0.8	0.0	0.0	0.5	0.8
Subtotal	2.1	0.5	21.6	20.6	4.7	3.2	28.4	24.3
Other Groundfish								
Goosefish	0.5	0.4	22.9	26.4	<0.1	<0.1	23.4	26.8
Scup	0.0	0.0	4.1	2.9	1.2	0.6	5.3	3.5
Black sea bass	0.0	0.0	0.9	0.9	1.4	2.6	2.3	3.5
Ocean pout	0.0	0.0	0.2	0.1	0.0	0.0	0.2	0.1
White hake	1.0	0.5	4.8	4.3	<0.1	<0.1	5.8	4.8
Cusk	0.2	0.2	1.1	0.8	<0.1	<0.1	1.3	1.0
Atlantic wolffish	<0.1	<0.1	0.5	0.5	<0.1	<0.1	0.5	0.5
Tilefish	0.0	0.0	0.8	0.7	<0.1	<0.1	0.8	0.7
Spiny dogfish	1.8	1.0	18.8	22.7	1.1	0.7	21.7	24.4
Skates	0.0	0.0	8.8	7.2	0.0	0.0	8.8	7.2
Subtotal	3.5	2.1	62.9	66.5	3.7	3.9	70.1	72.5
Principal Pelagics								
Atlantic herring	22.2	18.2	54.3	76.1	0.0	0.0	76.6	94.4
Atlantic mackerel	20.7	17.7	10.1	8.5	1.1	1.2	31.9	27.4
Subtotal	42.9	35.9	64.4	84.6	1.1	1.2	108.5	121.8
Other Pelagics								
Atlantic butterfish	0.0	0.0	3.6	2.0	0.0	0.0	3.6	2.0
Bluefish	0.0	0.0	4.3	3.6	7.9	7.2	12.2	10.8
Subtotal	0.0	0.0	7.9	5.6	7.9	7.2	15.8	12.8
Anadromous Fish								
River herring	<0.1	<0.1	0.4	0.6	0.0	0.0	0.4	0.6
American shad	0.0	0.0	0.6	0.6	0.0	0.0	0.6	0.6
Striped bass	0.0	0.0	0.8	1.6	3.3	5.5	4.1	7.1
Subtotal	<0.1	<0.1	1.8	2.8	3.3	5.5	5.1	8.3
Invertebrates								
Shortfin squid	6.0	1.0	18.3	14.1	0.0	0.0	24.3	15.1
Longfin inshore squid	0.0	0.0	22.5	18.0	0.0	0.0	22.5	18.0
American lobster	0.2	0.1	31.7	31.7	0.0	0.0	31.9	31.9
Northern shrimp	0.0	0.0	3.7	6.8	0.0	0.0	3.7	6.8
Atlantic surfclam	0.0	0.0	31.1	28.7	0.0	0.0	31.1	28.7
Ocean quahog	0.0	0.0	21.1	22.2	0.0	0.0	21.1	22.2
Sea scallop	5.0	2.0	7.5	7.7	0.0	0.0	12.5	9.8
Subtotal	11.2	3.1	135.9	129.2	0.0	0.0	147.1	132.5
Total	82.6	54.7	334.6	343.5	25.0	25.2	442.3	423.7

Table 2 (cont'd). Total landings of selected assessment species groups off the northeastern United States, from domestic and foreign commercial fishing, and from recreational fishing, 1996 and 1997 (1,000 mt)

Species	Commercial				Recreational		Total	
	Foreign		U.S.					
	1996	1997	1996	1997	1996	1997	1996	1997
Principal Groundfish								
Atlantic cod	1.9	2.9	14.3	13.0	2.9	1.0	19.1	16.9
Haddock	3.7	2.7	0.6	1.5	<0.1	<0.1	4.3	4.2
Redfish	<0.1	<0.1	0.3	0.3	0.0	0.0	0.3	0.3
Silver hake	0.0	0.0	16.2	15.5	<0.1	<0.1	16.2	15.5
Red hake	0.0	0.0	1.1	1.3	<0.1	0.2	1.1	1.5
Pollock	9.3	11.9	3.0	4.3	0.0	0.2	12.3	16.4
Subtotal	14.9	17.5	35.5	35.9	2.9	1.4	53.3	54.8
Flounders								
Yellowtail flounder	0.5	0.8	2.3	2.9	0.0	0.0	2.8	3.7
Summer flounder	0.0	0.0	5.8	4.1	4.7	5.0	10.5	9.1
American plaice	<0.1	<0.1	4.4	3.9	0.0	0.0	4.4	3.9
Witch flounder	<0.1	<0.1	2.1	1.8	0.0	0.0	2.1	1.8
Winter flounder	<0.1	0.1	4.8	5.3	0.7	0.6	5.5	6.0
Windowpane	0.0	0.0	1.0	0.5	0.0	0.0	1.0	0.5
Subtotal	0.5	0.9	20.4	18.5	5.4	5.6	26.3	25.0
Other Groundfish								
Goosefish	0.2	0.2	26.6	28.2	<0.1	<0.1	26.8	28.4
Scup	0.0	0.0	2.5	2.2	1.0	0.5	3.5	2.7
Black sea bass	0.0	0.0	1.5	1.1	2.6	1.5	4.1	2.6
Ocean pout	0.0	0.0	0.1	<0.1	0.0	0.0	0.1	<0.1
White hake	0.4	0.3	3.3	2.2	<0.1	<0.1	3.7	2.5
Cusk	0.2	0.1	0.5	0.4	<0.1	<0.1	0.7	0.5
Atlantic wolffish	<0.1	<0.1	0.4	0.3	<0.1	<0.1	0.4	0.3
Tilefish	0.0	0.0	1.1	1.8	<0.1	<0.1	1.1	1.8
Spiny dogfish	0.4	0.2	27.2	18.1	0.4	0.8	28.1	19.1
Skates	0.0	0.0	14.2	10.4	0.0	0.0	14.2	10.4
Subtotal	1.2	0.8	77.4	64.7	4.0	2.8	82.7	68.3
Principal Pelagics								
Atlantic herring	15.9	20.7	103.7	98.2	0.0	0.0	119.6	118.9
Atlantic mackerel	20.4	18.5	15.8	15.4	1.3	1.6	37.6	35.5
Subtotal	36.3	39.2	119.5	113.6	1.3	1.6	157.2	154.4
Other Pelagics								
Atlantic butterfish	0.0	0.0	3.6	2.8	0.0	0.0	3.6	2.8
Bluefish	0.0	0.0	3.9	4.0	7.4	7.6	11.3	11.6
Subtotal	0.0	0.0	7.5	6.8	7.4	7.6	14.9	14.4
Anadromous Fish								
River herring	<0.1	<0.1	0.4	0.4	0.0	0.0	0.4	0.4
American shad	0.0	0.0	0.6	0.5	0.0	0.0	0.6	0.5
Striped bass	0.0	0.0	2.2	2.2	6.7	6.7	8.9	8.9
Subtotal	<0.1	<0.1	3.2	3.1	6.7	6.7	9.9	9.8
Invertebrates								
Shortfin squid	8.7	15.4	17.0	13.6	0.0	0.0	25.7	29.0
Longfin inshore squid	0.0	0.0	12.5	16.2	0.0	0.0	12.5	16.2
American lobster	0.1	0.2	32.4	32.1	0.0	0.0	32.6	32.3
Northern shrimp	0.0	0.0	9.5	6.4	0.0	0.0	9.5	6.4
Atlantic surfclam	0.0	0.0	28.8	25.6	0.0	0.0	28.8	25.6
Ocean quahog	0.0	0.0	21.6	19.8	0.0	0.0	21.6	19.8
Sea scallop	3.0	4.2	7.6	6.0	0.0	0.0	10.6	10.2
Subtotal	11.8	19.8	129.4	119.7	0.0	0.0	141.3	139.5
Total	64.7	78.2	392.9	362.3	27.7	25.7	485.6	466.2

Aggregate Resource Trends

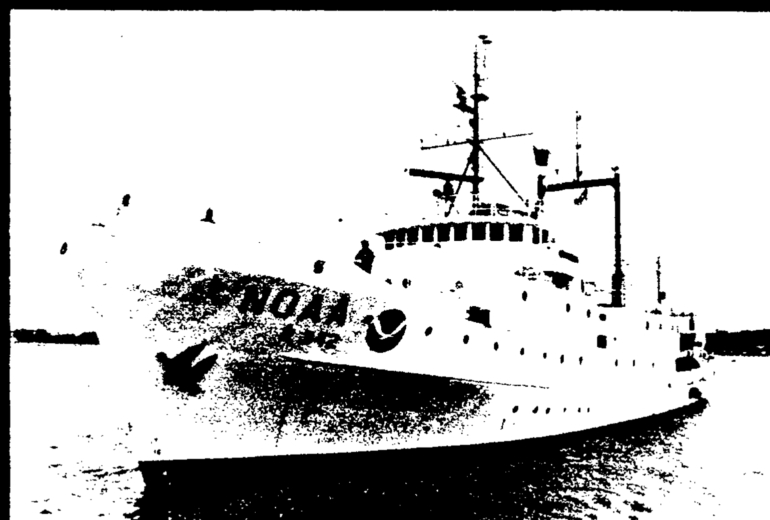
S. Murawski
F. Almeida

The fishery resources off the northeastern United States are harvested by a variety of fishing gears, including trawls, gillnets, handlines, traps, longlines, and dredges. While each type of gear takes a different mixture of species, few fishers target one species exclusively. The degree of mixture in the catches varies among the types of gear used in different areas. In addition, there are predatory and competitive relationships 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 in part due to these types of interactions. This complexity is reflected, for example, in the structure of some of the fishery management plans (FMPs). The groundfish resources off New England are managed under the Northeast Multispecies FMP (of the New England Fishery Management Council or FMC), while several pelagic stocks are managed under the Atlantic Mackerel, Squid, and Butterfish FMP of the Mid-Atlantic FMC.

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

Two sources of data are available for measuring trends in aggregate resource abundance: (1) research vessel survey data (termed "fishery-in-



R/V *Albatross IV* NOAA Fisheries NEFSC Photo by Brenda Figuerido

Sampling for age & growth studies during resource survey cruise NOAA Fisheries NEFSC Photo by Brenda Figuerido dependent data"), and (2) commercial catch and effort data (termed "fishery-dependent" data). While neither data source completely reflects the changes in all fishery resources, both provide useful information in interpreting recent changes in fishery resources and fishing activity.

FISHERY- INDEPENDENT DATA

The Northeast Fisheries Science Center (NEFSC) has conducted an intensive bottom trawl survey program off the northeastern United States for 35 years. An autumn survey has been conducted annually since 1963; a spring survey was initiated in 1968, and a winter survey (primarily providing information on flatfishes and other demersal resources of the Mid-Atlantic to Georges Bank region) began in 1992. The NEFSC surveys employ standard gear and sampling procedures following a stratified random sampling design and thus provide a valuable time series of data for monitoring resource trends. Several states also conduct fishery-independent monitoring programs using bottom trawl surveys to document the status of species distributed near shore (*e.g.* Massachusetts, Rhode Island, Connecticut, Delaware, Maryland and Virginia). 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 here:

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

2. **Other finfish**, including a variety of demersal and pelagic species, such as goosefish, black sea bass, white hake, and butterfish, that collectively are of considerable economic importance.

3. **Principal pelagics**, including Atlantic herring and Atlantic mackerel.

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

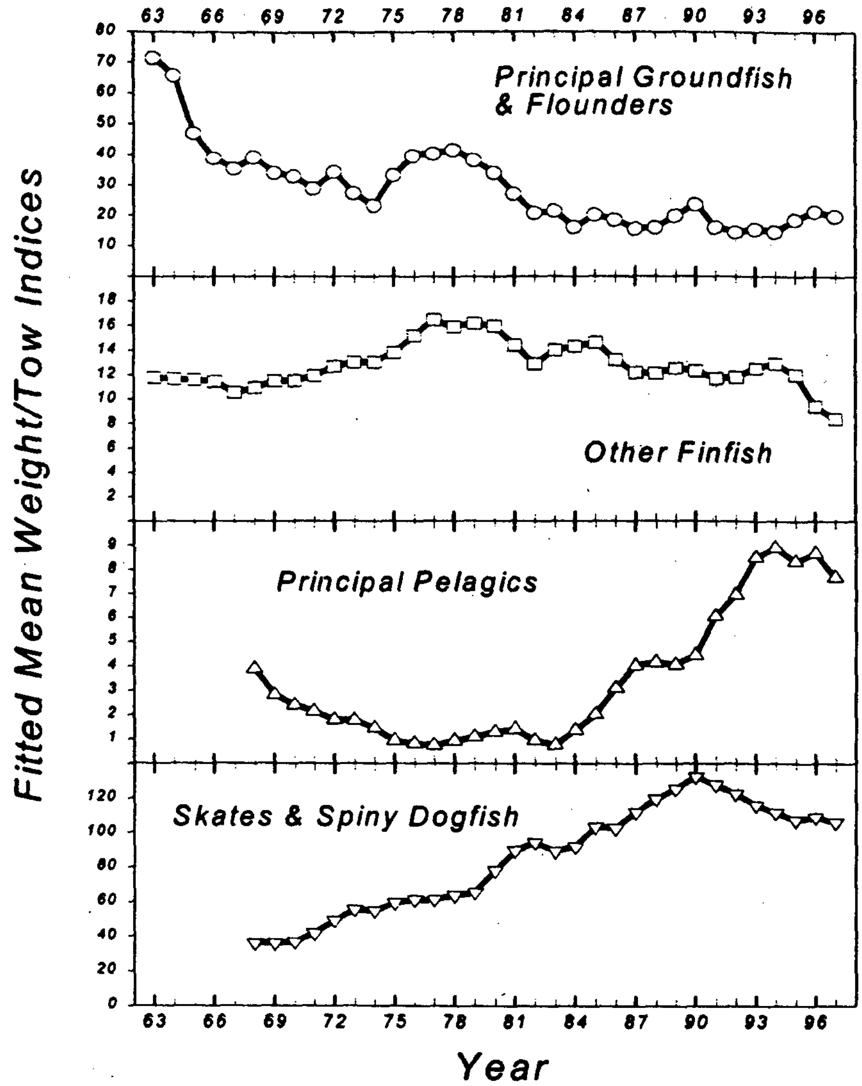


Figure 4. Trends in indices of aggregate abundance (catch per standard tow, kg) for four species groups, reflecting major resource trends, 1963-1997 (species groups given in text).

For each of these groups, an aggregate index of abundance has been developed to monitor resource trends (Figure 4). 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, an aggregate index of abundance has been computed as the sum of the individual species stratified mean catch-per-tow values, smoothed to compensate for between-year variability. No adjustments have been made for differences in vulnerability to the trawl gear by species; and thus the overall index in each case reflects trends in abundance of those species within each group that are most vulnerable. However, vulnerability to the gear is not thought to change markedly over time. The aggregate indices therefore appear to provide useful general measures of overall resource trends, although they are weighted toward certain species.

Principal Groundfish and Flounders

This group includes important gadid species (Atlantic cod, haddock, redfish, silver and red hake, and pollock) and several flatfish (yellowtail flounder, summer and winter flounder, American plaice, witch flounder and windowpane flounder). 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, silver and red hake, and most of the flatfish stocks. By 1974, indices of abundance for many of these species had dropped to the lowest levels observed at that time in the history of the survey time series.

Partial resource recovery occurred during the mid-to-late 1970s. This has been attributed to reduced fishing effort associated with increasingly restrictive management under the International Commission for the Northwest Atlantic Fisheries (ICNAF) during the early 1970s, and to implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977. Cod and haddock abundance increased markedly, stock biomass of pollock increased more or less continuously, and recruitment and abundance of several of the flatfish stocks also increased. The aggregate index peaked in 1978. Subsequently, the combined index again declined; the 1987 and 1988 values were among the lowest in the time series to that point. During 1989-1990, the aggregate index increased due to improved recruitment (primarily for cod, redfish, silver and red hake, and American plaice). The index dropped sharply in 1991 and remained at record-low levels during 1992-1994. Subsequent indices have been moderately higher primarily due to increased abundance of redfish and modest improvements in biomass of groundfish stocks on Georges Bank. However, the most recent indices are still well below the levels seen in the 1960s and late 1970s, when groundfish and flatfish populations were relatively high.

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 is significant.

The aggregate index for this group was relatively stable from 1963 to 1970 and then increased to peak levels during 1977 to 1980, reflecting unusually high survey catches of Atlantic croaker and spot and strong recruitment of butterfish from the 1979 and 1980 year classes. Survey catches of a number of other finfish species were anomalously low in 1982 for unknown reasons. Strong 1983 and 1984 butterfish year classes contributed to a peak in 1985. The index decreased in 1986 and 1987 and stabilized during 1988-1995. Since then, the index has sharply declined to record-low levels due to declining abundance of white hake, black sea bass and ocean pout. Overall, the index for this species group has declined by half since 1977, reflecting increased exploitation of the species in this group as traditional fishery resource species have declined.

Principal Pelagics

Abundance of Atlantic herring and Atlantic mackerel has been monitored using spring survey data, since both species occur primarily within the boundaries of the survey area in March and April, when this survey is conducted. In general, survey catch-per-tow data for these species have been more variable than those for principal groundfish and flounders, although the aggregate index adequately depicts overall trends. The index dropped to minimal levels in the mid-1970s, reflecting pronounced declines in abundance of both herring and mackerel (including the collapse of the Georges Bank herring stock). Since 1983, the index has markedly increased with the 1994 value the highest in the time series (Figure 4). This trend is supported by virtual population analyses (VPA) which indicate high levels of abundance of both the coastwide herring stock and the northwest Atlantic mackerel stock in recent years. There is also evidence for recovery of the Georges Bank herring stock. The index of abundance for pelagic stocks has declined slightly since 1994.

Skates and Spiny Dogfish

The remaining aggregate index includes data for two important resource components, spiny dogfish and skates, which are monitored using spring survey data (Figure 4). Spiny dogfish and seven skate species are included in this index: little, winter, thorny, smooth, rosette, clearnose, and barndoor. The continued increase in this index from the late 1960s through 1990 reflects large increases in abundance of several species within this group. Since 1990, the index has markedly declined reflecting reductions in biomass due to harvesting of some skate species (primarily winter skate) and spiny dogfish.

FISHERY-DEPENDENT DATA

A considerable amount of information on the status of stocks is derived from data collected on the catches and performance of commer-

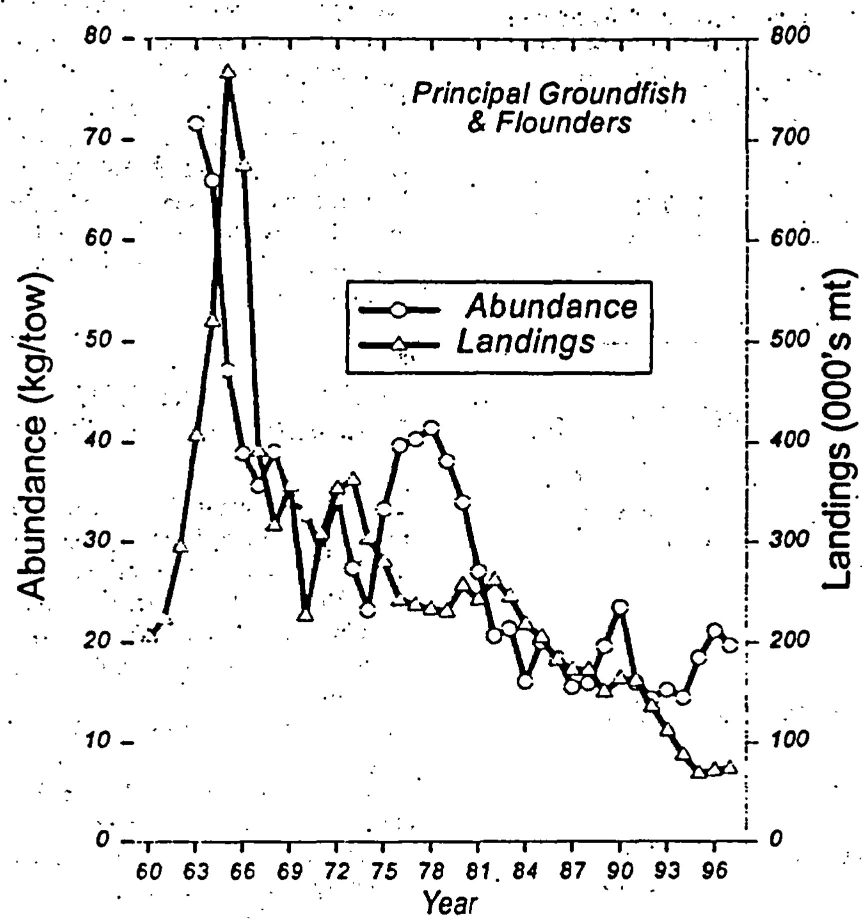


Figure 5. Trends in relative abundance and commercial landings of principal groundfish and flounders off the northeastern United States, 1963-1997. Landings include U.S. and foreign catches.

cial and recreational fisheries. Fishery-dependent data include landings (catches brought ashore), discards (catches culled at sea), fishing effort (*e.g.* number and duration of sets of gear; time spent fishing), and biological sampling of landings and discards. In general, landings trends alone are insufficient as indicators of trends in stock abundance since they are influenced by many factors including prices paid for fish, changes in fishing effort, and regulations (*e.g.* closed areas, trip limits, *etc.*).

Use of Landings Data

When trends in landings are evaluated in conjunction with a measure of stock abundance, some useful conclusions can be derived. The trend in landings of principal groundfish and flounders during 1960-1997 is plotted with the NEFSC autumn bottom trawl survey aggregate index of abundance for this species group in Figure 5. There is a general correspondence in these two data sets, with several important points of divergence. Landings increased greatly in response to high catches by foreign fleets beginning in 1963. The resource declined substantially in response to the effort buildup. Increasingly restrictive management resulted in a period of stock rebuilding and correspondingly lower landings during the mid-to-late 1970s. This rebuilding was short-lived, however, and landings and abundance again declined during the 1980s and early 1990s. Since 1992 the trends in abundance and landings have again diverged, and some stocks have begun to rebuild.

A simple index of exploitation can be derived by dividing the landings by the corresponding survey abundance index (Figure 6). This index is a crude measure of the exploitation rate since it does not account for discarded catch, and assumes that all landings are reported. Nevertheless, changes in the exploitation rate index show that fishing intensity on principal groundfish and flounders has declined during the 1990s to the lowest levels seen in the time series. Indices of exploitation for the other species groups show differing patterns over time, reflecting the transition from intensive fishing, primarily by foreign fleets in the late 1960s and 1970s to use by domestic fleets.

Fishery Abundance Indices

Overall effort in northeast offshore fisheries increased rapidly after the institution of the MFCMA. This pattern of effort increase was seen in all regions (Gulf of Maine, Georges Bank, Southern New England-Middle Atlantic), and gear types. Effort leveled off in the trawl sector in the mid-1980s, as catch rates fell and the profitability of many fisheries was insufficient to attract additional new vessel construction.

A measure of resource abundance can be derived directly from fishery-dependent data by dividing catch (or landings, if the discarded component can be assumed to be relatively small) by fishing effort used to obtain the catch. This so-called catch per unit of effort (or CPUE) provides indices of abundance and/or biomass which are useful when management restrictions do not significantly alter the relationship between effort and catch (*e.g.* by changing the spatial distribution of effort or restricting landings through trip limits or other measures). Such CPUE values from the New England otter trawl fisheries were used as indices of abundance for many New England groundfish stocks during the 1970s to early 1990s, because regulations did not generally limit the total quantity of landings or the amount of effort. Trends in trawl fishery CPUE

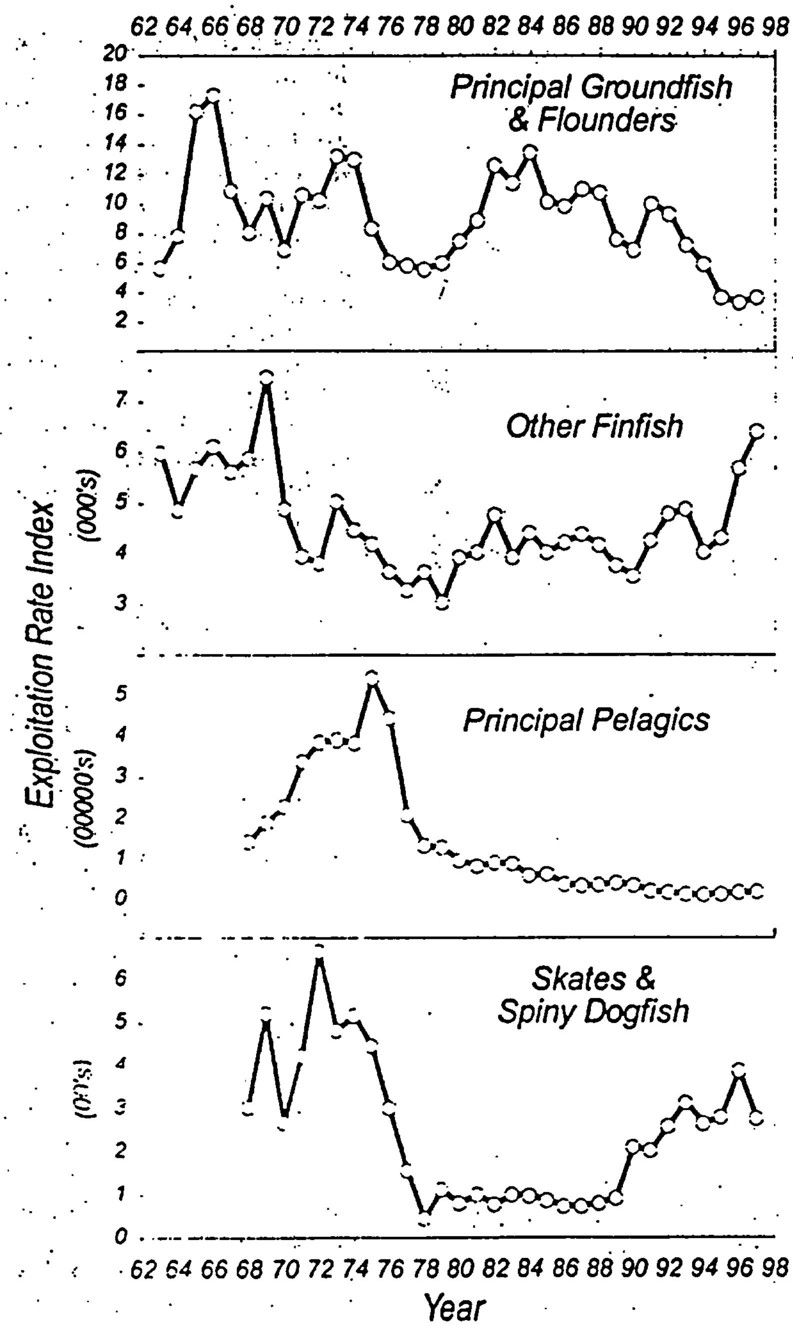


Figure 6. Indices of exploitation for aggregate species groups off the northeastern United States, 1963-1997. Each index is derived by dividing landings (in thousands of metric tons) by the relative abundance index (mean weight per standard tow in the NEFSC autumn bottom trawl surveys) for each species group.

(landings per standardized day fished by trawlers operating in the Gulf of Maine, Georges Bank and Southern New England region during this period) are similar to those from fishery independent measures of abundance (Figure 7). Both data sets detected the rebuilding of the resource in the late 1970s, followed by the decline in the 1980s, and temporary increase at the end of that decade. This CPUE index cannot easily be extended back in time, due to the difficulty in calibrating the effort of large foreign factory trawlers. Likewise, restrictions on effort and on areas fished, and changes in fishing reporting procedures render post-1994 data difficult to compare with 1976-1993 effort and CPUE. The amount of effort (days at sea) has declined significantly in both the groundfish and sea scallop directed fisheries as effort control has become the primary management measure in these fisheries. Given the reduced number of days, closed areas on Georges Bank, Southern New England and the Gulf of Maine, and changes in mesh size for groundfish and sea scallops, merging current CPUE with previous data is problematic.

CONCLUSIONS ABOUT RESOURCE ABUNDANCE

Both fishery-independent and fishery-dependent data suggest major changes in the abundance of resources in the Northwest Atlantic, especially since implementation of the MFCMA in 1977. Increases in abundance of groundfish and flounders associated with the reduction of foreign fishing during the mid-1970s were followed by increased domestic fishing effort and landings. Abundance of principal groundfish and flounders began declining after 1978, reached record low levels in the early 1990s, and has since improved slightly, although abundance and biomass for most stocks remain low. Abundance of other finfish slowly declined since 1977, with more rapid declines in recent years. Abundance of principal pelagics has sharply increased in recent years. Extensive changes in the species composition of the catches have also occurred over the past three decades, with shifts to previously less desirable species. During this same time, major increases in the abundance of historically nontargeted species such as spiny dogfish and skates, have occurred followed by the development of directed fisheries for these stocks.

Most of the changes in resource abundance can be directly attributed to changes in fishing mortality. For example, increases in abundance of groundfish and flounder occurred during 1975 to 1978 when fishing effort was being reduced by international and domestic management actions. Decreases in abundance began in the early 1980s when fishing effort from domestic fleets substantially increased. The record high levels of fishing effort in the late 1980s and early 1990s resulted in rapid reduction of new year classes before they were able to achieve full growth and reproduce.

One marked result of the reduced abundance of traditional groundfish stocks has been a change in the mix of species targeted in the trawl fisheries. The aggregate U.S. catch of cod, haddock and yellowtail flounder from 1976 to 1997 is plotted in the upper panel of Figure 8. There is an obvious declining trend in the total since 1983, and an increasing reliance on cod. The bottom panel gives the aggregate catches of four species which have exhibited large increases in landings since MFCMA: goosefish, spiny dogfish, northern shortfin (*Illex*) squid, and longfin inshore (*Loligo*) squid. The increasing reliance on nontraditional species, often supporting export markets, is a major trend since MFCMA. Declines in the abundance of traditional stocks have increased fishing pressure on previously underexploited resources, often resulting in changes in the status of these alternative species (*e.g.* goosefish and spiny dogfish are now considered overexploited). This is but one example of the versatility domestic fleets have shown in their ability to target different resources and to pursue a variety of alternatives.

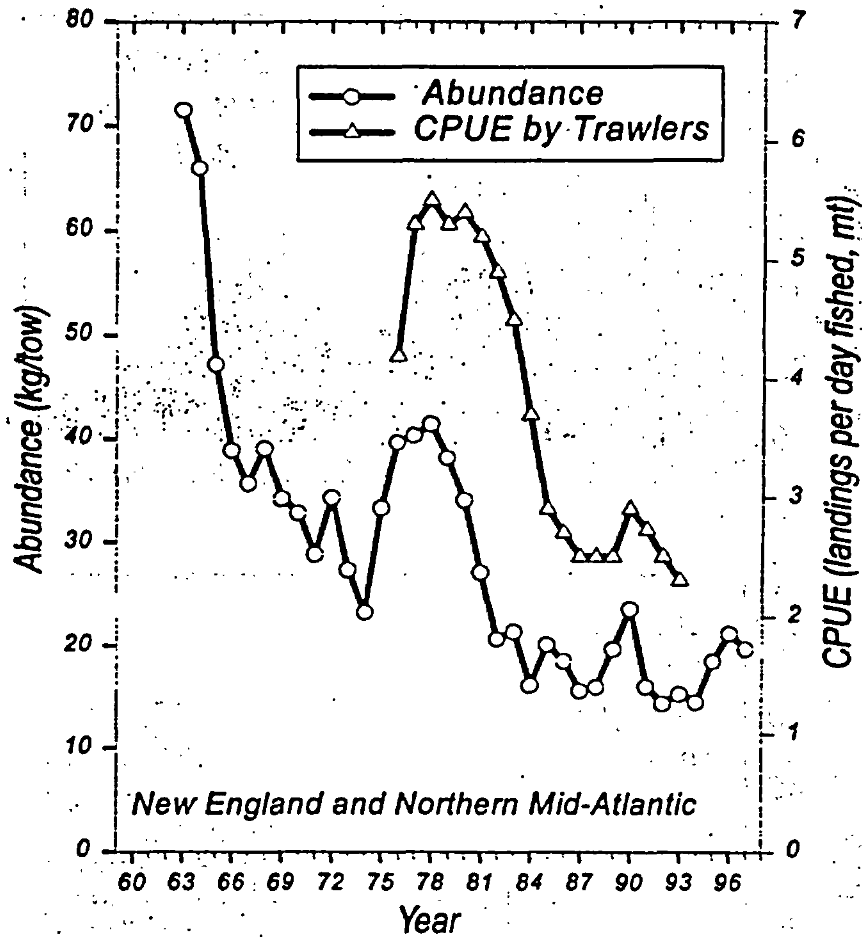


Figure 7. Comparisons of two indices of relative abundance of principal groundfish and flounders off the northeastern United States. Indices are the standardized catch per unit of effort (landings in metric tons per day fished, 1976-1993), and the relative abundance index (stratified mean weight per tow in NEFSC autumn bottom trawl surveys, 1963-1997).

SUMMARY OF STOCK STATUS

The status of 51 finfish and invertebrate stocks of the Northeast Region is summarized in Tables 3 and 4, and Figure 9. Status can be measured in several ways: (1) the abundance of the stock measured against historic levels, (2) landings from the stock relative to past landings levels, and (3) the exploitation rate (fraction of the stock taken by fishing) relative to quantitative overfishing definitions.

In this report, stock status is evaluated realtive to both abundance (low, medium and high levels) and exploitation status (underexploited, fully exploited, and overexploited). Using this categorization scheme, 59% (30 stocks) are considered to be at a low level of abundance, 31% (16 stocks) at medium, and only 10% (5 stocks) at high abundance (Table 3). Two-thirds of the stocks considered in this report are overexploited; only 10% (5 stocks) are underexploited relative to overfishing definitions (northern red hake, herring, butterfish, mackerel, and surfclam). Since only 12% (6 of the 51 stocks) are currently fully exploited and also at medium-high abundance, the vast majority of the region's resources have been historically mismanaged (*e.g.* overexploited and at low abundance levels or underexploited).

New England and Mid-Atlantic groundfish and anadromous species currently have more than 70% of their stocks in the low abundance category. Spiny dogfish and skates, and pelagics show the highest fractions of stocks in the high abundance range (50%). Mid-Atlantic and New England groundfish species have the highest fractions of overexploited stocks (100% and 70%, respectively). The pelagic group has the highest percentage (75%) of underexploited stocks (Table 3).

Recent (1995-96) and five-year (1992-96) trends in landings and abundance are presented in Table 4. During 1995-96, landings declined in 16% of the stocks, and were unchanged in 50%. Three groundfish stocks showed major increases (more than 25%) in landings during 1995-96 (haddock, winter flounder, and yellowtail on Georges Bank) as did three pelagic stocks (Atlantic herring, Atlantic mackerel, and butterfish). Landings

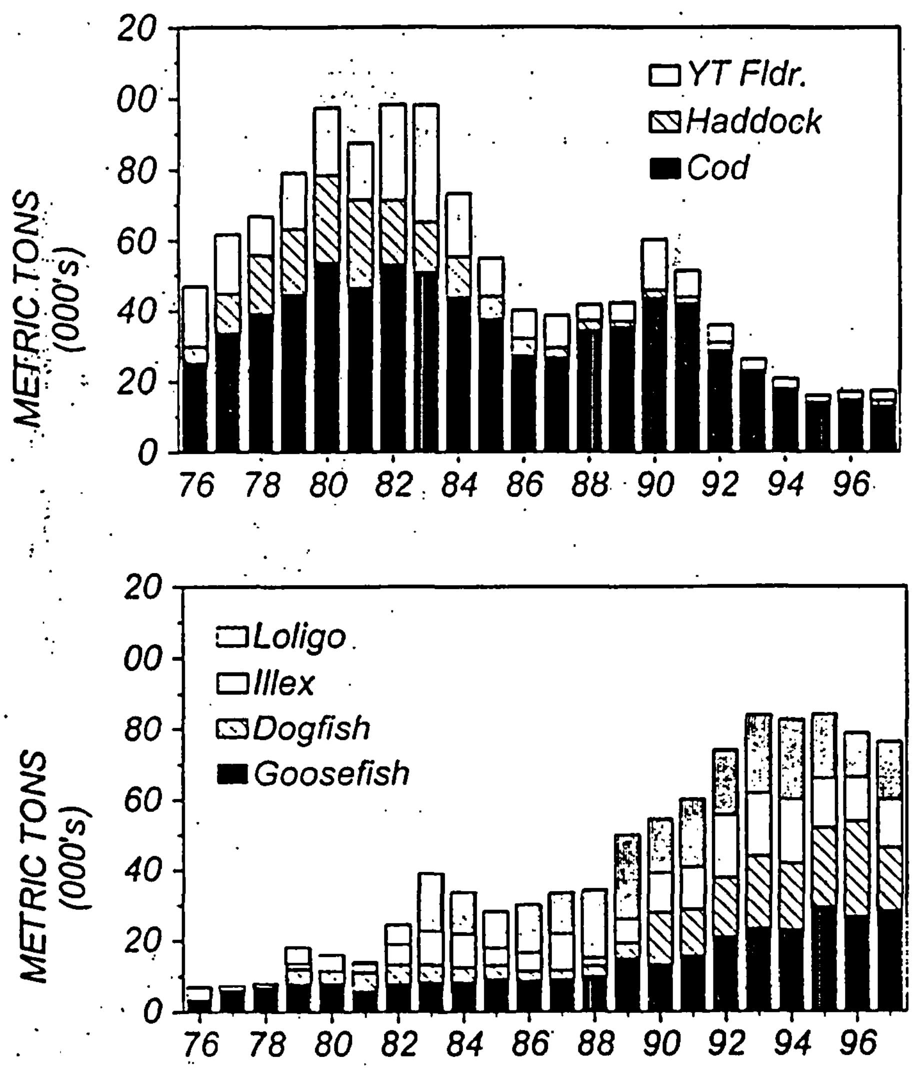


Figure 8. Relative changes in U.S. landings of two species groups, 1976-1997. Top panel details trends for cod, haddock, and yellowtail flounder. Bottom panel presents landings of spiny dogfish, squids, and goosefish.

for skates, northern shrimp, northern shortfin squid and striped bass also increased notably. During 1992-1996, landings decreased in 59% of the stocks, increased in 25%, and were unchanged in 16%. Increased abundance was noted for 18% of the stocks while 25% decreased in 1996 compared to 1995. However, during the past five years, 26% of the stocks declined, 36% exhibited no significant change, and 38% increased.

Management Actions

Improvements noted for some resource components in recent years reflect recent management actions by the New England and Mid-Atlantic Fishery Management Councils and the Atlantic States Marine Fisheries Commission. Amendment 5 to the Multispecies FMP was implemented in 1994 to decrease fishing effort by 50% over five to seven years. Amendment 7 (implemented in 1996) closed large areas of fishery habitat to fishing indefinitely, and accelerated days-at-sea effort reductions.

These measures have resulted in marked reductions in fishing mortality rates for four of the main New England groundfish stocks (Georges Bank cod, Georges Bank haddock, Georges Bank yellowtail flounder and Southern New England yellowtail flounder). The exploitation status of the latter three stocks has recently changed from overexploited to fully exploited. Obviously, other overfished components of the groundfish resource are benefitting as well. Monkfish and spiny dogfish, the focus of increased fishing activity in recent years, will be regulated under provisions of new FMPs being developed cooperatively by the New England and Mid-Atlantic Fishery Management Councils.

Amendments 4, 5, and 6 to the Sea Scallop FMP were implemented beginning in 1994 to replace meat count regulations with direct controls on fishing effort (*e.g.*, days at sea). The elimination of controls on meat count has resulted in increased exploitation on small scallops, even though a larger ring size (3-1/2 in.) is now required in scallop dredges. The closure of the Georges Bank grounds has put additional pressure on other scallop grounds, and has prompted additional closures of grounds off Hudson Canyon and the Virginia Capes. Long-term management provisions to address continuing overfishing of the resource and to manage closed areas are currently being debated.

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

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

For further information

Mayo, R.K, M.J. Fogarty and F.M. Serchuk. 1992. Aggregate fish

Figure 9. Summary of the status of 51 finfish and invertebrate stocks reviewed in this report. Stocks are classified by current exploitation rate (underexploited, fully exploited, or overexploited), and current abundance level (low, medium, or high). Percentages refer to total number of stocks by category.

Abundance Level	Underexploited	Fully Exploited	Overexploited	
High	Atlantic herring Atlantic mackerel 4%	Striped bass 2%	Am. lobster- GOM Spiny dogfish 4%	10%
Medium	Atlantic surfclam Butterfish No. red hake 6%	Longfin inshore squid Ocean quahog Northern shortfin squid Skates No. windowpane 10%	Summer flounder Am. lobster- GB&S, SNE-LIS No. silver hake Yellowtail flounder-CC, Am. plaice Winter flounder-GB Northern shrimp 15%	31%
Low	0%	Haddock-GB Yellowtail flounder -SNE,GB Redfish Pollock, Am. shad 12%	Scup, Black sea bass, Sea scallop Cod-GB, Witch flounder, Cusk, Tilefish, Cod-GOM Wolffish, Goosefish, Bluefish White hake, Yellowtail flounder-MA, River herring, Ocean pout Haddock-GOM, So. silver hake, So. red hake Winter flounder - SNE-MA, GOM, Atl. sturgeon, shortnose sturgeon So. windowpane Atl. salmon 47%	59%
	10%	24%	66%	

Table 3. Abundance and exploitation status of 51 finfish and invertebrate stocks off the northeastern United States, 1997. Stocks are grouped into six categories: New England groundfish, Mid-Atlantic groundfish, pelagics, dogfish & skates, invertebrates, and anadromous

Category	Number of Stocks	Abundance	Number	%	Exploitation Status	Number	%
New England groundfish[1]	23	High	0	0%	Under	1	4%
		Medium	6	26%	Fully	6	26%
		Low	17	74%	Over	16	70%
Mid-Atlantic groundfish[2]	7	High	0	0%	Under	0	0%
		Medium	1	14%	Fully	0	0%
		Low	6	86%	Over	7	100%
Pelagics[3]	4	High	2	50%	Under	3	75%
		Medium	1	25%	Fully	0	0%
		Low	1	25%	Over	1	25%
Dogfish & skates[4]	2	High	1	50%	Under	0	0%
		Medium	1	50%	Fully	1	50%
		Low	0	0%	Over	1	50%
Invertebrates[5]	9	High	1	11%	Under	1	11%
		Medium	7	78%	Fully	3	33%
		Low	1	11%	Over	5	56%
Anadromous[6]	6	High	1	17%	Under	0	0%
		Medium	0	0%	Fully	2	33%
		Low	5	83%	Over	4	67%
All	51	High	5	10%	Under	5	10%
		Medium	16	31%	Fully	12	24%
		Low	30	59%	Over	34	66%

[1] New England groundfish = Georges Bank and Gulf of Maine Atlantic cod (two stocks), Georges Bank and Gulf of Maine haddock (two stocks), Northern silver hake, Northern red hake, white hake, goosefish, witch flounder, American plaice, Northern windowpane, Southern windowpane, Gulf of Maine, Georges Bank and Southern New England-Middle Atlantic winter flounder (three stocks), Cape Cod, Georges Bank and Southern New England yellowtail flounder (three stocks), ocean pout, redfish, pollock, cusk, and wolffish

[2] Mid-Atlantic groundfish = summer flounder, scup, black sea bass, tilefish, Mid-Atlantic yellowtail flounder, Southern silver hake, Southern red hake

[3] Pelagics = Atlantic herring, Atlantic mackerel, butterfish, and bluefish

[4] Spiny dogfish and skates = spiny dogfish, skates (includes 7 species listed in the species summary)

[5] Invertebrates = Atlantic surfclam; ocean quahog; Atlantic sea scallop; Gulf of Maine, Georges Bank and South, and Southern New England-Long Island Sound American lobster (three stocks); northern shrimp; northern shortfin squid, and longfin inshore squid.

[6] Anadromous = striped bass, Atlantic salmon, river herrings (alewife and blueback herring), American shad, Atlantic sturgeon, and shortnose sturgeon

Table 4. Summary of changes in landings and abundance for 51 finfish and invertebrate stocks off the northeastern United States (stocks in each category are given in Table 3).

Category	Number of Stocks	Change[1]	Landings[2] 1995-96	Landings[2] 1992-96	Abundance[3] 1995-96	Abundance[3] 1992-96
New England groundfish	23	--	2 (9%)	14 (61%)	3 (13%)	3 (13%)
		-	3 (13%)	4 (17%)	1 (4%)	1 (4%)
			14 (61%)	3 (13%)	14 (61%)	9 (39%)
		+	1 (4%)	0 (0%)	1 (4%)	2 (9%)
		++	3 (13%)	2 (9%)	4 (17%)	8 (35%)
Mid-Atlantic groundfish[4]	7	--	0 (0%)	2 (40%)	1 (17%)	3 (50%)
		-	0 (0%)	0 (0%)	1 (17%)	0 (0%)
			2 (40%)	2 (40%)	4 (66%)	2 (33%)
		+	3 (60%)	0 (0%)	0 (0%)	0 (0%)
		++	0 (0%)	1 (20%)	0 (0%)	1 (17%)
Pelagics	4	--	0 (0%)	1 (25%)	1 (50%)	1 (50%)
		-	0 (0%)	0 (0%)	0 (0%)	0 (0%)
			1 (25%)	1 (25%)	1 (50%)	1 (50%)
		+	0 (0%)	0 (0%)	0 (0%)	0 (0%)
		++	3 (75%)	2 (50%)	0 (0%)	0 (0%)
Dogfish & skates	2	--	0 (0%)	0 (0%)	0 (0%)	1 (50%)
		-	0 (0%)	0 (0%)	1 (50%)	0 (0%)
			0 (0%)	0 (0%)	0 (0%)	1 (50%)
		+	1 (50%)	1 (50%)	0 (0%)	0 (0%)
		++	1 (50%)	1 (50%)	1 (50%)	0 (0%)
Invertebrates[5]	9	--	1 (14%)	2 (29%)	1 (20%)	1 (20%)
		-	0 (0%)	1 (14%)	1 (20%)	0 (0%)
			4 (57%)	1 (14%)	3 (60%	1 (20%)
		+	0 (0%)	0 (0%)	0 (0%)	0 (0%)
		++	2 (29%)	3 (43%)	0 (0%)	3 (60%)
Anadromous	6	--	1 33%)	2 (67%)	0 (0%)	0 (0%)
		-	0 (0%)	0 (0%)	0 (0%)	0 (0%)
			1 (33%)	0 (0%)	0 (0%)	0 (0%)
		+	0 (0%)	0 0%)	0 (0%)	0 (0%)
		++	1 (33%)	1 (33%)	1 (100%)	1 (100%)
All	51	--	4 (9%)	21 (48%)	6 (15%)	9 (23%)
		-	3 (7%)	5 (11%)	4 (10%)	1 (3%)
			22 (50%)	7 (16%)	22 (56%)	14 (36%)
		+	5 (11%)	1 (2%)	1 (3%)	2 (5%)
		++	10 (23%)	10 (23%)	6 (15%)	13 (33%)

[1] Symbols are as follows: (--) major decrease; (-) minor decrease; ( ) no change; (+) minor increase; (++) major increase. Major = >25%; minor = 10-25%; no change = <10%.

[2] Landings data combined for silver hake, red hake, and American lobster stocks; and stocks currently under landings moratoria (Atlantic salmon, Atlantic and shortnose sturgeon) not included.

[3] Abundance indices or VPA results for 1996 not available for tilefish, Atlantic herring, Atlantic mackerel, Atlantic surfclam, ocean quahog, Atlantic salmon, Atlantic and shortnose sturgeon, river herrings, and American shad.

[4] Does not include landings data for silver or red hake.

[5] Landings and abundance indices combined for American lobster.

biomass and yield on Georges Bank. Journal of Northwest Atlantic Fishery Science 14: 59-78.

MMC [Multispecies Monitoring Committee]. 1997. Report of the New England Fisheries Management Council's Multispecies Monitoring Committee. NEFMC: Saugus, MA.

NEFSC [Northeast Fisheries Science Center]. 1997. Report of the Twenty-fourth Northeast Regional Stock Assessment Workshop (24th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-12.

NEFSC [Northeast Fisheries Science Center]. 1997. Report of the Twenty-fifth Northeast Regional Stock Assessment Workshop (25th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-14.

NEFSC [Northeast Fisheries Science Center]. 1998. Report of the Twenty-sixth Northeast Regional Stock Assessment Workshop (26th SAW), Stock Assessment Review Committee (SARC) and consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-05.

NRC [National Research Council]. 1998a. Improving fish stock assessments. National Academy Press, Washington, D.C. 177 p.

NRC [National Research Council]. 1998b. Review of Northeast fishery stock assessments. National Academy Press, Washington, D.C.

Fishery Economic Trends

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S. Steinback
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REGIONAL SUMMARY

The Northeast's commercial oceanic and estuarine fisheries produced domestic landings worth $961 million dockside in 1997, a increase of just $1 million over 1996. In 1994, 1995, and 1996 domestic landings totaled $924 million, $1.026 billion, and $960 million respectively. Annual totals of quantity and value for total finfish and shellfish for 1993-1997 are provided at the end of Table 5. Finfish landings brought in $349 million in 1997, representing 36% of the revenue generated in the region. Shellfish landings brought in $613 million, accounting for the remaining 64% of revenue.

In 1997, landings decreased to 721 thousand mt, a 4% decrease from 1996 levels and an 11% decrease from the 1995 peak of 811 thousand mt. Finfish landings (531 thousand mt) decreased by 4% from 1996 figures, while shellfish landings (190 thousand mt) declined by 2% in 1997.

Important species of finfish and shellfish landed or raised in the Northeast region are shown in Table 5, along with their quantity, value, and price for the last five years. Landings of finfish, lobster, shrimp, and crab are given in live weight; landings of all other shellfish are expressed in meat weight. The most important species, ranked in terms of 1997 ex-vessel value (first-sale dockside), are American lobster, sea scallop, blue crab, Atlantic salmon, oysters, goosefish, hard clam, surfclam, menhaden, and *Loligo* squid. Seven of the ten most valuable species are invertebrates, and six of the ten species are harvested predominantly inshore (0-3 miles) or are raised.

Atlantic herring made the greatest absolute gain in landings in 1997.

NOAA Fisheries NEFSC Photo Archive

Table 5. Important species landed or raised in the Northeast, their landings (L, thousand mt), ex-vessel values (V, millions of dollars), and prices (P, dollars/lb), 1993-1997[1]

Year	L	V	P	L	V	P	L	V	P	L	V	P	L	V	P
	American lobster			Sea scallop			Blue crab			Atlantic salmon[2]			Oysters		
1993	26.3	160.4	2.77	7.4	97.9	6.03	57.1	69.5	0.55	6.7	42.6	2.86	4.2	35.9	3.90
1994	31.7	207.3	2.96	7.6	84.0	5.00	43.1	73.8	0.78	6.1	35.6	2.64	2.8	36.1	5.94
1995	31.8	214.6	3.06	8.0	91.1	5.16	56.7	101.2	0.81	10.0	56.7	2.56	3.1	38.0	5.48
1996	32.5	242.8	3.39	7.9	98.2	5.64	37.7	64.3	0.77	10.0	46.2	2.10	2.8	36.9	6.02
1997	32.3	223.6	3.14	6.0	87.4	6.60	43.0	79.4	0.84	12.2	49.5	1.84	3.2	39.4	5.61
	Goosefish			Hard clam			Atlantic surfclam			Menhaden			Squid (*Loligo*)		
1993	18.5	21.7	0.53	4.3	43.6	4.58	33.5	38.2	0.52	317.0	41.9	0.06	22.3	29.6	0.60
1994	21.1	26.2	0.56	3.5	35.3	4.61	32.4	45.7	0.64	252.3	34.0	0.06	22.6	31.9	0.64
1995	25.1	36.1	0.65	4.2	42.1	4.50	30.1	45.1	0.68	344.9	45.7	0.06	18.5	23.8	0.58
1996	25.3	32.3	0.58	3.2	35.1	4.94	28.8	41.3	0.65	283.1	37.9	0.06	12.5	18.6	0.68
1997	28.8	35.0	0.55	3.0	34.2	5.09	25.6	36.1	0.64	245.4	33.6	0.06	16.2	26.5	0.74
	Atlantic cod			Sea urchins			Ocean quahog			Bluefin tuna			Winter flounder		
1993	23.0	45.0	0.89	19.2	27.2	0.64	26.2	29.3	0.51	1.0	19.3	8.92	5.3	15.3	1.31
1994	17.8	36.6	0.93	17.6	33.4	0.86	21.1	18.7	0.40	1.0	19.6	8.72	3.6	11.2	1.41
1995	13.7	28.6	0.95	15.6	35.7	1.04	23.2	21.7	0.42	0.9	20.4	10.66	4.0	12.7	1.43
1996	14.3	26.7	0.85	10.1	24.0	1.08	21.1	20.4	0.44	0.9	16.5	8.42	4.8	14.5	1.38
1997	13.0	24.5	0.86	8.5	20.5	1.09	19.8	19.8	0.45	1.0	16.4	7.40	5.3	15.7	1.34
	Summer flounder			Silver hake			Atlantic herring			Northern shrimp			American plaice		
1993	4.4	15.3	1.57	17.3	14.0	0.37	49.5	6.5	0.06	2.3	5.2	1.03	5.8	15.0	1.17
1994	5.0	18.3	1.67	16.0	13.7	0.39	45.2	5.7	0.06	3.7	6.5	0.79	5.1	13.5	1.21
1995	5.0	20.4	1.86	14.7	14.0	0.43	68.8	8.8	0.06	6.8	13.2	0.88	4.6	13.2	1.29
1996	4.0	14.3	1.64	16.2	13.6	0.38	87.7	10.9	0.06	9.5	15.1	0.72	4.4	12.3	1.27
1997	4.1	15.5	1.73	15.6	15.1	0.44	96.9	11.6	0.05	6.4	11.5	0.82	3.9	11.4	1.31
	Soft clams			Atlantic mackerel			Yellowtail flounder			Striped bass			Penaeid shrimp		
1993	2.1	20.5	4.47	4.7	1.3	0.13	3.6	10.4	1.30	0.6	2.7	2.05	0.0	0.0	3.00
1994	1.2	12.5	4.80	8.9	2.6	0.13	3.1	8.1	1.19	0.8	3.1	1.81	0.0	0.0	4.93
1995	1.1	10.7	4.48	8.4	2.7	0.15	1.9	6.0	1.42	1.8	6.2	1.54	0.0	0.0	2.27
1996	1.0	8.3	3.75	15.8	4.6	0.13	2.4	7.6	1.43	2.1	8.0	1.72	0.0	0.0	2.31
1997	1.0	9.9	4.31	15.4	9.5	0.28	2.9	9.5	1.50	2.3	7.5	1.46	1.0	7.4	3.23
	Witch flounder			Scup			Squid (*Illex*)			Spiny dogfish			Swordfish		
1993	2.6	9.0	1.57	4.4	5.7	0.58	18.0	8.5	0.21	15.8	4.6	0.13	1.5	9.9	2.92
1994	2.7	9.3	1.58	4.0	5.8	0.66	18.4	10.4	0.26	13.4	4.3	0.15	1.2	8.5	3.09
1995	2.2	8.4	1.73	2.9	5.8	0.91	14.1	8.1	0.26	16.3	7.1	0.20	1.2	7.7	2.89
1996	2.1	7.7	1.67	2.7	6.3	1.07	17.0	9.7	0.26	18.2	7.5	0.19	0.8	5.6	3.06
1997	1.8	6.6	1.69	2.2	6.4	1.32	13.6	6.1	0.20	17.6	5.8	0.15	1.0	5.5	2.60
	Pollock			Tilefish			Butterfish			Black sea bass			Yellowfin tuna		
1993	5.7	8.4	0.67	1.8	5.0	1.23	4.5	6.8	0.69	1.3	2.9	0.99	0.6	2.6	2.06
1994	3.7	6.8	0.82	0.8	3.4	1.96	3.6	4.1	0.51	0.8	2.2	1.18	0.6	2.0	1.52
1995	3.4	6.8	0.92	0.7	2.9	1.98	2.2	2.6	0.55	0.9	2.9	1.50	1.1	3.8	1.64
1996	3.0	4.5	0.69	1.1	4.2	1.68	3.6	5.2	0.66	1.5	3.6	1.13	0.4	1.9	2.14
1997	4.3	5.3	0.57	1.8	4.9	1.24	2.8	4.7	0.76	1.2	3.9	1.48	0.9	3.7	1.96
	Haddock			Skates			White hake			Bigeye Tuna			Weakfish		
1993	0.9	2.7	1.38	12.9	3.0	0.11	7.5	7.2	0.44	0.8	5.9	3.55	1.1	1.9	0.78
1994	0.3	1.0	1.38	8.8	5.0	0.26	4.7	5.7	0.55	0.8	7.7	4.36	1.1	2.0	0.77
1995	0.4	1.2	1.33	7.1	3.4	0.22	4.3	6.2	0.65	0.9	8.0	4.19	1.8	2.5	0.62
1996	0.6	1.5	1.18	14.2	6.3	0.20	3.3	4.6	0.63	0.4	2.8	3.62	1.5	2.6	0.80
1997	1.5	3.6	1.09	10.5	3.3	0.14	2.2	3.2	0.65	0.5	2.9	2.85	2.4	2.8	0.53
	Bluefish			Mussels			Red hake			Windowpane			Redfish		
1993	2.8	1.9	0.31	3.0	2.7	0.40	1.7	0.9	0.25	1.7	2.3	0.63	0.8	0.8	0.46
1994	3.1	1.9	0.28	2.5	1.9	0.35	1.7	0.9	0.25	0.5	0.6	0.52	0.4	0.6	0.62
1995	2.3	1.8	0.36	3.0	2.5	0.37	1.6	1.0	0.28	0.8	1.0	0.58	0.4	0.6	0.62
1996	2.7	1.9	0.32	2.6	2.3	0.39	1.1	0.7	0.29	1.0	0.9	0.42	0.3	0.5	0.66
1997	3.3	2.2	0.30	2.0	1.7	0.38	1.3	0.8	0.28	0.5	0.6	0.51	0.3	0.3	0.54

	Total Shellfish[3]		Total Finfish[3]		Total[3]	
	L	V	L	V	L	V
1993	210.7	542.6	537.2	344.5	747.9	887.1
1994	216.7	604.7	461.4	319.3	678.1	923.9
1995	223.2	653.2	587.3	373.2	810.6	1026.4
1996	194.5	623.9	555.3	335.8	749.8	959.7
1997	189.8	612.8	531.3	348.5	721.1	961.3

[1] North Carolina landings and price data not included for 1993-1996. [2] Amounts raised and value at first sale [3] Price not meaningful for totals

Several observations can be made from the price and landings data presented in Table 5. First, American lobsters continue to contribute the greatest percentage of the region's ex-vessel revenue. Second, while sea scallop remained the second most valued species in the Northeast in 1997, ex-vessel revenue and landings were still far less than peak values observed during the early 1990s.

Landings of the region's "traditional" groundfish species (cod, haddock, and yellowtail flounder) increased from 17.3 thousand to 17.4 thousand mt in 1997, a mere 100 mt increase over 1996. The value of these traditional groundfish in 1997 was $37.6 million, 5% more than in 1996 ($35.8 million). The three "traditional" groundfish species accounted for only 4% of total 1997 catch by value, and just 2% by weight.

Sea urchins, for which no fishery existed prior to 1987, rose to become the ninth most valuable species in 1995, was rated the eleventh most

Table 6. Landings (L, thousands of metric tons, landed weight) and ex-vessel revenue (R, millions of dollars) for Northeast fisheries, by gear type, 1994-1996

Gear Types	1994 L	1994 R	1995 L	1995 R	1996 L	1996 R
Pots & traps - lobster	26.3	149.4	32.2	200.9	34.4	239.7
Otter trawl, bottom - fish	123.0	177.3	105.0	168.2	133.2	164.5
Dredge - sea scallop	10.4	85.0	9.9	88.8	9.2	96.8
Dredge - surfclam & ocean quahog	51.6	56.2	52.9	62.5	49.9	58.7
Purse seine - menhaden	247.3	32.4	335.4	43.7	277.9	36.9
Sink gill net	26.2	31.4	29.6	35.8	30.8	34.9
Pots & traps - blue crab	31.3	51.5	21.2	35.8	6.9	24.1
Diving gear	13.4	26.8	12.7	30.2	8.3	20.7
Longline, bottom and pelagic	6.7	28.1	7.3	26.8	5.4	18.7
Otter trawl, bottom - shrimp	3.6	6.2	7.0	12.9	9.2	14.6
Hand line, other	1.1	13.9	1.5	16.5	2.1	14.6
Rakes	1.2	13.0	1.2	15.3	1.1	13.4
Tongs and grabs	1.3	14.9	1.1	13.9	1.1	13.3
Hoes	1.3	12.9	1.1	11.0	0.9	7.8
Purse seine - herring	34.5	4.5	34.6	4.6	55.1	7.0
Otter trawl, bottom - scallop	0.7	5.8	0.8	7.2	0.7	6.6
Unknown [1]	24.6	142.5	44.7	162.3	64.2	128.0
All other gears	48.3	71.4	61.8	56.2	31.3	52.5
Total	**652.9**	**923.2**	**759.9**	**992.6**	**721.7**	**952.8**

[1] Includes oyster dredge

Table 7. Number of identifiable vessels using otter trawls and scallop dredges, and total number of vessels regardless of gear type in the Northeast region by tonnage class (TC) and sub-region, 1991-1996[1]

Year/Subregion		Otter Trawls					Scallop Dredges					All Vessels [2]				
		TC1	TC2	TC3	TC4+	Total	TC1	TC2	TC3	TC4+	Total	TC1	TC2	TC3	TC4+	Total
1991	Northeast [3]		403	483	139	1025		32	114	153	299		808	735	309	1852
	New England		368	339	115	822		29	65	126	220		628	469	241	1338
	Mid-Atlantic & Chesapeake		36	170	34	240		4	72	52	128		192	335	108	635
1992	Northeast		422	473	117	1012		50	112	148	310		871	722	298	1891
	New England		374	328	93	795		48	62	119	229		681	454	227	1362
	Mid-Atlantic & Chesapeake		51	174	36	261		3	71	50	124		203	333	106	642
1993	Northeast		435	484	121	1040		69	100	136	305		923	731	285	1939
	New England		341	327	98	766		67	50	110	227		677	452	218	1347
	Mid-Atlantic & Chesapeake		96	189	41	326		2	60	40	102		256	338	104	698
1994	Northeast	34	502	446	131	1113	2	65	82	131	280	405	1622	673	280	2980
	New England	31	419	299	94	843	2	64	29	89	184	389	1387	410	198	2384
	Mid-Atlantic & Chesapeake	3	86	184	55	328	0	1	68	85	154	18	274	332	149	773
1995	Northeast	47	606	442	133	1228	3	64	80	134	281	442	1684	646	283	3055
	New England	40	488	291	90	909	3	62	36	106	207	387	1395	408	221	2411
	Mid-Atlantic & Chesapeake	7	122	190	56	375	0	2	59	71	132	62	349	318	133	862
1996	Northeast	47	624	424	134	1229	9	120	82	132	343	409	1863	607	276	3155
	New England	44	510	284	96	934	9	118	43	105	275	379	1572	381	217	2549
	Mid-Atlantic & Chesapeake	3	117	182	54	356	0	2	56	56	114	32	352	303	113	800

[1] TC1=less than 5 gross registered tons (grt), TC2=5-50 grt, TC3=51-150 grt, TC4=151+grt

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

[3] 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, Mass, New Hampshire, Rhode Island, or Connecticut. Mid Atl.& Chesapeake vessels include those that landed at least once in New York, New Jersey, Maryland, Virginia, or Delaware. The "Northeast" row eliminates duplication of vessels that landed in both sub-regions.

Table 8. Percentage of total landings by weight attributed to gear type used in harvest of selected species, 1996

GEAR TYPE	Cod	Yellowtail flounder	Haddock	Other multi-species[1]	Menhaden	Summer flounder	American lobster	Sea scallops	Swordfish	Atlantic herring
Bottom trawl	57.4	87.1	66.3	91.7	0.1	94.9	1.6	8.6	1.9	2.5
Midwater trawl	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	34.6
Hook gear	9.1	0.0	17.0	0.8	0.0	0.0	0.0	0.0	87.7	0.0
Gillnet	29.9	10.8	14.9	7.0	0.2	0.3	0.2	0.0	9.2	0.0
Pots traps	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Lobster pot	0.2	0.0	0.0	0.0	0.0	0.0	98.2	0.0	0.0	0.0
Scallop dredge	0.0	1.5	0.0	0.1	0.0	1.1	0.0	91.2	0.0	0.0
Other gear	3.4	0.6	1.8	0.4	99.7	3.3	0.0	0.2	0.1	62.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

GEAR TYPE	Atlantic mackerel	Butter-fish	Loligo	Black sea bass	Scup	Goosefish	Northern shrimp	Bluefin tuna
Bottom trawl	84.9	94.2	94.7	51.1	81.7	51.7	96.2	0.0
Midwater trawl	8.3	2.3	3.6	0.0	0.0	0.0	0.0	0.0
Hook gear	0.0	0.0	0.0	0.1	0.0	0.2	0.0	2.5
Gillnet	1.3	0.7	0.0	0.6	0.3	33.0	0.0	0.0
Pots traps	1.4	0.7	0.6	38.8	13.1	0.0	3.8	0.0
Lobster pot	0.0	0.0	0.0	2.4	0.3	0.0	0.0	0.0
Scallop dredge	0.0	0.0	0.0	0.0	0.0	15.1	0.0	0.0
Other gear	4.1	2.1	1.1	7.0	4.6	0.0	0.0	97.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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

valuable in 1996, and the twelfth most valuable in 1997.

Value of farmed Atlantic salmon declined in 1996 by more than $10 million, but increased in 1997. However, this species retained its standing as the fourth most valuable in both years, continuing to demonstrate the importance of marine aquaculture to the Northeast economy. Atlantic salmon (and steelhead trout) are still being raised at more than 20 sites in Maine.

Relatively few species accounted for most of the landed value in the Northeast in 1997, with the top 10 generating 67% ($645 million) of the landings value. Lobster and sea scallop remained the two most valuable species in the Northeast region, accounting for 32% of the total value of all species landed. American lobster accounted for the largest revenue gain (in absolute terms) in 1996, while blue crab held this distinction for 1997. *Loligo* squid also made a notable gain in 1997, increasing almost $8 million. Atlantic herring made the greatest absolute gain in landings in 1997. Although menhaden landings fell, they still accounted for 34% of total landings (by weight) but only 3% by value in 1997.

Table 6 provides data for landings and revenue earned by gear type, for 1994-1996. Pots and traps produced the greatest amount of total revenue in 1996, followed by bottom otter trawl and sea scallop dredges. These three gear types accounted for more than half of the region's ex-vessel revenue. Menhaden purse seines and bottom otter trawls account for well more than half of the landings by weight.

Many vessels employ more than one gear type. The ability to change from one fishing method to another is of particular importance in fisheries where different species are harvested, requiring different techniques at various seasons of the year.

Table 7 provides the total number of identifiable vessels (those vessels of known tonnage, excluding under-tonnage vessels for 1991 through 1993) using scallop dredge, otter trawl, and totals for all gears combined, by tonnage class for 1991-1996. Tonnage Class 1 vessels are less than 5 gross registered tons (grt); Tonnage Class 2 vessels range from 5 to 50 grt; Tonnage Class 3 vessels are 51-150 grt; and Tonnage Class 4 vessels are greater than 150 grt.

The total number of vessels appears to have increased during 1994-1996, but this is partly due to the changes that have occurred in our data collection system; since 1994, data for Tonnage Class 1 vessels have been collected and recorded on a per-vessel basis, whereas formerly such data were combined. Thus, total numbers could be included in the table. A substantial increase in the number of Tonnage Class 2 scallop vessels also occurred in New England in 1996, partly due to activity by part-time scallopers who did not use their permit in 1995 but did so in 1996.

Table 8 provides the percentage of total landings by identifiable gear type for selected species in the Northeast for 1996. This table indicates the variability in harvesting strategies for individual species. For example, summer flounder is taken predominantly with bottom trawls, while goosefish is taken primarily by bottom trawls, gillnets, and scallop dredges.

DATA COLLECTION CONSIDERATIONS

NMFS has recently made many changes to its data collection, archival, and analysis systems to support the increasingly complex needs of fisheries management. In the Northeast Region, 1993 marked the end of a traditional voluntary method of data collection from vessel owners, operators, and dealers. Regulations implemented in 1994 in several FMPs required mandatory reporting.

Under the voluntary method of data collection, NMFS obtained information on landings through the collection of weighout sales receipts (at the point of first sale) using a network of federal and state port agents located in the Northeast. This information was augmented by interviews with vessel operators when vessels landed, as well as a monthly or annual canvas.

The mandatory reporting system became effective in April 1994 for summer flounder transactions, and in June 1994 for multispecies and scallop transactions. The mandatory reporting system consists of two components, one from dealers and one from the vessel owners and/or operators. The dealer reports contain total landings and revenue information, broken down into market category. Essential data elements on fishing location, gear used, and effort (previously annotated by port agents through interviews) do not exist in the dealer reports and must be extracted from corresponding vessel trip reports.

Dealer reports are assumed to provide accurate totals for landings and revenue; vessel trip reports (VTRs) are used as a subset of the dealer data. The VTR data are still undergoing auditing procedures at various levels and are therefore considered provisional.

VESSEL PERMITS

In the Northeast, most permits are issued by the NMFS Northeast Regional Office and are required mostly for fisheries that fall under Fishery Management Plans (FMPs) of the New England and Mid-Atlantic Fishery Management Councils. Tuna fpermits are issued by the NMFS Highly Migratory Species Division Office in Silver Spring, Maryland. The FMPs are for either a single species (*e.g.*, lobster), or for a species complex (*e.g.*, multispecies). When a fishery is under a federal FMP, participants in that fishery must have an appropriate permit. Possession of that permit constitutes acceptance of the regulations contained in the FMP. Possession of a permit triggers the requirement for mandatory reporting by vessels in the sea scallop, multispecies, summer flounder, and surfclam and ocean quahog fisheries.

Permit data help managers evaluate the distribution of vessel owners, complementing data on distribution of vessel landings. Permit data are also the source of vessel characteristics data (*e.g.*, length, tonnage, horsepower). Permit and related data on days-at-sea usage are important for evaluating active and latent fishing effort, capacity, and to some extent levels of capitalization, as well as for tracking and measuring impacts of measures such as limited access and vessel buyouts. Data on landings reported in relation to type of permit also allows evaluation of how effective some regulations are in achieving management goals.

Broadly speaking, Northeast permits allocate fishing privileges under some combination of the following four categories: commercial versus recreational, and limited access versus open access. Commercial permits allow sale of the catch. Permits for recreational fishing do not; most federal recreational permits are held by party and charter boats, although there is an angler permit for tuna. In addition, unlike all other party/charter permits in the Northeast, tuna party/charter vessels are commercial. These commercial and recreational permits may be either "open access" or "limited access", as described next.

For some fisheries where effort limitations are required, a moratorium is established. In such a case, certain requirements ("qualifying criteria") must be met by the vessel owner in order to acquire a permit. Generally, the vessel must have landed the species covered under the FMP in question during a specified period (usually several years in duration). Sometimes a minimum level of landings of the species is also required. Those who meet these requirements are granted a "limited-access" permit. Once the qualifying criteria are established, and qualified vessels determined (through a lengthy process that includes an appeals period), then no additional vessels can be granted a limited-access permit in that fishery for the life of the moratorium. An "open-access" permit, by contrast, can be acquired by anyone at any time. Some fisheries have both limited- and open-access categories within a single fishery, with open-access permits having much more restrictive regulations.

Between 1994 and 1996, NMFS issued permits under seven northeastern FMPs: Northeast Multispecies; Atlantic Sea Scallop; American Lobster; Summer Flounder; Surfclam and Ocean Quahog; Atlantic Mackerel, Squid, and Butterfish; and Atlantic Tunas. Five of these fisheries are at least partially managed under limited-access arrangements (summer flounder as of 1992, multispecies as of 1994, Atlantic sea scallop as of 1994, American lobster as of 1995, and Atlantic tuna as of 1982).

Under the Multispecies FMP, vessels not qualifying for limited ac-

Table 9. Numbers of unique permitted vessels by fishery management plan permit category and tonnage class, 1994-1996 [1,2,3]

Fishery Management Plan/ Permit Category		Tonnage Class 1			Tonnage Class 2			Tonnage Class 3			Tonnage Class 4			Totals		
		1994	1995	1996	1994	1995	1996	1994	1995	1996	1994	1995	1996	1994	1995	1996
Multispecies [4]	Limited access	66	70	102	1090	1056	1107	450	437	427	139	132	127	1745	1695	1763
	Open access	867	839	415	1681	1762	877	308	319	227	122	123	114	2978	3043	1633
	Total	933	909	517	2771	2818	1984	758	756	654	261	255	241	4723	4738	3396
Sea Scallop [4]	Limited access	<3	<3	<3	22	16	15	167	170	159	170	163	154	N/A	N/A	N/A
	Open access	179	189	159	1230	1328	1308	454	445	430	110	112	101	1973	2074	1998
	Total	N/A	N/A	N/A	1252	1344	1323	621	615	589	280	275	255	N/A	N/A	N/A
Lobster [5]	Limited access (com)		217	321		1972	2453		465	489		182	201		2836	3464
	Limited access (rec)		3	<3		16	14		<3	<3		0	0		N/A	N/A
	Open access (com)	495			2302			709			296			3802		
	Open access (rec)	62			270			50			0			382		
	Total	557	N/A	N/A	2572	1988	2467	759	N/A	N/A	296	182	201	4184	N/A	N/A
Summer Flounder	Limited access (com)	58	49	41	410	388	358	512	500	480	226	218	207	1206	1155	1086
	Open access charter/party	108	99	67	545	530	448	99	103	93	<3	<3	<3	N/A	N/A	N/A
	Total	166	148	108	955	918	806	611	603	573	N/A	N/A	N/A	N/A	N/A	N/A
Atlantic Mackerel, Squid & Butterfish	Open access (com)	476	449	416	1616	1598	1641	691	662	656	289	276	265	3072	2985	2978
	Open access (rec)	106	91	68	513	467	421	103	105	103	0	0	0	722	663	592
	Total	582	540	484	2129	2065	2062	794	767	759	289	276	265	3794	3648	3570
Bluefin Tuna [4]	Open access (rec)	2297	2908	7887	1019	1399	4419	16	31	126	0	7	30	3332	4345	12462
	Open access (com)	4441	5196	5531	6000	7451	7963	572	856	810	137	217	212	11150	13720	14516
	Limited access (com)	0	0	0	0	0	0	<3	<3	<3	4	4	4	N/A	N/A	N/A
	Total	6738	8104	13418	7019	8850	12382	N/A	N/A	N/A	141	228	246	N/A	N/A	N/A
Surfclam and Ocean Quahog [6]	ONLY surfclam open access/com & rec	41	41	28	199	186	182	99	88	92	45	43	41	384	358	343
	ONLY ocean quahog open access com. & rec.	10	11	14	102	113	130	16	16	17	3	3	3	131	143	164
	BOTH surfclam & ocean quahog open access comm. & rec	74	71	82	429	459	535	312	317	324	153	156	155	986	1003	1096
	Total.	125	123	124	730	758	847	427	421	433	201	202	199	1483	1504	1603

[1] Vessels with both commercial and recreational permits under a single FMP are listed under commercial only, to avoid double counting.

[2] *Tonnage class (TC) 1 vessels are <5 gross registered tons (grt); TC2, 5-50 grt; TC3, 51-150 grt; TC4, 151+ grt.*

[3] Where a category contains fewer than three vessels, the exact number is not reported, for purposes of confidentiality. Rows or columns containing such entries show no totals, but are labeled "N/A."

[4] For these FMPs there are also multiple sub-categories within some of the categories listed here.

[5] In 1994 there were two categories for American lobster, open access commercial and open access recreational. In 1995 and 1996 these became limited access commercial and limited access recreational. For years when a given category did not exist, the cell is blank.

[6] These two fisheries are under an ITQ system. Possession of a permit, therefore, does not convey harvest privileges (see text).

cess can still fish both commercially and recreationally under the highly restrictive open-access categories. (Most recreational multispecies vessels are under open-access categories, though a few have qualified for limited-access permits.) There is also a commercial open-access category for sea scallop. Under the Summer Flounder FMP, nonqualifying vessels can fish only under an open-access party/charter category which is noncommercial. Under the American Lobster FMP, all permits are limited access, whether commercial or recreational. For tuna, the small purse-seine category is closed to new entrants, but all other categories (commercial and recreational) are open access.

Table 9 indicates the distribution of permits in the Northeast, by FMP and category, and by vessel tonnage class, for 1994, 1995, and 1996. By comparing the numbers of vessels over the three-year period one can begin to examine the potential effects of limited access on the number of vessels in the fishery -- one measure of capacity. The size component is important because of concern that smaller vessels may have more difficulty in qualifying for limited-access permits. Figure 10 offers related data on total numbers of permits. These data are not broken out by size, but cover a longer time span (nine years) giving more historical perspective.

Several data considerations in Table 9 should be noted. First, it is not possible to be permitted concurrently under both limited and open access. For FMPs with only open-access or only limited-access categories, however, a vessel can sometimes be permitted as both commercial and recreational. In such cases, the vessel is included solely in the commercial

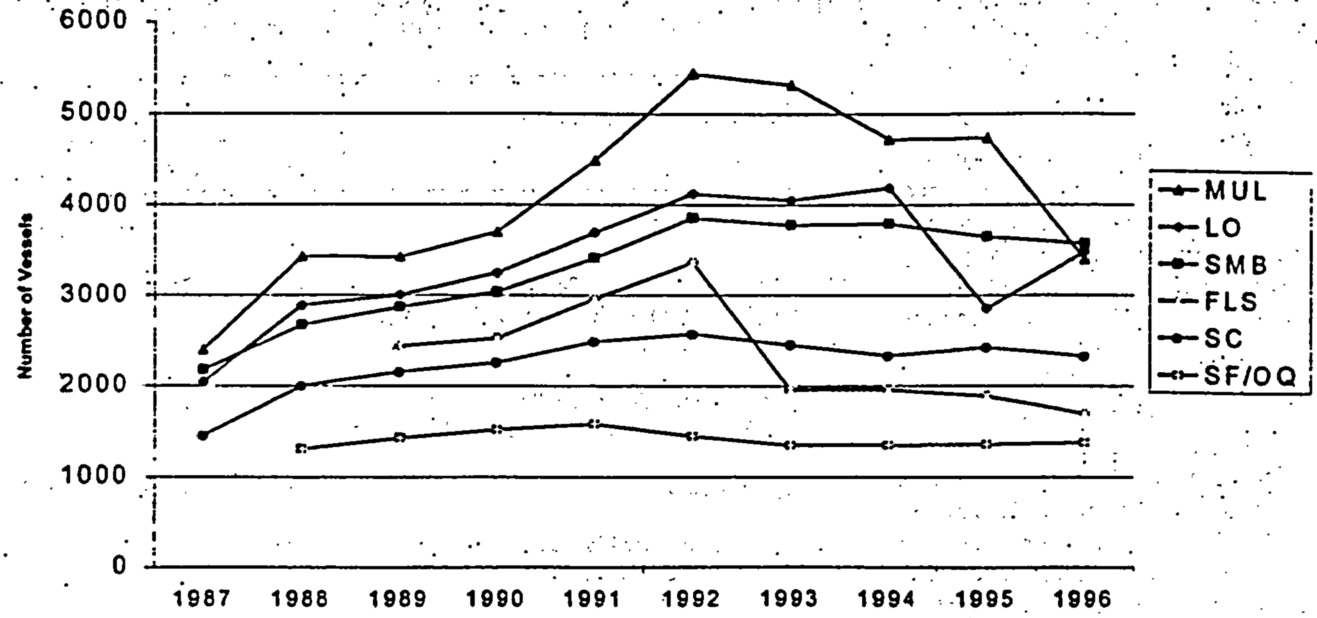


Figure 10. Numbers of unique permitted vessels, 1987-1996: MUL = Multispecies; LO = American Lobster; SMB = Atlantic Mackerel, Squid, and Butterfish; FLS = Summer Flounder; SC = Sea Scallop; SF/OQ = Surfclam & Ocean Quahog.

category. Recreationally permitted vessels are those that have only a recreational permit. This was done to avoid double counting vessels.[1]

It should also be noted that, except for the limited-access category under the Summer Flounder FMP (with its landings requirement), there have always been more permits issued than were actually used. In the past it has been difficult to determine numbers of active permits because the NMFS landings database consolidated landings made by vessels under 5 grt. With the advent of mandatory reporting through logbooks under limited access for the multispecies, sea scallop, and summer flounder fisheries, all vessels with these permits must report total landings, even for trips not landing any of these species. These three FMPs accounted for 70% of all permitted vessels in 1996. This has made it possible to obtain a much more accurate count of participating vessels.

For Figure 10, 1987 was chosen as the base year. It was the first year that annual permits were issued in the Northeast. Permits obtained in previous years (beginning in the 1970s) were issued in perpetuity, making it difficult to judge annual change.

The most striking features of Table 9 and Figure 10 are the declines in total numbers of permits with the advent of limited access. This trend appears to reflect a number of factors, such as the tendency of fishers to apply for permits whenever the possibility of limited access for a particular fishery is raised (*e.g.* in 1990 for multispecies). However, not all of these permits will be actively fished. Once limited access is implemented, the number of permits drops because not all of the later entrants will have met the qualifying criteria. It does not usually drop to the level observed prior to limited entry discussions, however, because the fishery may have gained in popularity. Also, not all of those who qualified based on past participation will remain active, yet they retain their permits (unless required to show landings to keep it) because they do not want to lose limited-access status.

This influx of people hoping to qualify for limited entry, combined with the problem of fully identifying active vessels from the commercial landings databases prior to 1994, has made it difficult to judge the true impact of limited entry on numbers of active fishers and vessels. We can make some preliminary assessments, however, noting that some relevant issues are fishery-specific.

For the lobster fishery, there was some confusion among permit holders over who could, or should, apply for limited-access status. Thus, many of those who eventually qualified did not apply until 1996. This accounts for the drop in 1995, when limited entry was implemented, followed by a substantial rise in 1996. For multispecies, the drop was relatively small in 1994 when limited entry came into effect. The larger drop was in 1996, when more restrictive measures were implemented for both limited- and open-access categories, though the most stringent reductions were in open-access categories. For summer flounder, the large decrease likely owes to a combination of the landings requirement and the current state of the resource, rather than to simply the limited entry provisions. For tunas, there has been growth in all

[1] To give a sense of how many vessels would have been double-counted, 1996 data include 45 cases of a vessel holding both a commercial and a recreational summer flounder permit, 20 cases in the lobster fishery; and 197 cases in the squid, Atlantic mackerel, and butterfish fishery. Similarly, vessels in the latter fishery that held both "commercial" and "catcher/processors" permits are counted only once (as commercial). There were 26 such vessels in 1996. These data do not appear in the tables.

the open-access categories from 1994 to 1996[2], but especially in the recreational or angling category. Some of the increase in commercial open-access categories may owe to groundfishers seeking alternative species.

Surfclam and ocean quahog permits are a special case. Total numbers of surfclam and ocean quahog permit holders show a slight rise between 1994 and 1996. This occurred within the groups of those with ocean quahog only (from 131 to 164) and those with both surfclam and ocean quahog (from 986 to 1096). Numbers of those with only surfclam permits dropped over the period (from 384 to 343) Further, an overall increase appears to occur in numbers of Tonnage Class 2 vessels, while other tonnage categories are stable. However since September 1990, surfclams and ocean quahogs have been managed under individual transferable quotas (ITQs). Only quota-allocation holders may fish under these FMPs. So while it is still possible to acquire and hold a surfclam or ocean quahog permit (neither of which are under a moratorium), a permit conveys no fishing privileges. Therefore, perhaps individuals are holding and acquiring permits on the chance that either the ITQ system will be dismantled or that additional allocations may be granted by the federal government in the future at no cost. Certainly anyone desiring an allocation may buy one from a current allocation holder. Conversely, it is possible to hold an allocation without holding a permit. This is because, unlike permits, allocations are granted solely to persons (individual or corporate) and are not tied to a specific vessel.

In the surfclam and ocean quahog fisheries, the number of ITQ allocations has remained fairly stable.[3]

[2] In 1994, multiple tuna permit categories were allowed. Beginning in 1995, a permit holder was required to choose one category only, according to specific guidelines. To facilitate comparison, 1994 permits were assigned to the category required under the new rules.

[3] Although numbers of allocation holders are similar to the numbers of Tonnage Class 1 permit holders, there is no correlation between these two groups.

Table 10. Number of vessels holding selected fishery management plan permits or permit combinations in the Northeast fisheries, by year, 1994-1996

Permit or Permit Combination[1]	Number of Permits by Year		
	1994	1995	1996
American Lobster Only	457	646	1,083
Multispecies; Atlantic Sea Scallop; American Lobster; Summer Flounder; Atlantic Mackerel, Squid and Butterfish	951	718	743
Multispecies; Atlantic Sea Scallop; American Lobster; Atlantic Mackerel, Squid and Butterfish	790	517	581
Multispecies Only	634	697	570
Multispecies; Summer Flounder; Atlantic Mackerel, Squid and Butterfish	273	546	447
Multispecies; American Lobster	509	418	417
Multispecies; Atlantic Mackerel, Squid and Butterfish	343	539	396
Atlantic Mackerel, Squid and Butterfish Only	146	149	318
Multispecies; Atlantic Sea Scallop; Atlantic Mackerel, Squid and Butterfish	46	391	314
Multispecies; Atlantic Sea Scallop; Summer Flounder; Atlantic Mackerel, Squid and Butterfish	20	273	213
Multispecies; American Lobster; Atlantic Mackerel, Squid and Butterfish	444	193	206

[1] All combinations representing 5% or more of the total number of unique permitted vessels for a given year--excluding permits for tunas and for surfclams and ocean quahogs (see text).

There were 114 surfclam allocation holders in 1994, 113 in 1995, and 115 in 1996. For ocean quahogs there were 70 allocation holders in 1994, 68 in 1995, and 67 in 1996. (These data are not shown in tabular form.)

With respect to impacts of limited entry by vessel size, as noted in the section of this report titled "Fleets and Fish", the majority of the vessels in the Northeast are under 50 grt. For those fisheries with both limited- and open-access commercial categories (*i.e.*, multispecies and sea scallop), the open-access fleet tends to comprise smaller vessels on average than does the limited-access fleet; although there are a few very large open-access vessels. In 1996, 80% of open-access permitted vessels in the multispecies fishery were small (0-50 grt), while only 68% of those under limited-access permits fell within this range. For the sea scallop fishery in 1996, corresponding figures were 73% and 1% respectively. While some of the disparity in both cases may be related to small vessels having initial difficulty in qualifying for the moratorium (many gained limited-access status later, on appeal), it is more likely that open-access trip limits were sufficiently generous that owners of small vessels did not feel the need to apply for limited-access status. In the lobster fishery, for instance, many Tonnage Class 1 and 2 lobster vessel owners did not initially apply for limited access in 1995, but subsequently secured limited-access permits when they realized they could not fish outside of state waters without one.

The greater disparity for scallopers than for multispecies vessels owes to three factors. First, in all three years, vessels with scallop permits were larger on average than vessels with multispecies permits, despite the fact that these are overlapping sets, with some vessels holding both permits. (Average tonnages for scallop- and multispecies-permitted vessels in 1996 were 57 grt and 42 grt, respectively). Second, a number of inshore scallopers (which tend to be smaller, especially in Maine) did not apply for limited-access permits, probably because of the permit's requirement that holders follow federal gear regulations in state waters. Third, there was a minimum landing requirement in order to gain limited access under the sea scallop FMP (400 lb of scallop meats or 50 U.S. bushels of shell stock on any trip in the qualifying period). Under the multispecies FMP, the equivalent requirement was simply for landings (as little as one pound) during the qualifying period.

In the multispecies limited-access fleet, the numbers of Tonnage Class 1 and, to a lesser extent, Tonnage Class 2 vessels increased from 1994-1996, while the numbers of Tonnage Class 3 and 4 vessels declined or remained the same. This may be related to more relaxed measures for the smallest vessels (in 1994 and 1995 those less than 45 ft in length, and in 1996 those less than 30 ft in length). Measures granting less restrictive limits to scallop vessels fishing with smaller dredges, however, have not had a similar effect in that fishery.

Another important measure of potential effort, including possible shifts between fisheries in response to regulatory changes or other factors, is the number and variety of permits held by individual vessels. In the Northeast, a given vessel can potentially be permitted simultaneously under all seven FMPs. Table 10 provides information on numbers of vessels holding common combinations of permits for 1994-1996. Because surfclam and ocean quahog permits do not convey fishing privileges they are not considered. Tuna permits are not considered either because of scale. In 1996, for example, there were more than 26.9 thousand unique vessels with tuna permits included (an exact figure is not provided due to confidentiality considerations in Table 9), but 6,008 otherwise. Further, all of the 6,008 held tuna permits. The total number of unique permitted vessels for this analysis, therefore, was 5,896 in 1994, 5,939 in 1995, and 6,008 in 1996.

A large number of vessels were permitted under only a single FMP (*e.g.*, in 1996, 1,083 held only a lobster permit, 570 held only a multispecies permit, 318 held only an Atlantic mackerel, squid, and butterfish permit). In fact, statistically, the most common (modal) number of permits held by a given vessel in any of the three years is one. For those that did hold more than one permit, the most common group in 1996 was that including those who held all five non-ITQ and non-tuna permits, followed by a combination of multispecies; Atlantic mackerel, squid, and butterfish; American lobster; and Atlantic sea scallop; and finally, the multispecies; summer flounder; and Atlantic mackerel, squid, and butterfish combination. These combinations all include a mix of higher- and lower-value species (see discussions of landings and value earlier) and of fisheries under more and less restrictive regulations, indicating an attempt to balance risks and benefits.

Over the three years considered, the American lobster only category has consistently increased in size, especially in 1996 when lobster limited-access permit applications and appeals were finalized. This is not surprising given the high value of lobster landings in recent years. Numbers of multispecies permits increased from 1994 to 1995, but then dropped steeply in 1996, most likely owing to implementation of stricter rules -- especially in the open-access categories -- and continued low stock levels for this period. Numbers of those holding only the Atlantic mackerel, squid, and butterfish permit rose precipitously, probably owing to relatively high abundance of these species.

The size of the group with the most potential flexibility (those who held all five permits) dropped nearly 25% from 1994 to 1995, but then increased slightly from 1995 to 1996. Not all fisheries that Northeast vessels engage in, of course, require federal permits at this time. So, these figures cannot be taken as a strong predictor of levels of diversification within the Northeast fleet. Nonetheless, the change from 1994 to 1995 was statistically significant. The initial lessening of diversification in the variety of permits held within this subset of fisheries may be related to limited entry rules and/or to stock conditions. Review of data from the scup and the black sea bass fisheries, which came under limited entry in 1997, will be instructive in this regard.

FLEETS AND FISH

Tables 11 through 18 present condensed pictures of the activity of known vessels captured by the different data collection systems in effect during 1994-1996. The picture is complicated somewhat by the changes that occurred in our data collection system during these years and the consequent use of multiple databases. Because of this, caution is urged in the interpretation of effort related measures. In the future, these problems will be resolved by explicitly linking the dealer and vessel logbook databases together.

All information relative to individual vessel activity has been aggregated into annual summaries on the basis of gear use, area fished, and tonnage class. Most information concerns effort, landings, and revenue. No cost information is reported. Several caveats are in order concerning categorization of vessels by fleet. In general, if a vessel landed at least

Table 11. Characteristics, activity, and revenue data for New England otter trawl vessels by vessel tonnage class, 1994-1996; data for all trips included, regardless of gear used[1,2]

	Tonnage Class 1			Tonnage Class 2			Tonnage Class 3			Tonnage Class 4		
	1994	1995	1996	1994	1995	1996	1994	1995	1996	1994	1995	1996
Number of vessels	31	40	44	419	488	510	299	291	284	94	90	96
Average age	14	15	15	24	22	21	22	28	36	14	14	15
Average GRT	3	3	3	24	23	23	102	100	100	177	177	179
Average days absent	-	-	-	129	97	108	154	126	128	136	85	143
Average crew size	2.3	2.2	2.3	2.5	2.5	2.4	4.2	4.0	4.2	6.4	6.2	6.4
Revenue per day absent ($)	-	-	-	488	707	621	1637	2064	2148	4418	6742	4132
Landings per day absent (lb)	-	-	-	738	955	962	2583	3121	3579	7739	12758	8267
Total revenue ($, millions)	0.8	0.9	1.1	26.4	33.4	34.2	75.4	75.7	78.1	56.5	51.6	56.7

[1] Tonnage Class (TC) 1 vessels, <5 gross registered tons (grt); TC2, 5-50 grt; TC3, 51-150 grt; and TC4, >150 grt
[2] Dash indicates fewer than 10 vessels available on which to base effort estimates

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

New England Otter Trawl

In 1996, the total revenue for New England otter trawlers was derived primarily from goosefish (14%), cod (12%), *Loligo* squid and American plaice (both 10%), winter flounder (8%), and witch flounder and lobster (both 6%). The total number of vessels using this gear in New England increased in 1994, 1995 and 1996 for the first time since 1988 (not reported in table), even after allowing for the addition of Tonnage Class 1 vessels to the database (Table 7). In 1996, the fleet comprised 934 vessels, with the greatest increase occurring among Tonnage Class 2 vessels, which compose 55% of the total (Table 11). This may be related to Multispecies FMP regulations in effect during 1994-1996, which exempted smaller vessels from certain effort restrictions. Total revenue (in actual dollars) and effort measures increased for all four tonnage classes in 1996.

Table 12. Characteristics, activity, and revenue data for Mid-Atlantic otter trawl vessels, by vessel tonnage class, 1994-1996; data for all trips included, regardless of gear used[1]

	Tonnage Class 2			Tonnage Class 3			Tonnage Class 4		
	1994	1995	1996	1994	1995	1996	1994	1995	1996
Number of vessels	86	122	117	184	190	182	55	56	54
Average age	25	24	21	21	41	43	17	17	16
Average grt	30	26	24	104	108	108	180	177	180
Average days absent	125	55	97	149	125	155	142	118	172
Average crew size	2.4	2.2	2.3	4.6	4.7	4.8	7.1	7.5	7.3
Revenue per day absent ($)	286	1068	574	1291	1822	1569	3161	3846	2722
Landings per day absent (lb)	566	1736	762	3410	3832	3627	8260	8780	6895
Total revenue ($, million)	3.1	7.2	6.5	35.4	43.3	44.2	24.7	25.4	25.3

[1] Tonnage class (TC) 2 vessels, 5-50 gross registered tons(grt); TC3, 51-150 grt; and TC4, >150 grt; TC1 vessels omitted due to insufficient data

Mid-Atlantic Otter Trawl

In 1996, the total revenue for Mid-Atlantic otter trawlers was derived primarily from summer flounder (23%), *Loligo* and *Illex* squid (20% and 9%, respectively), whiting (14%), and scup (5%). The number of vessels using this gear in the Mid-Atlantic decreased to 356 in 1996, down from a high of 375 in 1995, the highest number since 1988 (Table 7 shows vessel totals since 1991). The increase in vessel numbers since the early 1990s may represent displaced effort from New England in response to tighter effort controls and area closures. The increases in the numbers of vessels in 1995 and 1996 occurred primarily in Tonnage Class 2 (Table 12), with the additions to Tonnage Class 1 being negligible. All tonnage classes exhibited increases in revenue per-day-absent in 1995, that fell again in 1996, despite variations in the average number of days absent from port over the past few years. Average days absent increased in 1996, presumably in an effort to counteract low landings.

Northeast Scallop Dredge

Table 13 shows the activity of the Northeast sea scallop dredge fleet. A dramatic increase in the number of Tonnage Class 2 vessels is evident, partly owing to part-time scallopers who did not use their permit in 1995 but did so in 1996. Total revenue (in actual dollars) rose over all three years in all size categories of vessels. Among Tonnage Class 2 and 4 vessels, revenue per-day-absent dropped off in 1996 while it rose slightly for Tonnage Class 3. Landings per-day-absent increased in 1996 for Tonnage Class 3 and 4 vessels.

Table 13. Characteristics, activity, and revenue data for Northeast vessels using scallop dredges, by vessel tonnage class, 1994-1996; data for all trips included, regardless of gear used[1]

	Tonnage Class 2			Tonnage Class 3			Tonnage Class 4		
	1994	1995	1996	1994	1995	1996	1994	1995	1996
Number of vessels	65	64	120	82	80	82	131	134	132
Average age	22	21	19	21	44	34	18	18	17
Average grt	23	21	19	120	118	120	181	181	180
Average days absent	73	70	61	195	220	218	198	242	295
Average crew size	2.6	2.5	2.5	7.5	7.6	7.3	9.1	9.1	8.3
Revenue per day absent ($)	639	665	498	1580	1518	1586	2310	2011	1825
Landings per day absent (lb, live wt)	873	979	848	4499	2714	3865	3784	3191	3671
Total revenue ($, million)	3.0	3.0	3.6	25.3	26.7	28.4	59.9	65.2	71.1

[1] Tonnage Class (TC) 2 vessels, 5-50 gross registered tons (grt); TC3, 51-150 grt; and TC4, >150 grt; TC1 vessels were omitted due to insufficient data

Northeast Shrimp Trawl

The northern shrimp fishery is seasonal (winter/spring.) In 1996, 98% of shrimp landings were made by vessels using shrimp trawls and 94% of the fleet consisted of Tonnage Class 2 or 3 vessels. The principal gears used by shrimp vessels during the six month off-season are otter trawls, gillnets, and lobster traps.

Table 14 shows the activity of the shrimp fleet, both in-season (shrimp trawls only) and off-season. Shrimp trawl gear was used during 61% of the days spent at sea, and contributed 45% to the total fleet revenues. In 1996, revenue and landings per-day-absent declined.

Table 14. Characteristics, activity, and revenue data for Northeast vessels using shrimp trawls, by vessel tonnage class 1994 - 1996; data included for all trips and trips using shrimp gear only[1,2]

	Tonnage Class 1			Tonnage Class 2			Tonnage Class 3		
	1994	1995	1996	1994	1995	1996	1994	1995	1996
All Trips									
Number of vessels	8	15	20	202	237	258	36	49	52
Average age	12	15	15	19	18	18	24	24	20
Average grt	3	3	3	22	22	22	77	80	85
Average days absent	-	-	-	37	34	39	-	-	-
Average crew size	2.1	2.3	2.1	2.3	2.4	2.3	3.4	3.2	3.3
Revenue per day absent ($)	-	-	-	1952	2250	1781	-	-	-
Landings per day absent (lb)	-	-	-	2711	2720	2487	-	-	-
Total revenue ($, million)	0.5	0.8	0.8	14.6	18.1	17.9	7.5	12.1	13.5
Trips Using Shrimp Trawls Only									
Average days absent	-	-	-	28	-	24	-	-	-
Average crew size	2.1	2.3	2.1	2.3	2.4	2.3	3.4	3.2	3.3
Revenue per day absent ($)	-	-	-	752	-	1310	-	-	-
Landings per day absent (lb)	-	-	-	971	-	1834	-	-	-

[1] Tonnage Class (TC) 1 vessels, <5 gross registered tons (grt); TC2, 5-50 grt; TC3, 51-150 grt; and TC4, >150 grt

[2] Dash indicates fewer than 10 vessels available on which to base effort estimates

Northeast Gillnet

This gear category excludes data for trips using large-mesh drift-net gear in the large pelagic fishery. In 1996, total revenue for small-mesh drift and sink gillnets was derived primarily from cod (24%), goosefish (24%), spiny dogfish (16%), and pollock (10%). Gillnet vessels are for the most part Tonnage Class 2 vessels that employ other gear (usually otter trawls and shrimp trawls) for approximately 15% of the year on average.

The number of vessels in this fishery increased from 367 in 1994 to 472 in 1996 (Table 15); this reflects in part changes in reporting systems, as mentioned. For the fleet as a whole, average revenue per-day-absent and landings per-day-absent decreased between 1996 and 1995.

Hook

This category of gear includes longlines, setlines, and line trawls. In 1996, 83% of the total revenue from these related gears was attributed to swordfish (26%), bigeye tuna (20%), cod (15%), yellowfin tuna (12%), and tilefish (10%).

Participation in this fleet increased from 316 vessels in 1994 to 362 vessels in 1995, before dropping to 278 vessels in 1996 (Table 16). Revenue per-day-absent for Tonnage Class 2 vessels increased over 1995 levels, although total revenue declined for Tonnage Classes 1, 2 , and 3.

Surfclam and Ocean Quahog Dredge

This fishery has stabilized in many respects owing to the individual transferable quota (ITQ) management system implemented in 1991. In 1995, the number of vessels in the fishery declined by 16% (to 100, which includes Tonnage Class 1) after several years of stability, as vessel quotas were further consolidated. In 1996 the number of vessels remained stable (101, including Tonnage Class 1).

The activity summarized in Table 17 is divided between the activity of all vessels in the Northeast region using surfclam/ocean quahog dredges and those vessels landing only in Mid-Atlantic ports. Of the 101 vessels operating in the region in 1996, 47 landed outside the Mid-Atlantic area.

During the last five years, some vessel owners agreed to harvest surfclams owned under another ITQ. These vessels received about half the market price of the catch. The lower price received by these vessels reflected the rental price for capital and labor services to harvest the resource, which was lower than the full market value of the clams. The ITQ owner then received the difference between the rental price and the full fair market value. The revenue for the surfclam fishery, as stated in Table 5, was adjusted so that the prices paid to ITQ owners were taken into account. In the case of vessel performance, however, unadjusted revenues are reported, reflecting what vessels actually earned (Table 17).

Table 15. Characteristics, activity, and revenue data for Northeast vessels using gillnets, by vessel tonnage class, 1994-1996; data included for all trips and trips using gillnets only[1,2]

	Tonnage Class 1			Tonnage Class 2			Tonnage Class 3		
	1994	1995	1996	1994	1995	1996	1994	1995	1996
All Trips									
Number of vessels	14	37	25	331	424	394	22	27	53
Average age	17	17	16	19	19	17	16	18	17
Average grt	3	2	3	18	19	20	97	84	80
Average days absent	43	24	55	150	105	121	-	153	165
Average crew size	1.9	1.8	2.3	2.7	2.7	2.7	4.2	3.8	4.0
Revenue per day absent ($)	448	1439	786	553	874	753	3230	2232	1112
Landings per day absent (lb)	1338	2844	1701	1061	1594	1532	3683	2031	1607
Total revenue ($, million)	0.3	1.3	1.1	27.5	38.9	35.9	6.9	7.1	9.7
Trips Using Gillnets Only									
Average days absent	38	17	36	140	94	104	-	-	116
Average crew size	1.9	1.8	2.3	2.7	2.7	2.7	4.2	3.8	4.0
Revenue per day absent ($)	331	1463	661	472	718	632	-	-	402
Landings per day absent (lb)	1170	3358	1988	1000	1485	1488	-	-	694

[1] Tonnage Class (TC) 1 vessels, <5 gross registered tons (grt); TC2, 5-50 grt; TC3, 51-150 grt; TC4 vessels omitted due to insufficient data
[2] Dash indicates fewer than 10 vessels available on which to base effort estimates

Offshore Lobster Traps/Pots

The delineation between offshore and inshore lobster fisheries is not precise, as many vessels fish both sides of the three-mile line that divides inshore from offshore. Roughly 20% of the lobster revenue in 1996 was from offshore trips, while 80% was from inshore. A small portion of lobsters are taken offshore as bycatch by the otter trawl fleet.

The offshore lobster fleet is dominated by Tonnage Class 2 and 3 vessels. Activity by Tonnage Class 1 and 4 vessels was too limited for inclu-

Table 16. Characteristics, activity, and revenue data for Northeast vessels using hook gear, by vessel tonnage class, 1994-1996; data included for all trips and trips using hook gear only[1,2]

	Tonnage Class 1			Tonnage Class 2			Tonnage Class 3			Tonnage Class 4		
	1994	1995	1996	1994	1995	1996	1994	1995	1996	1994	1995	1996
All Trips												
Number of vessels	58	70	19	184	217	184	61	59	58	13	16	17
Average age	15	14	17	15	16	15	17	17	17	14	14	12
Average GRT	2	2	3	20	20	20	94	95	95	173	168	167
Average days absent	32	12	-	89	62	57	-	-	-	-	-	-
Average crew size	2.2	2.0	2.2	2.5	2.6	2.6	4.6	4.5	5.5	6.2	6.4	5.5
Revenue per day absent ($)	262	2245	-	839	1240	1371	-	-	-	-	-	-
Landings per day absent (lb)	319	1895	-	934	1617	1983	-	-	-	-	-	-
Total revenue ($, million)	0.5	1.9	0.3	13.7	16.7	14.4	18.1	14.9	12.8	4.5	5.3	9.8
Trips Using Hook Gear Only												
Average days absent	30	12	-	79	42	44	-	-	-	-	-	-
Average crew size	2.2	2.0	2.2	2.5	2.6	2.6	4.6	4.5	5.5	6.2	6.4	5.5
Revenue per day absent ($)	122	1632	-	577	945	779	-	-	-	-	-	-
Landings per day absent (lb)	167	1035	-	491	1046	965	-	-	-	-	-	-

[1] Tonnage Class (TC) 1 vessels, <5 grt; TC2, 5-50 grt; TC3, 51-150 grt; and TC4, >150 grt
[2] Dash indicates fewer than 10 vessels available on which to base effort estimates

sion in Table 18. The inshore fleet is dominated by Tonnage Class 1 and 2 vessels.

Total revenue (and landings) of offshore lobster increased in 1996, but revenue per-day-absent fell for the smaller vessels. Both Tonnage Class 2 and 3 vessels relied heavily on offshore lobster pots; it apparently was not worthwhile for these vessels to diversify to other gear types.

AQUACULTURE

Although aquaculture is growing and has potential for supplementing wild-catch fishery products in many seafood markets, aquacultural activities in the Northeast are mostly experimental. The success of Atlantic salmon farms, however, has sparked interest in raising other species. Salmon production in Maine rose substantially in 1995 (as growers concentrated strictly on Atlantic salmon), while production of steelhead trout declined. The rate of growth of domestic farm-raised salmon in the Northeast has since slowed, owing to the scarcity of high quality sites and the cost of obtaining new farming permits. Almost all of the increase in production in the last several years has been at existing leases, as opposed to additional lease sites.

Considerable effort is being expended to examine the possibility of farm-raising a number of species that are presently available in commercial quantities only through wild harvest. Recent restrictions on traditional fishing practices have greatly increased interest in raising cod, haddock, and summer flounder experimentally in the Northeast. Surfclam, soft-shell clam, mussel, oyster, bay scallop and sea scallop are also emerging as viable species for aquaculture shellfish projects.

TRADE

Historically, the Northeast region has run a trade deficit in edible fishery products because of the large port of entry in the city of New York and the region's proximity to Canadian fishing ports. Between 1994 and 1996, this deficit decreased by $230.1 million. Imports declined by $155.2 million (6.6%) in value between 1994 and 1996, while exports increased $74.9 million (14%). (See Tables 19 and 20).

Increases in the value of product specific imports during this time (Table 19) include fresh or frozen salmon ($21.8 million), frozen

Table 17. Characteristics, activity, and revenue data for Northeast surfclam and ocean quahog vessels and Mid-Atlantic vessels only, by vessel tonnage class, 1994-1996[1,2]

	Tonnage Class 2			Tonnage Class 3			Tonnage Class 4		
	1994	1995	1996	1994	1995	1996	1994	1995	1996
All Regional Surfclam/Ocean Quahog Vessels									
Number of vessels	35	29	39	59	44	33	24	23	25
Average age	20	20	13	25	23	21	20	20	20
Average grt	20	15	15	104	112	113	176	176	177
Average days absent	31	60	51	80	106	87	-	-	-
Average crew size	2.6	2.5	2.6	4.0	4.0	4.3	4.9	5.0	5.0
Revenue per day absent ($)	1409	1076	1201	6474	6422	10228	-	-	-
Landings per day absent (lb, live wt)	6524	4316	4433	73826	70176	108811	-	-	-
Total revenue ($, million)	1.5	1.9	2.4	30.6	30.0	29.4	22.9	21.3	23.2
Mid-Atlantic Surfclam/Ocean Quahog Vessels Only									
Number of vessels	9	3	2	49	36	31	24	22	21
Average days absent	-	-	-	65	109	66	-	-	-
Average crew size	3.0	3.6	3.5	4.0	4.3	4.3	4.9	4.7	5.2
Revenue per day absent ($)	-	-	-	490	7270	14006	-	-	-
Landings per day absent (lb, live wt)	-	-	-	99727	78042	145290	-	-	-
Total revenue ($, million)	0.6	0.7	0.4	27.0	28.5	28.7	22.9	20.8	19.9

[1] Tonnage Class (TC) 2 vessels, 5-50 gross registered tons (grt); TC3 vessels, 51-150 grt; and TC4 vessels, > 150 grt; TC1 vessels were omitted due to insufficient data
[2] Dash indicates fewer than 10 vessels available on which to base effort estimates

Table 18. Characteristics, activity, and revenue data for Northeast vessels using offshore lobster gear by vessel tonnage class, 1994-1996; data included for all trips and offshore lobster trips only[1]

	Tonnage Class 2			Tonnage Class 3		
	1994	1995	1996	1994	1995	1996
All Trips						
Number of vessels	56	59	81	34	38	38
Average age	20	21	18	15	14	13
Average grt	25	22	22	85	83	91
Average days absent	48	35	35	199	184	221
Average crew size	3.5	2.5	2.6	4.3	4.3	4.3
Revenue per day absent ($)	1844	2125	2061	1419	1471	1744
Landings per day absent (lb)	948	1282	1304	663	689	830
Total revenue ($, million)	5.0	4.4	5.8	9.6	10.3	14.6
Offshore Lobster Trips Only						
Average days absent	43	35	33	159	184	212
Average crew size	3.5	2.5	2.6	4.3	4.3	4.3
Revenue per day absent ($)	1103	982	1477	1619	1361	1269
Landings per day absent (lb)	398	393	532	615	541	501

[1] Tonnage Class (TC) 2 vessels, 5-50 gross registered tons (grt); TC3, 51-150 grt; TC1 and TC4 vessels were omitted due to insufficient data.

groundfish blocks ($31.8 million); fresh lobster ($7.1 million); and other lobster products ($9.0 million). These were offset by decreases in the value of imported fresh or frozen sea herring ($1.8 million), frozen whole groundfish, halibut and other flatfish ($2.5 million), ocean perch fillets ($20.2 million), fresh groundfish and flatfish fillets ($4.6 million), frozen groundfish and flatfish fillets ($11 million), canned tuna ($28.6 million), minced fish ($12.6 million), crab products ($10 million), frozen lobster ($12.7 million), scallops ($35.6 million), and shrimp products ($151 million).

Product-specific exports (Table 20) that increased in value between 1994 and 1996 included fresh or frozen herring ($2.5 million), processed herring products ($5.7 million), fresh or frozen salmon ($10.6 million), fresh or frozen cod ($8.2 million), fresh or frozen mackerel ($2.6 million), fresh or frozen dogfish ($8.1 million), fresh or frozen fish fillets ($9.9 million), fish sticks and portions ($1.7 million), roe products other than sea urchin roe ($1.9 million), fresh lobster ($19.9 million), frozen lobster ($2.9 million), fresh shellfish ($2.6 million), and fresh or frozen scallops ($1.5 million). These were partially offset by decreases in the value of exports of fresh or frozen tuna ($9.3 million), live sea urchin ($2.8 million), sea urchin roe ($7.8 million), frozen shrimp ($1.4 million), canned shrimp ($1.1 million), crab products ($1.8 million), and fresh or frozen squid ($9.7 million).

Canada has traditionally been the largest fishery trading partner for the New England states. Between 1994 and 1995, however, overall imports into New England increased, while Canadian imports declined (Table 21). This was followed in 1996 by both an increase in overall imports, and an increase in Canadian imports over 1995 levels. Overall Canadian market share dropped from 27% to 22% between 1994 and 1995, and then increased to 24% in 1996. Because Canada closed several major fishing areas and implemented other restrictive harvesting practices over the last several years, the drop in Canadian imports is not surprising. Among the individual categories, Canadian market share of cod, other finfish, and scallops increased during this time period, while market share of other groundfish and flatfish declined. The Canadian market share of scallops increased, even though the total imports of scallops from Canada declined. This is owing to a general decline in scallop imports between 1994 and 1996.

Table 19. Value of imported edible fishery products in the northeast, 1994-1996 (millions of dollars)

Product Category	1994	1995	1996
Fresh or frozen sea herring	3.4	1.6	1.6
Fresh whole groundfish, halibut and other flatfish	40.0	35.7	39.9
Frozen whole groundfish, halibut and other flatfish	18.3	20.1	15.8
Fresh or frozen salmon	68.1	70.9	89.9
Frozen groundfish blocks	120.7	157.0	152.5
Other fish fresh or frozen	69.9	71.3	74.9
Ocean perch fillets	61.2	53.6	41.0
Fresh groundfish and flatfish fillets	39.3	35.3	34.7
Frozen groundfish and flatfish fillets	287.2	296.4	276.2
Other fresh or frozen fillets	141.4	147.7	151.0
Salted or dried groundfish	35.2	34.3	35.0
Salted herring	3.8	3.4	3.2
Canned tuna	141.4	123.0	112.8
Canned sardines	29.2	32.2	28.7
Minced fish	25.4	12.1	12.8
Clam products	12.3	11.1	11.6
Crab products	87.1	86.0	77.1
Lobster, fresh	117.4	125.0	124.5
Lobster, frozen	161.7	168.0	149.0
Other lobster products	48.8	56.2	57.8
Scallops	158.4	134.5	122.8
Shrimp products	503.3	440.9	352.3
Squid	19.8	19.3	25.2
Other fishery products	164.7	182.8	212.5
Totals	**2,358.0**	**2,318.4**	**2,202.8**

Table 22 lists the top ten countries (by value) receiving exports of fishery products from the Northeast region during 1994, 1995, and 1996. Canada was the region's most important trading partner in terms of export value, followed by Japan. Six of the top ten countries belonged to the European Union, and as a block they accounted for more of the total export value than did Japan. Exports to the top ten nations increased in value 7% between 1994 and 1995, and 1% between 1995 and 1996. Together, the top ten nations accounted for 78% of the value of all fishery product exports from the Northeast Region in 1996.

Table 20. Value of exported fishery products (including re-exports)[1] in the Northeast, 1994-1996 (millions of dollars)

Product Category	1994	1995	1996
Fresh or frozen herring	1.1	1.2	3.6
Processed herring products	9.8	11.1	15.5
Fresh or frozen salmon	25.6	36.1	36.2
Fresh or frozen cod	6.1	14.3	14.3
Fresh or frozen mackerel	2.1	2.3	4.7
Fresh or frozen dogfish	20.1	26.6	28.2
Butterfish	3.2	2.2	3.5
Fresh or frozen tuna	23.8	18.4	14.5
Other fish, fresh or frozen	74.2	95.3	96.0
Fresh or frozen fish fillets	22.5	30.0	32.4
Fish sticks & portions	3.1	4.3	4.8
Sea urchin, live	10.7	10.1	7.9
Sea urchin, roe	56.6	53.3	48.8
Other roe products	7.9	10.2	9.8
Shrimp fresh	3.1	2.0	3.2
Shrimp frozen	40.3	43.7	38.9
Shrimp canned	10.0	10.9	8.9
Lobster, fresh	107.7	109.7	127.6
Lobster, frozen	4.8	7.1	7.7
Other lobster products	0.2	0.4	1.0
Crab products	9.6	7.9	7.8
Fresh or frozen squid	22.4	21.1	12.7
Shellfish fresh	5.2	6.5	7.8
Clam products	4.4	4.4	4.7
Fresh or frozen scallops	14.0	15.1	15.5
Other shellfish	5.4	5.7	8.1
Other edible fishery products	40.8	37.8	45.5
Totals	534.7	587.7	609.6

[1] Re-exports consist of commodities of foreign origin which have entered the United States for consumption or into Customs bonded warehouses or U.S. Foreign Trade Zones, and which, at the time of exportation, are in substantially the same condition as when imported (U.S. Census Bureau, Guide to Foreign Trade Statistics, Internet address: http://www.census.gov/foreign-trade/www/sec2.html)

Table 21. New England imports of selected fishery products[1] from Canada and all other countries 1994-1996 (thousands of metric tons)

	1994		1995		1996	
Product	Canada	Other	Canada	Other	Canada	Other
Cod	27.3	125.6	23.8	130.7	33.9	105.8
Flatfish[2]	17.1	16.0	12.2	28.3	14.0	15.8
Other groundfish[3]	58.3	185.4	49.9	204.2	44.1	244.5
Other finfish	28.1	44.1	23.6	45.5	31.6	39.4
Scallops	8.6	5.1	6.6	4.8	5.9	2.8
Total	139.4	376.2	116.1	413.5	129.5	408.3

[1] With the exception of scallops, product forms include whole fresh or frozen, frozen blocks, and fresh or frozen fillets. Finfish weights are expressed in live weight equivalents and scallops in meat weight equivalents.

[2] Includes halibut.

[3] Includes cusk, hake, haddock, pollock, and ocean perch.

PROCESSING

Fish processors in the Northeast Region use both domestic landings and, increasingly, imported products. Processing is defined as any activity that adds value to raw products, for example, filleting, cooking, breading, canning, or smoking. The most important processed products (by value) are fresh or frozen fish fillets, and breaded, cooked fish.

In 1995, New England plants produced most (92%) of the fresh and frozen fish fillets, steaks, or other processed portions produced in the Northeast, while Mid-Atlantic plants produced 73% of the canned products and 91% of the cured products.

Edible fish product processing of regionally caught species was led 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 processed product surveys during 1990-1995) are shown in Table 23.

In New England, the number of employees in processing plants increased in 1995, after two particularly low years in 1993 and 1994. Employment in Mid-Atlantic processing plants declined annually through 1994, but increased in 1995.

The number of processing firms throughout the Northeast region has declined steadily through 1995, reflecting the shrinking supply of fresh domestic fish as well as little substitution of imported product for domestic. The average number of employees per plant has increased, since the number of processing plants in the region is at a new low.

The number of plants and employees in wholesaling establishments in the region (both New England and Mid-Atlantic) showed a dramatic rise in 1995 (61% for number of employees; 42% for number of plants). The number of wholesaling plants in the Mid-Atlantic more than doubled in 1995.

FOREIGN FISHING AND JOINT VENTURES

Foreign fishing operations within 200 miles of the U.S. coastline came under direct federal control through the passage of the Magnuson Fishery Conservation and Management Act in 1976. Joint venture arrangements started in 1982. Since that time, directed foreign fishing has been phased out; and during 1992-1996, there were no joint ventures within this region.

Internal Waters Processing arrangements have been successful, stable operations for more than 10 years. These programs are administered by the states (Maine, Massachusetts, Rhode Island, New York, and New Jersey in particular) and allow U.S. vessels to fish for herring (and some mackerel) in state waters and offload to foreign ships (Russian) for processing. In 1994, 1995, and 1996, a handful of vessels were involved and about 3,000, 9,000, and 11,000 mt of herring were landed, respectively, in each year under these agreements.

RECREATIONAL FISHING

Preliminary data collected by the Marine Recreational Fisheries Statistics Survey (MRFSS) indicate that the total number of finfish caught by recreational anglers in the Northeast Region declined to 109.8 million in 1996 (from 110.5 million in 1995; Figure 11). Catches in the Mid-Atlantic decreased slightly (from 88.5 million fish in 1995 to 86.4 million fish in 1996), while catches in New England increased 6% (from 22.0 million fish in 1995 to 23.4 million fish in 1996). Anglers in the Mid-Atlantic accounted for approximately four times the finfish catch of their counterparts in New England.

Striped bass, scup, Atlantic mackerel, bluefish and summer flounder were the most common recreationally caught species in 1996 in New England (Figure 12). Together, these

Table 22. Top ten countries receiving exports of fishery products from the Northeast region, ranked by value of exports 1994-1996 (millions of dollars)

	Year		
Country	1994	1995	1996
Canada	151.4	180.5	189.1
Japan	118.2	106.7	96.7
France[1]	60.0	55.5	57.1
South Korea	19.7	31.6	27.2
Spain[1]	26.4	23.3	26.2
United Kingdom[1]	14.5	19.4	22.6
Italy[1]	23.9	23.3	21.1
Germany[1]	8.7	15.4	17.3
Hong Kong	7.9	9.0	11.6
Belgium[1]	10.8	9.2	8.8
Total	**441.5**	**473.9**	**477.7**

[1]Denotes European Union countries

Table 23. Processing and wholesaling establishments for marine products and their employment levels for 1990-1995[1]

	Processing		Wholesaling		Total	
Year/Area	Plants	Employees	Plants	Employees	Plants	Employees
1990						
New England	247	5,832	689	2,928	936	8,760
Mid-Atlantic[2]	178	6,890	357	2,278	535	9,168
Totals	425	12,722	1,046	5,206	1,471	17,928
1991						
New England	245	5,530	685	2,976	930	8,506
Mid-Atlantic	166	6,776	333	2,158	499	8,934
Totals	411	12,306	1,018	5,134	1,429	17,440
1992						
New England	232	5,367	698	2,912	932	8,279
Mid-Atlantic	171	6,516	364	2,354	529	8,870
Totals	403	11,883	1,062	5,266	1,465	17,149
1993						
New England	221	4,727	670	3,041	891	7,768
Mid-Atlantic	161	6,027	348	2,490	509	8,517
Totals	382	10,754	1,018	5,531	1,400	16,285
1994						
New England	206	4,794	614	3,471	820	8,265
Mid-Atlantic	144	5,036	317	3,056	461	8,092
Totals	350	9,830	931	6,527	1,281	16,357
1995						
New England	194	4,952	625	5,043	819	9,995
Mid-Atlantic	127	5,385	697	5,489	824	10,874
Totals	321	10,337	1,322	10,532	1,643	20,869

[1] Data for 1996 not available
[2] Mid-Atlantic region includes Virginia, Maryland, District of Columbia, Delaware, New Jersey, New York, and Pennsylvania

five species compose roughly 75% (by number) of the total New England recreational catch. Of particular interest is the absence of Atlantic cod in Figure 12. For the first time since 1992, Atlantic cod was not one of the top five most-caught species in New England.

In the Mid-Atlantic, the five most commonly caught recreational species were the same as in 1995. Summer flounder, Atlantic croaker, black sea bass, weakfish, and striped bass were the most commonly caught species, in order, in 1996 (Figure 13). These species accounted for approximately 63% of the total recreational catches in number (up from 59% in 1995).

Recreational fishing effort in the Northeast Region reached a 10-year high in 1996. Approximately 23.3 million trips were taken in 1996, a 5.2% increase from 1995 (22.1 million; see Figure 14). In the Mid-Atlantic, effort increased considerably (from 15.5 million to 16.5 million) to a new high, while effort in New England matched the 10-year high set in 1991 (6.8 million).

Shore fishing trips outnumbered private/rental boat trips for the second consecutive year in New England and accounted for the highest percentage of recreational fishing effort (48% of total fishing trips; Figure 15). Private/rental boat fishing was second (46% of trips), and party/charter boat fishing was third. Effort increased slightly in the shore mode (from 3.1 million trips in 1995 to 3.2 million in 1996). Private/rental fishing increased moderately (from 2.9 million trips to 3.1 million) and party/charter boat fishing trips declined to 0.4 million trips (from 0.5 million trips in 1995).

In the Mid-Atlantic, private/rental boat fishing accounted for the highest percentage of recreational fishing effort (53% of total fishing trips; Figure 16). Shore fishing was second (36% of trips), and party/charter boat fishing was third. Effort increased slightly in the private/rental boat mode (from 8.4 million trips in 1995 to 8.7 million in 1996). Shore fishing reached a 10-year high in 1996.

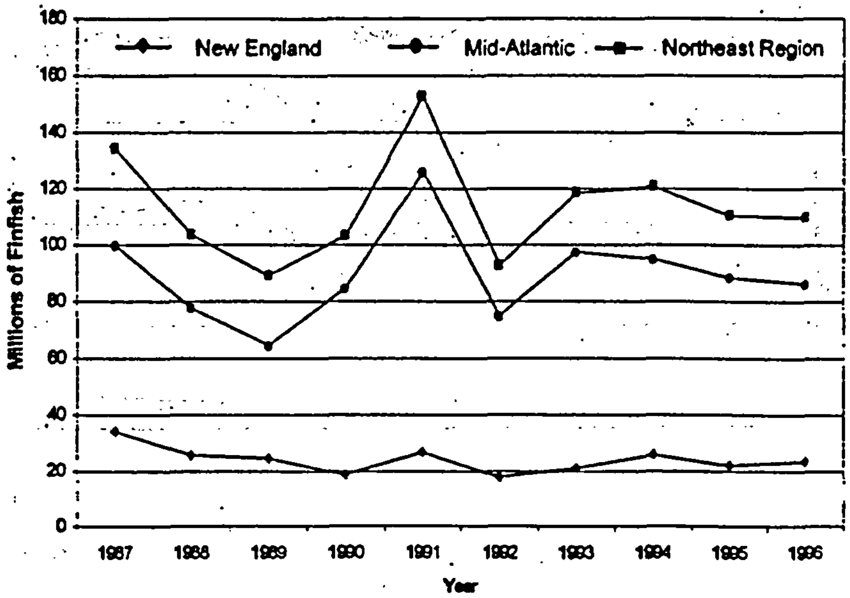


Figure 11. Estimated number of fish caught by recreational fishermen, by subregion.

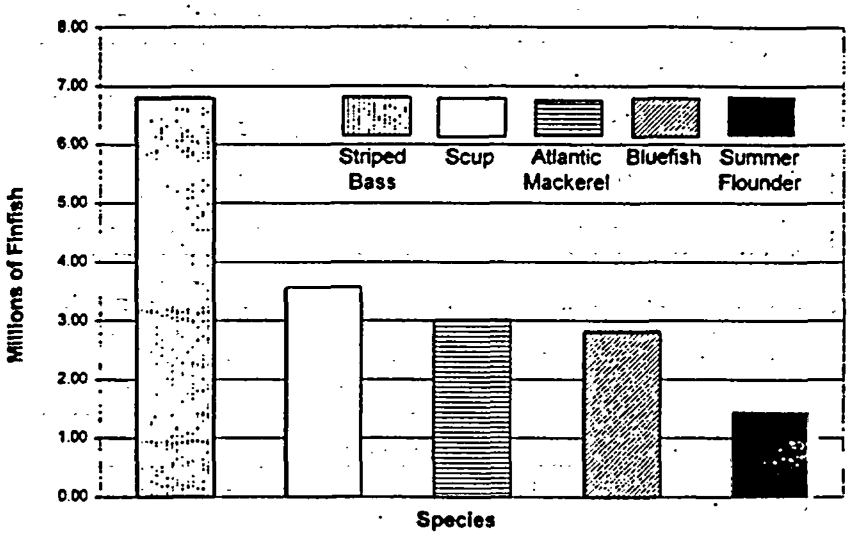


Figure 12. Top five species caught by recreational fishermen in New England in 1996.

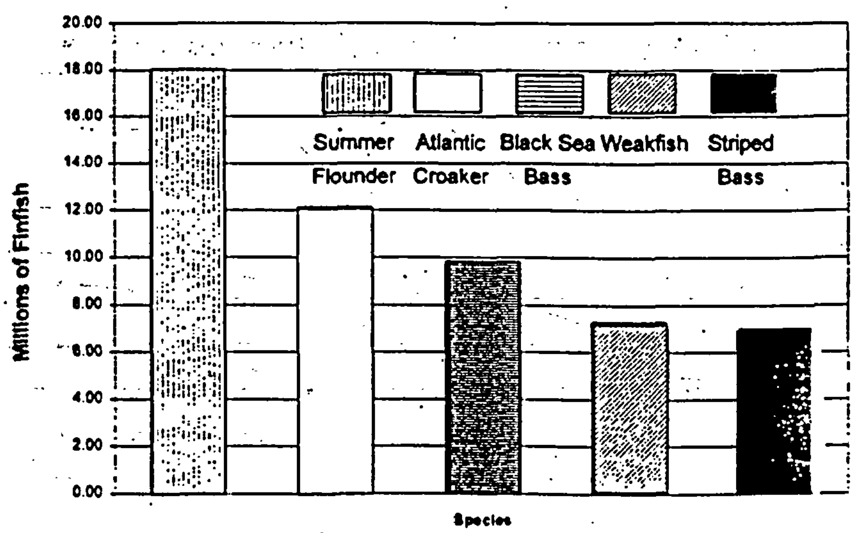


Figure 13. Top five species caught by recreational fishermen in the Mid-Atlantic in 1996.

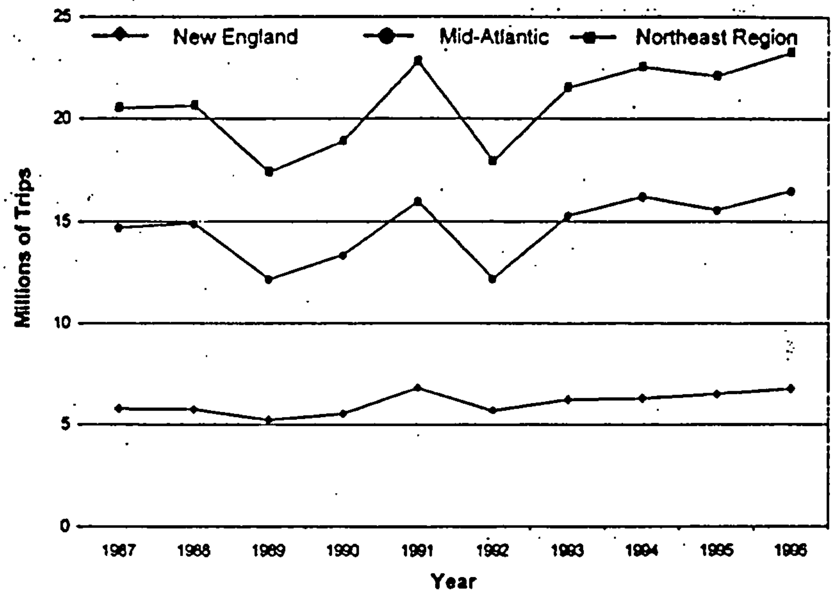


Figure 14. Estimated number of recreational fishing trips by subregion, 1987-1996.

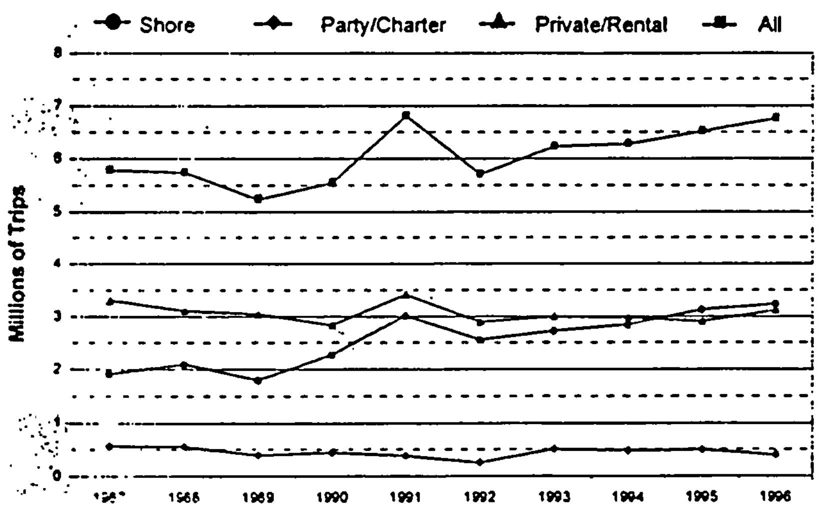


Figure 15. Estimated number of recreational fishing trips by mode in New England, 1987-1996.

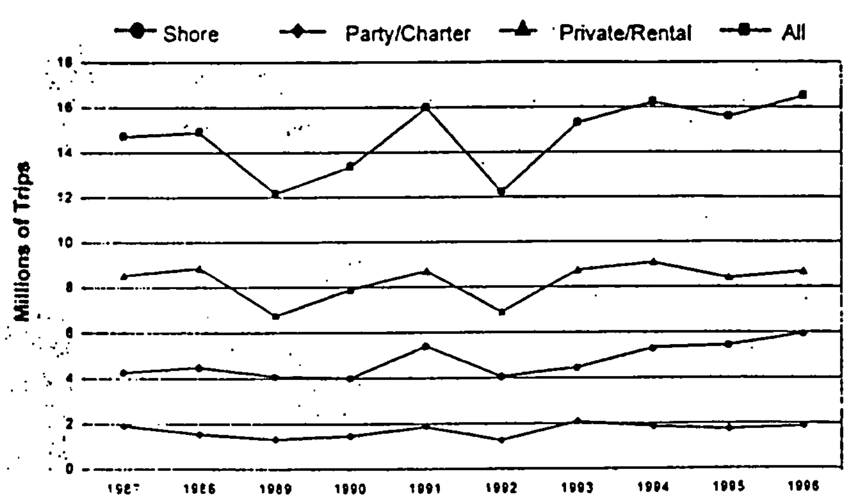


Figure 16. Estimated number of recreational fishing trips by mode in the Mid-Atlantic, 1987-1996.

Approximately 5.9 million trips were taken in 1996, an 8.6% increase from 1995 (5.4 million). Party/charter boat fishing trips increased slightly to 1.9 million trips (from 1.7 million in 1995).

The NMFS has increased efforts to collect marine recreational economic and social data in the Northeast Region in recent years. A comprehensive economic survey of recreational anglers in the Northeast Region was conducted in 1994 in conjunction with the MRFSS and a similar survey is being conducted in 1998. In addition, the MRFSS has recently begun to collect economic information as part of its baseline survey, and economic studies of the party/charter industry have been funded in Maine, Massachusetts, New York, and New Jersey. Over time, social and economic data collected from these studies will help provide a foundation for evaluating marine recreational fisheries and future recreational policies.

NET NATIONAL BENEFITS

Previous issues of this report have discussed how economics relate to the Magnuson Act of 1976, and presented various economic concepts, including resource rents and the economic value of fish resources based on their ability to grow and reproduce. A recent report, "Our Living Oceans, The Economic Status of U.S. Fisheries" also provides a thorough discussion of this topic.

Many of the fisheries in the Northeast Region are moving toward various types of limited access that could lead to greater fleet efficiency. In the groundfish, summer flounder, lobster, and sea scallop fisheries, moratoria on entry are in place; in the surfclam and ocean quahog fishery, individual transferable quotas have been in effect since 1990.

Special Topic:

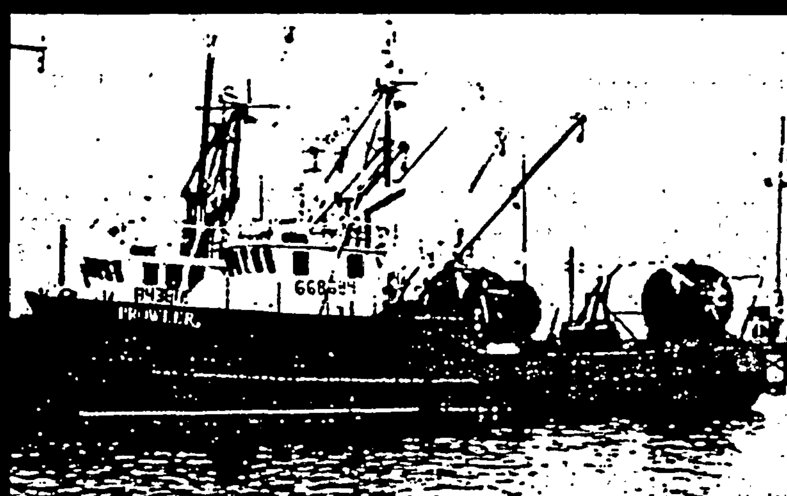
The Northeast Groundfish Fishery Buyout Program

by A. Kitts
E. Thunberg
G. Sheppard

INTRODUCTION

Since the passage of the Magnuson-Stevens Fishery Conservation and Management Act and establishment of the Exclusive Economic Zone (EEZ) in 1977, the fishery for groundfish in the northeastern U.S. has been managed under three fishery management plans (FMPs) developed by the New England Fishery Management Council (Council) and NOAA's National Marine Fisheries Service (NMFS). From 1977 to 1982, the fishery was managed primarily by quotas for cod, haddock, and yellowtail flounder. During this period, the stocks began rebuilding following historic overfishing by foreign fleets.

Even as the foreign fleets were being excluded from the EEZ, the U.S. domestic fleet was experiencing an unprecedented increase in new vessel construction. This increase was due, in varying degrees, to the economic opportunity created by both the displacement of the foreign fleets and increased stock abundance and to a suite of incentive programs (*i.e.* the Fishing Vessel Obligation Guarantee Program, and the Fishing Vessel Capital Construction Fund Program) to encourage replacement and new construction of fishing vessels. Furthermore, the increase in fleet size was not limited by the management plan.



Maine-based trawler *F/V Prowler* was one of 79 vessels whose owners submitted successful bids for buyout funds.

Photo courtesy NOAA Fisheries NERO

Trends in vessel construction and vessel entry into the northeast groundfish fishery are difficult to discern due to changing data collection protocols and inconsistent reporting over time. Additions to the U.S. domestic fishing fleet were routinely reported in the *Fisheries of the United States* (*FUS*) from 1964 to 1972. However, no distinction was made between newly constructed vessels and vessels that may have been converted to fishing from some other use. By contrast, data on newly constructed vessels from 1973 to 1980 were reported in the *FUS* but numbers of vessels converted from other uses were not reported. Throughout this time series, whether any of the added or newly constructed vessels were ever used for fishing purposes were not reported. Data on vessel activity are

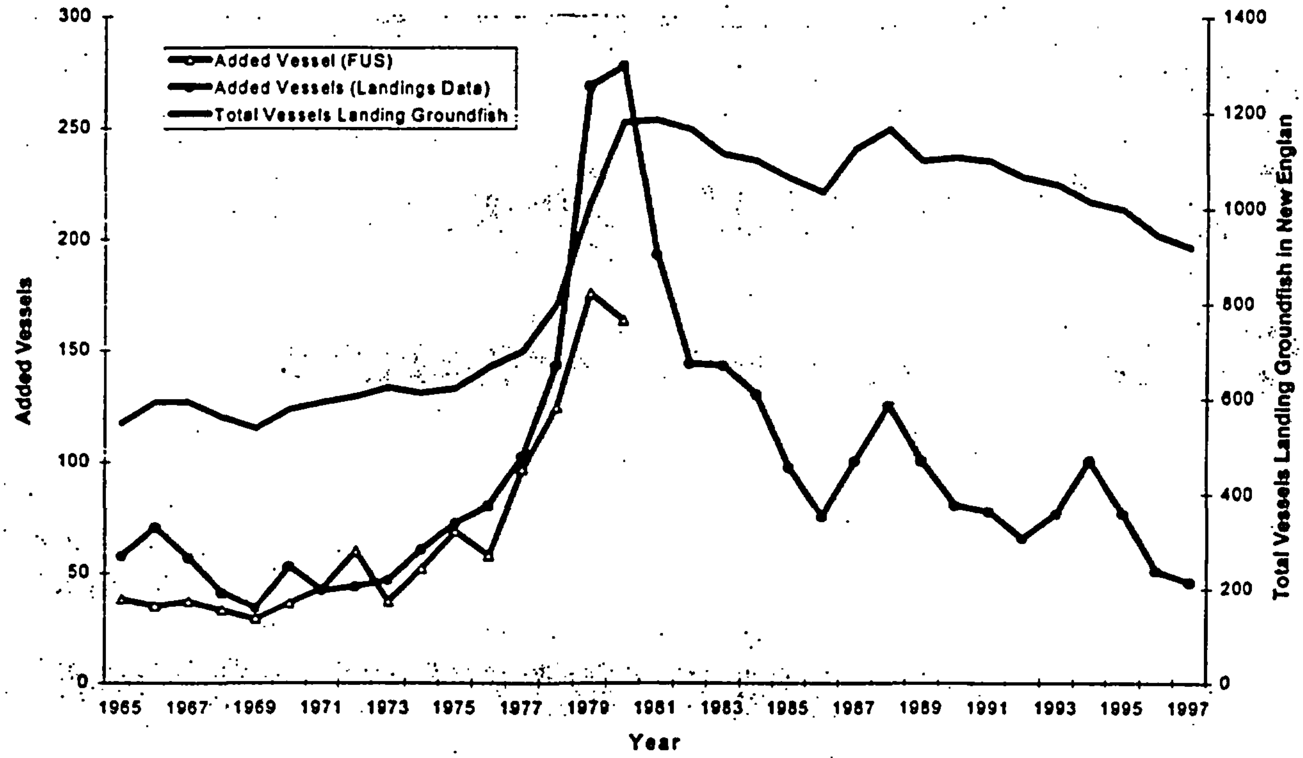


Figure 17. Additions to the New England fishing fleet and total number of vessels landing groundfish in Maine, Massaachusetts, or Rhode Island, 1965-1997.

available from the NMFS weighout data from 1964 to 1997. These data can be used to determine in what year vessels entered the groundfish fleet but cannot be directly linked to the vessel construction data reported in the *FUS*. Nevertheless, the two data sources can be used to draw some inferences about the buildup in the northeast groundfish fleet that occurred between 1974 and 1984.

Figure 17 illustrates patterns of vessel construction (data from *FUS* are denoted by a line with triangle markers) and vessel entry into the northeast groundfish fishery over time. Due to database changes, a consistent time series could only be constructed using data on vessels and landings from three New England states (Maine, Massachusetts, and Rhode Island). These three states account for the majority of vessels and landings of groundfish in the northeast and are likely to be representative of the northeast region as a whole. The total number of identified unique vessels (*i.e.* fishing craft > 5 gross registered tons [GRT]) landing in the New England region (solid line) as well as the total number of vessels > 5 GRT that were added to the landings data base in each year (line with circle markers) are reported in Figure 17.

Each series shows a consistent trend of relative stability in terms of total vessels and added vessels from 1965 until 1973. During this time, an annual average of 581 vessels participated in the New England groundfish fishery. Approximately 50 vessels that had not previously been identified in any prior year were added annually to the weighout landings data. However, in any given year, as new vessels were being added other vessels were leaving for a net annual average increase of nine vessels. Newly constructed or newly documented New England vessels from 1965 to 1973 averaged 38 vessels (FUS).

From 1974 to 1980 the northeast fishing fleet increased dramatically. New vessel construction peaked in 1979 at 176 vessels, an average annual increase of 22.3%. Similarly, the number of vessels that were added to the landings data base increased at an annual rate of 31.1%, to 278 vessels in 1980. The total number of vessels recorded as having landed groundfish in New England was 1,185 in 1980, an average annual increase of 8.7%. Since 1980, the number of New England vessels landing groundfish has gradually declined at a rate of 1.4% per year, but remains at nearly twice that of the pre-Magnuson Act period.

The buildup in the northeast fishing capacity over these years resulted in an increasing number of vessels fishing on annual quotas. Without some basis for controlling the number of participants (for example limited entry or properly specified property rights), effort intensified and quotas were filled rapidly, leading to boom and bust market conditions and numerous management and enforcement problems. At the same time impacts on the resource were becoming evident. Growing dissatisfaction with catch quotas led to their removal and replacement with indirect controls on fishing effort in 1982. These indirect controls (gear restrictions and minimum fish sizes) were implemented under what was called the Interim Plan. This plan was designed to provide adequate resource protection while a more comprehensive and effective approach could be developed. With the near doubling of the number of vessels in the New England groundfish fleet, however, such measures were not sufficient to control exploitation and groundfish stocks continued to decline.

The current Northeast Multispecies Fishery Management Plan or Multispecies Plan became effective in 1986. The Plan added seven more species to the management unit (three more species were added through the amendment process in 1991) and made a number of regulatory changes. However, the basic format of indirect effort control was retained. At present, ten of the species the Council manages under this plan are defined as regulated or "large mesh" species: cod, haddock, pollock, yellowtail flounder, winter or blackback flounder, witch flounder, American plaice, redfish, white hake, and windowpane flounder. The three remaining "small mesh" species are red hake, silver hake, and ocean pout.

Without limiting entry or direct effort controls, groundfish stocks became severely overfished and the resource declined to record low levels. In May 1994, NMFS implemented a major revision to the Multispecies Plan (Amendment 5), as proposed by the Council. Amendment 5 capped the number of vessels in the fishery through a limited access program, and controlled the amount of time many vessels in the fleet could spend at sea. Gillnet vessels were restricted, due to protection measures for harbor porpoise, and hook vessels were limited in the number of hooks allowed. These measures were designed to end overfishing (as defined prior to the 1997 Sustainable Fisheries Act).

Subsequently, the Council began to develop further modifications to the Multispecies Plan to rebuild the depleted resource. Amendment 7 was proposed by the Council in early 1996 and was implemented by NMFS in July 1996. The key components of Amendment 7 were the adoption of a more rigorous days-at-sea (DAS) reduction schedule, the removal of most exemptions from DAS controls, and a more flexible adjustment process to respond to specific resource conditions.

Such measures imposed economic hardships; and several financial assistance programs were implemented to mitigate the economic impact that reduced time at sea would have on fishing industries and marine dependent communities. Through the Emergency Supplemental Appropriations Act of 1994, $30 million was provided to U.S. Department of Commerce for the Northeast Fisheries Assistance Program. This program included the Fishing Capacity Reduction Demonstration Program ($2 million), hereafter referred to as the pilot buyout program, the establishment of Fishing Family Assistance Centers, loan guarantees to improve fishing infrastructure, and research grants to develop opportunities for fishermen in aquaculture, underutilized species, and other businesses. Subsequently, $25 million was made available through the Interjurisdictional Fisheries Act for the Fishing Capacity Reduction Initiative, hereafter referred to as the expanded buyout program. Results of these two buyout programs are described next.

FISHING CAPACITY REDUCTION PROGRAMS

The buyout programs were developed and implemented by NOAA's Office of Sustainable Development (OSD) in two phases beginning with the pilot buyout program initiated in June, 1995. This program was designed to determine the level of interest in such a program and to test a variety of implementation protocols such as bidding procedures, scrapping provisions, and eligibility and selection criteria. The pilot buyout program culminated successfully in February, 1996 with the purchase and disposal of 11 vessels having permits in the Northeast multispecies fishery. Based on a favorable review of the pilot buyout program, the OSD decided to proceed with an expanded version of the vessel buyout program. With relatively few changes to the protocols established under the pilot buyout program, the $23 million expanded buyout program was initiated in September 1996 and by May of 1998, 68 vessels had been removed from the multispecies fishery through this program.

Buyout Objectives

As stated in the Federal Register (June 22, 1995, 60:120:32504) the goal of the pilot buyout was "...to demonstrate that a vessel removal program can be successfully designed and implemented and that such a program can be an effective tool in the conservation and management of U.S. fisheries." Although this goal mentions conservation, the same Federal Register announcement also states that the purpose for the program was "...to address the needs of those directly affected by the decline of traditional fisheries in the Northeast." Thus, the dual purposes of 1) providing a means for distressed groundfishermen to exit the fishery, and 2) conserving the resource by permanently removing groundfish vessels and their related permits were part of the initial design and implementation of both buyout programs. The Federal Register notice for the expanded buyout program (August 28, 1996, 61:168:44300) reiterates these dual purposes by stating that the "...objectives are to provide grants to eligible fishermen adversely impacted by the groundfish fishery disaster, and to aid the long-term viability of the groundfish fishery resource through the reduction of active harvesting capacity at the lowest cost."

Table 24. Principal features of fishing capacity reduction programs

Feature	Pilot Buyout Program	Expanded Buyout Program
Eligibility: possession of multispecies limited access permit	Allowable Amendment 5 permit types (of the 6 possible types): 1) Individual days-at-sea allocation 2) Fleet days-at-sea allocation 3) Gillnet permit	Any of the 7 limited access permit types under Amendment 7
Eligibility: capable of fishing for groundfish in federal waters under own power prior to application	Required	Required
Eligibility: have derived 65% or more of gross annual revenues from 10 regulated groundfish species	For 3 of the 4 years from 1991-1994	For 3 of the 4 years from 1991-1994
Score formula used to rank applicants (lower score = higher rank)	Bid divided by average annual groundfish revenue from the three highest years (1991-1994)	Bid divided by average annual groundfish revenue from the three highest years (1991-1994)
If accepted, surrender all federal fishing permits	Required	Required
If accepted, scrap vessel	Required	Transfers to eligible entities for nonfishing uses allowed

Design of Buyouts

An extensive series of public hearings were held in Northeast ports prior to both buyout programs to elicit support and ideas for designing the program. The resulting design of the buyout reflected many of the features and ideas generated by industry participation. The primary design features for the pilot and expanded vessel buyout programs are listed in Table 24.

To be eligible for the buyout program, the vessels' owner must have possessed a limited access multispecies permit. In the pilot buyout program eligibility was limited to a subset of limited access permit categories. In the expanded buyout program, eligibility was opened to all limited access permit categories. The vessel owners were required to demonstrate that at least 65% of fishing revenue was derived from landings of regulated groundfish species in three of four years from 1991 to 1994, and that their vessel was capable of fishing under its own power in Federal waters.

The bidding was done by a reverse auction, in which each vessel owner was required to prepare a bid or price at which he/she would be willing to render the vessel in an unfishable condition and surrender all Federal fishing permits. Selection of vessels was based on a hierarchical ranking of the ratio of the bid to the vessel's groundfish revenue. This criterion was selected to provide a means for comparing bids across dissimilar vessels. Numerous alternative ranking or scoring methods were discussed based on various combinations of vessel characteristics and groundfish landings or revenues. In the end, average yearly groundfish revenue was believed to be a reasonable proxy for fishing power. It was also easy for applicants to compute their scores. Each vessel was ranked from lowest to highest according to this ratio and selections were made in this order until all budgeted monies were consumed. Owners of selected vessels were then notified and given an opportunity to reconsider. Mutually accepted bids continued on to closure proceedings. Otherwise the vessel was dropped from consideration and the next highest ranked vessel was selected.

Prior to closure, the vessel owner was required to show that the vessel was being scrapped, or sunk or (in the case of the expanded buyout program) committed to some nonfishing use. Vessel owners were required to surrender all Federal fishing permits and to pay any costs associated with scrapping or transferring the vessel, including legal or accounting costs and, paying liens, debts, or taxes. The owner had to consider these costs, together with possible income from the sale of vessel equipment (gear, electronics, etc.) in developing the bid amount. Vessel owners were not required to surrender their right to reenter the multispecies fishery or enter any other fishery provided they could purchase a vessel with the appropriate permits.

DESCRIPTIVE STATISTICS

Vessels Removed

Of the original $27 million budgeted for the vessel buyouts, $2 million was set aside to fund a health insurance program for Northeast fishermen. An additional $0.6 million was used for administrative expenses of the expanded buyout program, leaving $24.4 million for the actual purchase of groundfish vessels. With these funds, 79 vessels were removed; 11 from the pilot buyout and 68 from the expanded buyout program. The average bid for retired vessels was $308,734 and ranged from a low of $50,000 to a high of $1 million. The average score of retired vessels was 0.922 which means that, on average, vessel owners thought the value of their vessel was approximately equal to one year of groundfish revenue (using 1991 to 1994 revenue).

The majority of vessels were either scrapped (62) or sunk (7). Scrapping required permanent disassembly while sinking was to be done in an ecologically safe manner. In addition, transfer to a non-fishing use was permitted in the expanded buyout program. A vessel could be transferred to "...a U.S. public entity, a U.S. nonprofit organization, or a foreign national government for research (including fisheries research), education, training, humanitarian, safety, or law enforcement purposes."(published in *U.S. Federal Register* August 28, 1996; 61:168:44300). Transfers required (1) a provision in the title that the vessel be scrapped once the purpose for which it was transferred had been completed, and (2) a permanent restriction prohibiting that vessel from holding a fishery endorsement. Ten vessels were transferred in accordance with these requirements.

The number of retired vessels by state and city are listed in Table 25. The state and city were determined according to the vessel owners' address as listed on the permit application. The majority of vessels were from Massachusetts (55) and Maine (19). Table 26 provides descriptive statistics for vessel characteristics for vessels that were removed by the buyout program. Retired vessels averaged 100 GRT but ranged from a minimum of 5 GRT to a maximum of 198 GRT. The average age of the vessel was 21.7 years but newer vessels (6 years of age) as well as considerably older vessels (69 years) were retired. The main engine horsepower averaged 502 hp but ranged from 160 to 1,125 hp. Overall vessel length averaged 64.9 feet and ranged from 35 to 105 feet.

The trawl was the dominant gear used by buyout program vessels (60). Eighteen vessels reported using gillnet

Table 25. Number of vessels retired by owners' state and city/region of residence

State	Vessels	City/Region	Vessels
Massachusetts	55	New Bedford	19
Maine	19	Gloucester	11
Rhode Island	1	Cape Cod	11
New Hampshire	3	Portland	8
New York	1	Other	30

Table 26. Characteristics of retired vessels

Vessel Characteristic	Average	Minimum	Maximum
Gross registered tons	100	5	198
Age when retired (years)	21.7	6	69
Propulsion engine horse power	502	160	1,125
Vessel length (feet)	64.9	35	105

Table 27. Impacts of removing vessels through the pilot and expanded buyout programs measured by yearly revenue (R, millions of dollars), landings (P, million pounds), based on annual averages from 1994-1996, and effort removed (based on 1996)

	R & P All Species Landed		R & P Landings of 10 Regulated Groundfish Species Only		Allocated and Used DAS for Limited Access Vessels, 1996		Allocated and Used Ton-Days[1] Limited Access Vessels, 1996	
	Dollars	Pounds	Dollars	Pounds	Allocated	Used	Allocated	Used
Average per buyout vessel	$0.3	0.4	$0.2	0.2	152.9	111.8	15,911	13,539
Total for all buyout vessels	$23.9	35.3	$17.4	16.7	12,083	8,831	1,256,963	1,069,564
Fleet totals	$268.9	434.2	$85.7	82.9	248,988	52,508	12,378,349	4,794,924
Percent Removed	8.9%	8.1%	20.3%	20.1%	4.9%	16.8%	10.2%	22.3%

[1]Ton-days were calculated as the product of gross registered tons and days at sea

gear as a primary gear type and one vessel reported using some combination of otter trawl and gillnet gear. Of the 79 vessels, 41 held individual days-at-sea allocation permits, 36 held fleet days-at-sea permits, and 2 held combination groundfish and scallop permits.

IMPACTS OF REMOVAL

As described earlier, both the vessel's multispecies permit and all other federal fishing permits were removed in the buyout process. Thus, while the primary impact of the vessel buyout was on groundfish, the program provided relief to other Northeast fisheries as well. With respect to groundfish, the impact of removing 79 vessels can be assessed using several different indicators. These indicators are the removal of: annual average (1994 to 1996) pounds and revenue of all species, average annual pounds and revenue of the 10 regulated groundfish species, 1996 allocated and used days-at-sea, and 1996 allocated and used ton-days (*i.e.* days-at-sea multiplied by GRT). The nominal value of these indicators, and their percentage of the entire groundfish fleet, are reported in Table 27. The vessels in the expanded program were removed in the latter part of 1997, so their pounds, revenue, and effort are reflected in the total fleet figures. Since the pilot program vessels were removed during 1995, their estimated activity was added to the fleet totals for 1995 and 1996.

The first two rows of Table 27 report averages and totals for all buyout vessels. The third row reports totals for all multispecies vessels including open access permit holders and buyout vessels and the fourth row reports the percentage reduction in each indicator attributable to the buyout. Based on 1994 to 1996 data, the 79 buyout vessels on average accounted for $23.9 million in gross revenues and 35.3 million pounds landed annually for all species. Total gross revenues and landings for all multispecies vessels were $268.9 million and 434.2 million pounds, respectively. Thus, the impact of the buyout on all species was a reduction of 8.9% of total industry revenues and 8.1% in landings.

Since the buyout was designed to remove groundfish vessels, the impact of the buyout is greater on groundfish landings and revenues than the impact on landings of all species combined. On average, the 79 buyout vessels accounted for $17.4 million in gross revenues and 16.7 million pounds landed annually of the 10 regulated species managed under the Multispecies FMP. Total gross revenues and landings of the 10 regulated species by all multispecies vessels were $85.7 million and 82.9 million pounds, respectively. As a percentage of total groundfish revenue the buyout vessels accounted for 20.3% or 20.1% in terms of pounds landed.

Table 28. Additional permits held by retired vessels

Permit Category	Vessels	Permit Category	Vessels
General category bluefin	56	Ocean quahog	36
Incidental category bluefin	1	Scup	10
Private category bluefin	19	Commercial lobster	71
General category scallop	69	Charter lobster	1
Limited access scallop	2	Summer flounder	42
Surf clam	43	Shark	3
Atl. mackerel/*Illex* squid	54	Black sea bass	2
Loligo squid/butterfish	53	Swordfish	1

Table 29. Average (1994-1996) yearly pounds landed and revenue earned by retired vessels from species other than groundfish

Permit Category	Vessels	Average Pounds	Average Revenue
Bluefin Tuna	11	444	$3,998
Sea scallops	17	1,933	$1,531
Mackerel	41	4,107	$565
Squids	16	24,620	$12,382
Butterfish	14	1,084	$436
Scup	15	981	$591
Lobster	45	2,470	$9,991
Summer flounder	44	3,204	$4,964
Shark	33	414	$348
Black sea bass	13	409	$355
Monkfish	79	82,276	$45,056
Small mesh	60	7,080	$2,336
Other species	79	137,227	$23,760

Impact measures based on landings and revenues provide a useful indicator of the short-run impacts of the buyout program; but the amount of allowable effort removed provides a more useful indicator of potential longer term benefits. Two indicators of effort removal are considered. First, measured simply as removed days-at-sea, the vessel buyout removed the equivalent of 4.9% of all allocated days and 16.8% of all days that were actually used based on data for the 1996 multispecies fishing year (May 1, 1996 to April 30, 1997). An alternative measure that combines fishing time with some proxy for differential fishing power across vessels is a ton-day. Calculated as ton-days, the buyout program removed the equivalent of 10.2% of the allocated total and 22.3% of actual days that were used during the 1996 fishing year. Note that the impact on fishing effort measured in terms of total allocated ton-days is proportionally larger than the same measure based on used fishing time. This difference is due to the fact that the buyout vessels were, on average, larger vessels as compared to the remaining vessels. Consequently, removing these larger vessels resulted in a proportionally larger reduction in potential fishing effort.

The reduction in allocated days measures the permanent reduction in potential fishing effort, while the reduction in used days represents what may be thought of as a intermediate term impact. That is, while the total number of allocated days may be expected to remain relatively constant over time, changes in the rates at which fishing time is used may be expected to fluctuate. As groundfish stocks recover, for example, use rates for allocated days might be expected to increase. Further examination of Table 27 provides some useful insights into this problem of activation of "latent effort", *i.e.* effort that was previously not used or underused. For the groundfish fleet, only 21.1% of the fleet's allocated days-at-sea were used in 1996 (38.7% if ton-days are used). This indicates that given changes in resource or market conditions it would be possible for the remaining vessels to increase their effort and fill the void left by the buyout vessels. However, with the declining allocations under Amendment 7, this will become less of a problem. Also, some of these vessels receive an allocation but have fished very little or not at all for a number of years. It is likely that at least some of these vessels would increase their effort under more favorable resource conditions.

The buyout program was designed to remove vessels that concentrated on groundfish, but since the surrender of all federal fishing permits was required, additional benefits accrued to other fisheries. Table 28 provides numbers of other federal fishery permits surrendered by the retired vessels. In all, 463 federal fishery permits were surrendered in addition to 79 multispecies permits. Of these, most vessels held a commercial lobster permit and a general category scallop permit. Other permits held by at least 70% or more vessels included general category bluefin tuna and Atlantic mackerel/squid/butterfish permits. Average annual landings and revenues associated with the permits listed in Table 28 is reported in Table 29.

Given the relatively low cost of acquiring and keeping permits, any given vessel might hold several different permits over extended periods without using them. Thus, the number of vessels that actually recorded landings of a given species was often less than the number of permits held for that species. For example, even though nearly every vessel held a lobster permit, only 45 of the 71 vessels with a lobster permit actually reporting having landed lobsters between 1994 and 1996 (Table 29). Where the number of vessels reporting landings is greater than the number of vessels holding a particular permit, the landings by nonpermitted vessels is probably bycatch where vessels are held to some trip limit. Landings of monkfish and small-mesh groundfish (red hake, silver hake, and ocean pout) are also reported in Table 29, even though they are landed under a multispecies permit. Monkfish was the most important alternative species landed by the buyout vessels.

CONCLUSIONS

Both the pilot and expanded buyouts achieved their goals of 1) providing a means for distressed groundfishermen to exit the fishery, and 2) conserving the resource by permanently removing groundfish vessels and their related permits. By design, the buyouts successfully removed vessels that were very active in the groundfish fishery. To the extent vessels were active in other fisheries, the buyouts also removed actual and potential effort in those fisheries. The bidding and ranking process also encouraged vessel owners to submit bids at their lowest acceptable level. The problem of latent effort is unresolved. There is the potential for remaining vessels to increase their groundfish activity and erode some buyout benefits. The potential extent of this problem remains to be determined.

For further information

Fisheries of the United States [issued annually; covering 1964-1982]. Issues prior to 1970 were prepared by U. S. Fish and Wildlife Service and are available via interlibrary loan. Issues since 1970 are available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

Species Synopses

The synopses of information on the status of the stocks of the 39 species or groups of species presented in this section are based on commercial and recreational fishery data and on research survey data, as described in the Introduction to this report. Each synopsis briefly reviews the biology of the animals and the general nature of the fishery, summarizes recent catch statistics and stock assessment results, indicates the general status of the stock, and where possible, predicts future stock status.

For each stock or species a summary table[1] of catch statistics is presented, along with graphs depicting trends in landings and stock abundance. The measures of stock abundance used include research vessel survey catch per tow, estimated stock biomass from virtual population analyses, and catch per unit of fishing effort.

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

NMFS research crew sorting a trawl haul during a resource survey cruise

NOAA Fisheries NEFSC Photo Archive

References in the text to catches or indices of abundance usually refer to values given in the tables and figures. In some cases, however, summary statistics provided in the text for different areas, fishing gears, or data sources are not presented in the tables and figures. Catch statistics in the tables are given in thousands of metric tons (mt), rounded to the nearest 100 metric tons; values less than 100 mt are indicated as <0.1.

Many of the assessments summarized in this section have been prepared and/or reviewed through the Northeast Regional Stock Assessment Workshop (SAW) process described in the Introduction. The reports of these workshops, and reports in which the assessments are described in greater detail, appear in the NEFSC Reference Document series and are cited where applicable. These documents are available on request from the NEFSC.

[1] The tables in this section are labeled using decimal notation by species and table within that species. For example, Table 7.2 indicates the second table for the seventh species synopsis, yellowtail flounder.

For further Information

Box, G.E.P., 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.

Atlantic Cod

by R.K. Mayo
L. O'Brien

The Atlantic cod, *Gadus morhua*, is a demersal gadoid species found on both sides of the North Atlantic. In the Northwest Atlantic it occurs from Greenland to North Carolina. Cod may attain lengths of up to 130 cm (51 in.) and weights of 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. Cod are omnivorous, feeding on a variety of invertebrates and fish species.

In U.S. waters, cod are assessed and managed as two stocks: Gulf of Maine, and Georges Bank and Southward. Both stocks support important commercial and recreational fisheries. Commercial fisheries are conducted year round, primarily with otter trawls and gill nets. Recreational fishing also occurs year round; peak activity occurs during the late summer in the lower Gulf of Maine, and during late autumn to early spring from Massachusetts southward.

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

United States commercial and recreational fisheries for cod are managed under the New England Fishery Management Council's Multispecies Fishery Management Plan (FMP). Under this FMP cod are included in a complex of 10 groundfish species which have been managed by time/area closures, gear restrictions, minimum size limits, and, since 1994, direct effort controls including a moratorium on permits and days-at-sea restrictions under Amendments 5 and 7. Trip limits are also in effect for Gulf of Maine cod. The ultimate goal of the management program is to reduce fishing mortality to levels which will allow stocks within the complex to rebuild to above minimum spawning biomass thresholds. The Canadian fishery on Georges Bank is managed under an individual quota system.

Atlantic cod in wire bucket — NOAA Fisheries NEFSC photo by Brenda Figuerido

Total commercial cod landings from the Georges Bank and Gulf of Maine stocks in 1996 were 16,100 mt, a slight increase from 14,700 mt in 1995, but 30% less than in 1994. United States commercial landings in 1996 equalled 14,200 mt, 4% higher than in 1995, but 20% less than in 1994 (17,800 mt). The total recreational cod catch in 1996 equalled 2,900 mt, about 35% lower than the 1993-1995 average.

Gulf of Maine

Total commercial landings (exclusively U.S.) in 1996 were 7,200 mt, a 6% increase over 1995, but a 60% decrease from the record-high 1991 total of 17,800 mt. The 1996 U.S. landings were among the lowest since 1973 and were well below the 1977-1986 average of 12,100 mt. Discards of cod were relatively high in 1989 and 1990, (1,500 and 3,600 mt, respectively), but have since declined to lower levels. Since 1993, discards of Gulf of Maine cod have ranged between 200 and 400 mt annually. The U.S. recreational catch in 1996 totalled 2,100 mt, approximately equal to the 1993-1995 average (2,300 mt).

Northeast Fisheries Science Center (NEFSC) bottom trawl survey abundance and biomass indices declined to record low levels in both the autumn 1993 and spring 1994 surveys and have since remained relatively

Gulf of Maine

Atlantic Cod

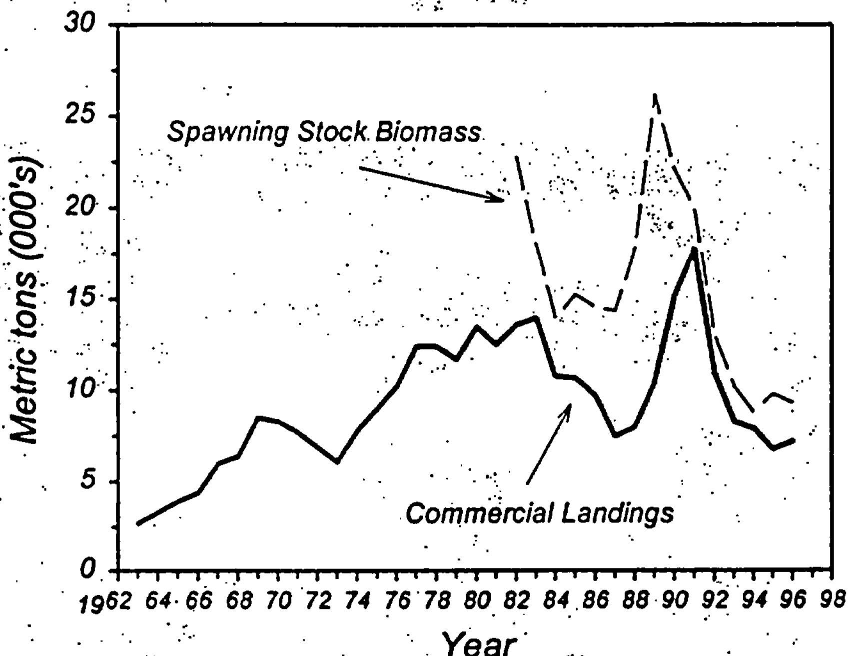


Table 1.1 Recreational catches[1] and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	3.1[2]	2.3	2.1	2.7	3.9	3.6	1.2	2.4	2.6	1.8	2.1
Commercial											
United States	12.1	7.5	8.0	10.4	15.2	17.8	10.9	8.3	7.9	6.8	7.2
Canada	<0.1	-	-	-	-	-	-	-	-	-	-
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	15.2	9.8	10.1	13.1	19.1	21.4	12.1	10.7	10.5	8.6	9.3

[1]Excludes cod caught and released
[2]1979-1986

Summary Status

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	=	2.5 years, males 2.2 years, females
Size at 50% maturity	=	38 cm (15.0 in.), males 33 cm (13.0 in.), females
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%} = 0.37$

$M = 0.20$ $F_{0.1} = 0.16$ $F_{max} = 0.29$ $F_{1996} = 1.04$

"...SSB will not increase appreciably in the near future even if fishing mortality is reduced substantially."

low through autumn of 1997. Survey catch-at-age data indicate that the strong 1987 year class is no longer predominant, having been replaced by a series of average to below-average year classes from 1993 through 1996.

Fishing mortality has remained above 1.0 (58% exploitation rate) during 1994, 1995 and 1996. Since 1983, fishing mortality has been 2-3 times the level needed to attain 20% maximum spawning potential ($F_{20\%} = 0.37$, 28% exploitation rate), the overfishing definition established for this stock, and well above F_{max} (0.29, 23% exploitation rate), the management target selected to allow the stock to rebuild.

The 1987 year class (17.7 million fish at age 2) was the highest in the 1982-1996 series and about twice the size of the above-average 1980 and 1986 year classes. Recent recruitment, however, has been poor, and the 1994 and 1995 year classes (each less than 1 million fish) are especially weak.

Spawning stock biomass (SSB) peaked in 1989 at 26,200 mt, following recruitment of the strong 1987 year class to the spawning stock. However, SSB declined to 8,800 mt in 1994, remained at less than 10,000 mt through 1996, and dropped to 6,900 mt in 1997. Given the size of the incoming weak 1994 and 1995 year classes, SSB will not increase appreciably in the near future even if fishing mortality is reduced substantially. With continued high levels of fishing mortality, SSB will decline further, increasing the probability of total stock collapse.

The Gulf of Maine cod stock is overexploited and remains at an extremely low biomass level. Fishing mortality must be substantially reduced to prevent further declines in SSB.

Georges Bank and Areas to the South

Total commercial landings (U.S. and Canada) in 1996 were 8,900 mt, 13% more than in 1995, but 41% less than in 1994. The 1996 U.S. total (7,000 mt) is the fourth lowest in the time series, which dates back to 1893, and is well below the 1977-1991 annual average of 28,700 mt. Canadian 1996 landings totalled 1,900 mt, 71% higher than in 1995, yet 64% lower than in 1994. Total commercial landings in 1997 were 10,400 mt, a 17% increase from 1996. The U.S. accounted for 72% (7,500 mt) of the total landings and Canada landed the remaining 28% (2,900 mt). The 1996 U.S. recreational catch (800 mt) was 63% less than the 1993-1995 average and remained well below the 1979-1986 average (3,700 mt). The 1997 U.S. recreational catch was 1,200 mt.

"Recovery of the stock will depend on continued low fishing mortality as well as improved recruitment."

The NEFSC bottom trawl survey indices for spring and autumn declined from 1995 to 1996. The 1993 and 1992 year classes contributed to the higher autumn index in 1995 as above average two and three old fish, respectively; however, abundance was not sustained in 1996. Indices remain well below the long term average and continue to indicate that the stock is at a low level. In 1997 survey indices continued to

Georges Bank
Atlantic Cod

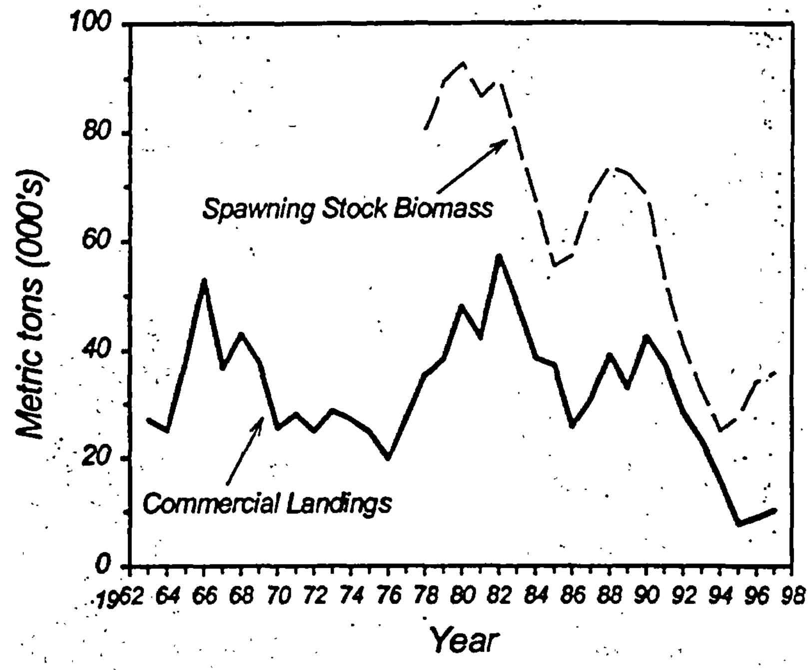


Table 1.2 Recreational catches[1] and commercial landings (thousand metric tons)

Category	Year: 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	3.7[2]	0.8	4.4	2.0	1.0	1.9	0.6	2.9	1.5	2.1	0.8
Commercial											
United States	30.8	19.0	26.3	25.1	28.2	24.2	16.9	14.6	9.9	6.8	7.0
Canada	9.2	11.9	12.9	8.0	14.3	13.4	11.7	8.5	5.3	1.1	1.9
Other	0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	43.8	31.7	43.6	35.1	43.5	39.5	29.2	26.0	16.7	10.0	9.7

[1]Excludes cod caught and released
[2]1979-1986

Summary Status

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	=	2.1 years (both sexes)
Size at 50% maturity	=	41 cm (16.1 in.), both sexes
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%} = 0.41$

$M = 0.20$ $F_{0.1} = 0.18$ $F_{max} = 0.34$ $F_{1997} = 0.26$


Man with Atlantic cod NOAA Fisheries NEFSC photo by Gareth W. Coffin

decline and the autumn abundance index is the lowest in the time series.

Fishing mortality in 1997 was estimated at F=0.26 (21% exploitation rate), above the 1996 level of F=0.20 and the current management target selected to allow the stock to rebuild above the minimum spawning stock biomass threshold ($F_{0.1}$=0.18, 15% exploitation rate). However, it was below the level needed to attain 20% maximum spawning potential ($F_{20\%}$ = 0.41, 31% exploitation rate), the overfishing definition established for this stock.

Spawning stock biomass increased from 55,000 to 72,000 mt between 1985 and 1989 due to recruitment of the strong 1983, 1985, and 1987 year classes. However, SSB has since declined and in 1994 dropped to a record low 25,000 mt. Spawning stock biomass increased in 1995 and 1996 (28,000 and 34,000 mt, respectively) as the 1992 and 1993 cohorts recruited to the spawning stock. The 1996 spawning stock biomass represents 49% of the minimum SSB threshold of 70,000 mt. Spawning stock biomass in 1997 was estimated to be 35,900 mt.

The Georges Bank cod stock remains at a low biomass level and is in an overexploited state. Recovery of the stock will depend on continued low fishing mortality as well as improved recruitment.

For further information

Mayo, R.K. Assessment of the Gulf of Maine cod stock for 1997. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 98-08.

NEFSC [Northeast Fisheries Science Center]. 1997. [Report of the] 24th Northeast Regional Stock Assessment Workshop (24th SAW). Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-12.

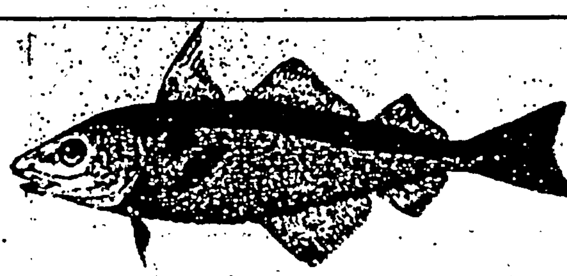
O'Brien, L. MS 1990. Effects of fluctuations in stock abundance upon life history parameters of Atlantic cod, *Gadus morhua* L. for the 1970-1987 year classes from Georges Bank and the Gulf of Maine. University of Washington, Seattle. M.S. Thesis.

O'Brien, L. Assessment of the Georges Bank cod stock for 1997. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Reference Document.*

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

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

Haddock



by R. Brown

The haddock, *Melanogrammus aeglefinus*, is a demersal gadoid species distributed on both sides of the North Atlantic. In the western North Atlantic, haddock range from Greenland to Cape Hatteras. Highest concentrations off the U.S. coast are associated with the two major stocks located on Georges Bank and in the southwestern Gulf of Maine. 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). Haddock exhibit age-dependent shifts in habitat use with juveniles occupying shallower water on bank and shoal areas, and larger adults associated with deeper water. Adult haddock do not undertake long migrations, but seasonal movements occur in the western Gulf of Maine and on the northeast peak of Georges Bank. Haddock prey primarily on small invertebrates, although adult haddock will consume fish on occasion.

Growth and maturation rates of haddock have changed significantly over the past 30 to 40 years, possibly in response to changes in abundance. Before 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.). During the early 1960s, all females age 4 and older were fully mature, and approximately 75% of age 3 females were mature. Presently, growth is more rapid, with haddock reaching 48 to 50 cm at age 3; and nearly all age 3 and 35% of age 2 females are mature. Although early maturing fish increase spawning stock biomass, the degree to which these younger fish contribute to reproductive success of the population is uncertain.

NEFSC scientist Roger Clifford with haddock and cod

NOAA Fisheries NEFSC photo by Brenda Figuerido

Spawning occurs between January and June, with peak activity during late March and early April. An average sized (55 cm, 22-in.) female produces approximately 850,000 eggs, and larger females are capable of producing up to 3 million eggs annually. Spawning concentrations occur on east-

Gulf of Maine

Haddock

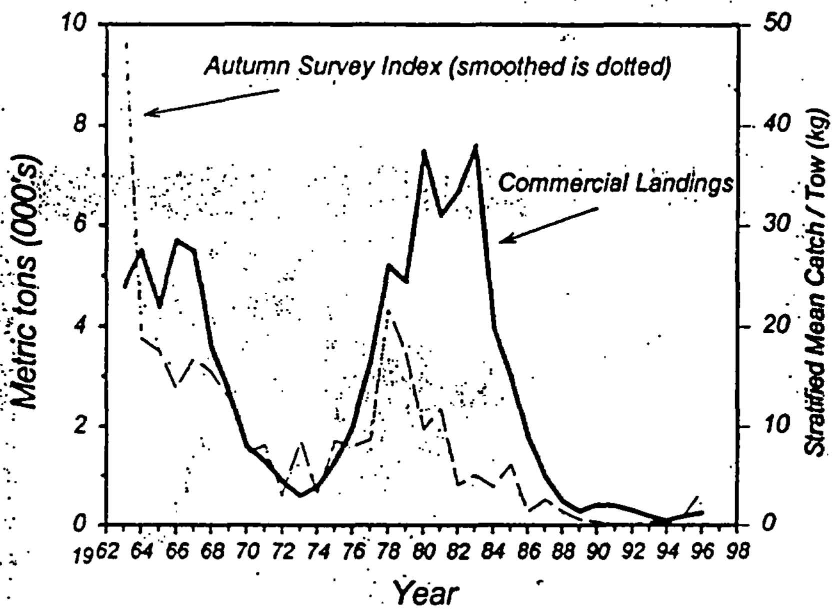


Table 2.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year										
	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
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	4.6	0.8	0.4	0.3	0.4	0.4	0.3	0.2	0.1	0.2	0.3
Canada	0.7	0.2	0.1	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	5.3	1.0	0.5	0.3	0.4	0.4	0.3	0.2	0.1	0.2	0.3

Summary Status

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, males
		2.2 years, females
Size at 50% maturity	=	30 cm (11.8 in.), males
		39 cm (15.4 in.), females
Assessment level	=	Yield per recruit
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.20$ $F_{0.1} = 0.24$ $F_{20\%} = 0.40$ F_{1996} = unknown

"Spawning stock biomass is below maintenance level and is likely to remain so for the foreseeable future."

ern Georges Bank, to the east of Nantucket Shoals and along the Maine coast. Juvenile haddock remain pelagic for several months before settling to the bottom.

The U.S. fishery for haddock is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan (FMP). Under this FMP haddock are included in a complex of 10 groundfish species which have been managed by time/area closures, gear restrictions, minimum size limits, and, since 1994, direct effort controls including a moratorium on permits and days-at-sea restrictions under Amendments 5 and 7. Trip limits are also in effect for haddock. The ultimate goal of the management program is to reduce fishing mortality to levels which will allow stocks within the complex to rebuild to above minimum spawning biomass thresholds. The Canadian fishery on Georges Bank is managed under an individual quota system, and Canadian waters on Georges Bank are closed to groundfishing annually from January until mid-June.

The principal commercial fishing gear used to catch haddock is the otter trawl. Recreational catches are insignificant. Total landings (U.S. and Canada) in 1996 from the Georges Bank and Gulf of Maine haddock stocks were 4,300 mt, approximately equal to the 1993 total (4,600 mt). United States landings decreased from 900 mt in 1993 to 600 mt in 1996.

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. Landings

"Significant rebuilding beyond current stock levels will require improved recruitment ..."

subsequently increased sharply to an annual average of 7,000 mt from 1980 to 1983 but have since declined to record lows. Recreational catches have also declined and since 1981 have been insignificant. Virtually all landings from this stock are now taken in the U.S. fishery.

The NEFSC autumn bottom trawl survey biomass index declined steadily since 1978 and between 1989 and 1992 fell to a new record low every year, reaching 0.1 kg per tow in 1992. The index has since increased; and the 1996 index value (3.5 kg per tow) was the highest since 1985. However, current indices are less than 20% of the level observed prior to collapse of this stock.

The sharp decline in landings observed since 1983 (7,600 to 300 mt) and the corresponding decline in the autumn survey index reflect the severely depleted state of this stock. Spawning stock biomass is below maintenance level and is likely to remain so for the foreseeable future. Recent restrictive management actions on Georges Bank may also have resulted in additional fishing effort on this stock, further threatening stock recovery. Fishing mortality must be reduced to enhance prospects for stock rebuilding.

Georges Bank

From 1935-1960, Georges Bank haddock stock biomass averaged over 150,000 mt, which produced stable commercial landings of 40,000 to 60,000 mt. Total commercial landings increased to over 150,000 mt in 1965 and 121,000 mt in 1966 due to recruitment of the exceptionally strong 1962 and 1963 year classes and in-

Georges Bank
Haddock

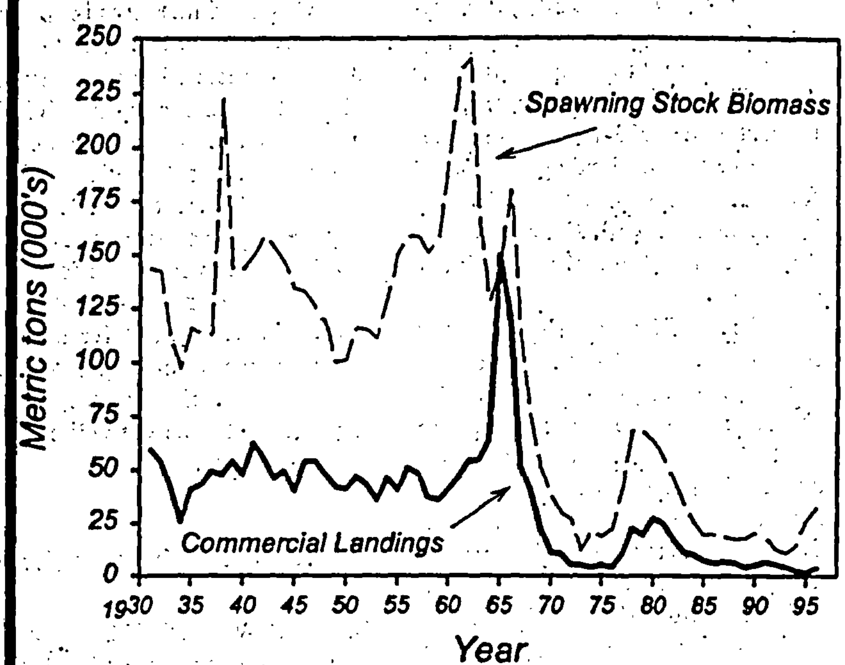


Table 2.2 Recreational catches and commercial landings (thousand metric tons).

Category	1977-86 Average	1987	1989	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	0.1	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	10.9	2.2	2.5	1.4	2.0	1.4	2.0	0.7	0.2	0.2	0.3
Canada	5.0	4.1	5.9[1]	3.1	3.3	5.5	4.1	3.7	2.4	2.1	3.7
Total nominal catch	15.6	6.3	8.4[1]	4.5	5.3	6.9	6.1	4.4	2.6	2.3	4.0

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

Summary Status

Long-term potential catch	=	47,000 mt
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	1.9 years, males
		2.2 years, females
Size at 50% maturity	=	34 cm (13.4 in.), males
		39 cm (15.4 in.), females
Assessment level	=	Age Structured
Overfishing definition	=	30% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{30\%} = 0.45$

$M = 0.20$ $F_{0.1} = 0.26$ $F_{1997} = 0.11$

tense fishing by distant-water fleets. The stock subsequently collapsed, with landings declining to less than 5,000 mt annually during the mid-1970s. Landings increased between 1977 and 1980, reaching 27,500 mt, but subsequently declined to 4,500 mt in 1989. Landings have remained below 4,000 mt since 1993, less than 10 percent of the 1935-1960 average. Of the 1997 total, U.S. landings accounted for only 23% (800 mt) of Georges Bank landings, while Canadian landings accounted for the remainder (2,700 mt).

The NEFSC autumn bottom trawl survey indicates that stock biomass declined markedly since the late 1970s. The index reached a historic low in 1991 (0.9 kg per tow), but subsequently increased owing to recruitment of the moderate 1992 year class. The 1997 index value (6.5 kg per tow) is well below levels observed in the 1960s and mid- to late 1970s. Recent analysis of survey data suggest that haddock are currently highly concentrated, resulting in increased relative vulnerability to fishing and survey gear.

Population estimates derived from virtual population analysis indicate that this stock has started to rebuild. Total stock size declined from 133 million fish in 1979 to 15 million fish in 1991, and has subsequently increased to 36 million fish at the beginning of 1995 and has stabilized at this level. Spawning stock biomass declined from 68,900 mt in 1978 to 10,900 mt by 1993, and has since increased to 40,200 mt in 1997.

Recruitment was poor during most of the 1980s and 1990s. The strongest recent year classes were those of 1983, 1985, 1987 and 1992, each contributing between 14 to 17 million fish at age 1. These year classes were less than one-third the size of the average year classes produced by this stock during the 1930s, 1940s, and 1950s. Fishing mortality on age 4 and older haddock exceeded 0.40 (30% exploitation rate) in 1992-1993, declined to 0.12 (10% exploitation rate) in 1995, and has since remained below the management target ($F_{0.1}$ = 0.26, 21% exploitation rate). Recent recruitment from the 1992 year class, coupled with restrictive management measures by the U.S. and Canada, have contributed to the initiation of stock rebuilding.

Observed increases in spawning stock biomass of Georges Bank haddock have resulted from conservation of existing year classes. This is a necessary first step in the stock rebuilding process. Significant rebuilding beyond current stock levels will require improved recruitment above levels observed in the past decade. To date, there are no indications in the survey data to suggest that incoming recruitment has increased above these levels. Until this occurs, restrictive management practices will continue to be necessary.

For further information

Brown, R.W. 1998. U.S. assessment of the Georges Bank haddock stock, 1997. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc*

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

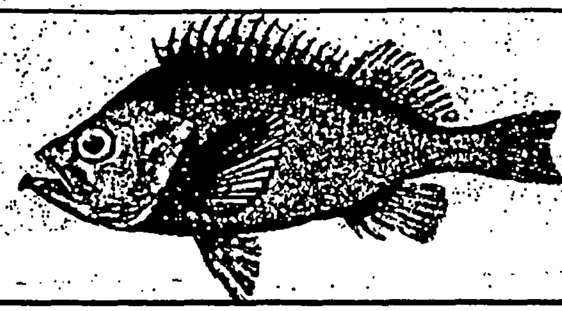
Gavaris, S. and L. VanEeckhaute. 1997. Assessment of haddock on eastern Georges Bank. DFO [Department of Fisheries and Oceans] *Atl. Fish. Res. Doc.* 97/54.

NEFSC [Northeast Fisheries Science Center]. 1997. [Report of the] 24th Northeast Regional Stock Assessment Workshop (24th SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-12.

O'Brien, L.O. and R.W. Brown. 1995. Assessment of the Georges Bank haddock stock for 1994. Woods Hole, MA: NOAA/NMFS/NEFSC. NEFSC *Ref. Doc.* 95-13.

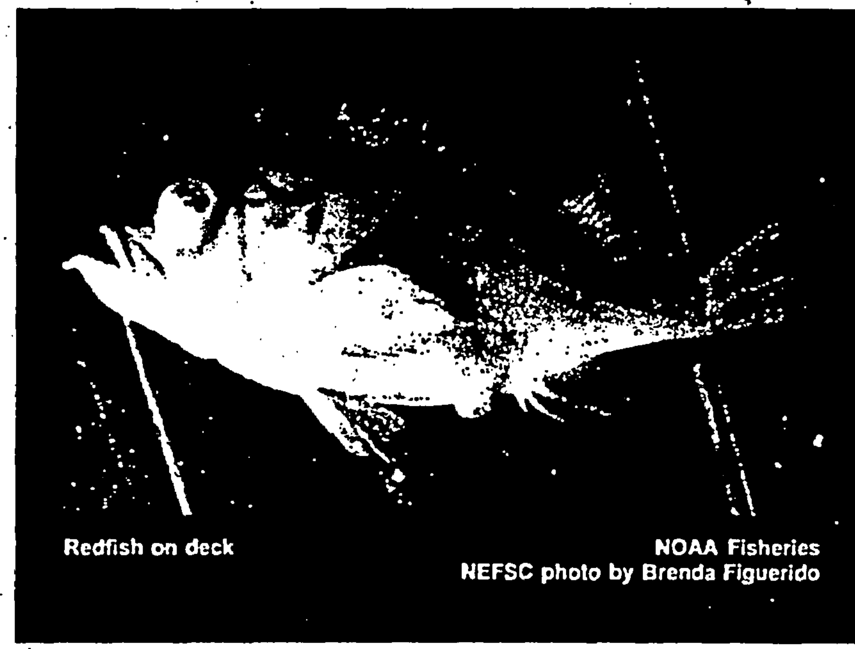
Haddock in captivity NOAA Fisheries photo by Brenda Figuerido

Redfish



by R.K. Mayo

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



Redfish on deck — NOAA Fisheries NEFSC photo by Brenda Figuerido

Redfish are managed under the New England Fishery Management Council's Multispecies Fishery Management Plan (FMP). Under this FMP redfish are included in a complex of 10 groundfish species which has been managed by time/area closures, gear restrictions, minimum size limits, and, since 1994, direct effort controls including a moratorium on permits and days-at-sea restrictions under Amendments 5 and 7. The ultimate goal of the management program is to reduce fishing mortality to levels which will allow stocks within the complex to rebuild to above minimum spawning biomass thresholds.

The principal commercial fishing gear used to catch redfish is the otter trawl. Recreational catches are insignificant. During the early development phase of the Gulf of Maine fishery, U.S. nominal catches rose rapidly to a peak level of about 60,000 mt in 1942 followed by a steep decline through the early 1950s. Nominal catches declined more gradually to less than 10,000 mt during the 1960s, and then increased somewhat, peaking at 20,000 mt in 1971 and again at 14,800 mt in 1979. Landings then declined steadily throughout the 1980s, dropping to 500 mt by 1991. After a slight increase to 800 mt in 1992 and 1993, landings declined again, reaching 322 mt in 1996, the lowest recorded level since the directed fishery began in the early 1930s.

The standardized catch per unit effort (CPUE) 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 bottom trawl survey biomass index declined from 40.4 kg per tow in 1968 to an average of 3.8 kg per tow during 1982-84, a 91% reduction. This index subsequently increased to an average of 6.5 kg per tow during 1985-1989 and increased further to an average of 10.0 kg per tow during 1990-1993. Biomass indices decreased again in 1994 and 1995 to less than 6.0 kg per tow, but increased substantially in 1996 to 30.6 kg per tow.

Increases in the survey biomass index between 1990 and 1993 are consistent with incremental annual increases in the NEFSC survey abundance index (mean number per tow) observed during the early 1990s, and reflect accumulated recruitment and growth of one or more above-average year classes produced in the mid-1980s. The large increase in the survey biomass index in 1996 was supported almost exclusively by fish in the 18-23 cm range at a corresponding age of approximately 5-6 years. Production of these redfish is likely to have occurred during 1990 and 1991, with reproduction augmented by early-maturing spawners from the mid-1980s year classes. Thus, stock biomass appears to have increased substantially through the combined effects of

Gulf of Maine and Georges Bank

Redfish

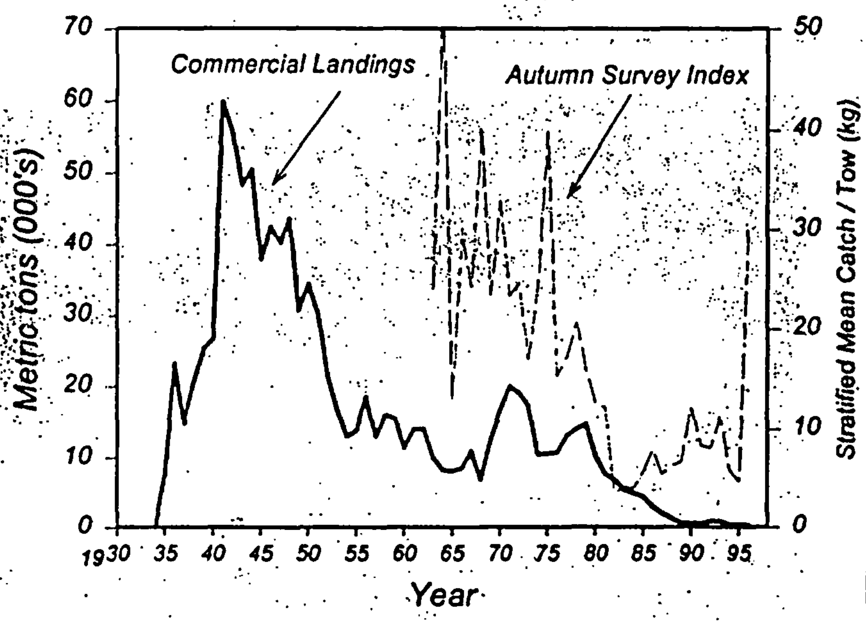


Table 3.1. Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	8.3	1.9	1.1	0.6	0.6	0.5	0.8	0.8	0.4	0.4	0.3
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	8.4	2.0	1.2	0.6	0.6	0.5	0.8	0.8	0.4	0.4	0.3

Summary Status

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	=	Fully exploited
Age at 50% maturity	=	5.5 years (both sexes)
Size at 50% maturity	=	21 cm (8.3 in.), males 22 cm (8.7 in.), females
Assessment level	=	Yield per recruit
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%} = 0.12$

$M = 0.05$ $F_{0.1} = 0.06$ $F_{max} = 0.13$ $F_{1996} \le F_{0.1}$

"...stock biomass appears to have increased substantially through the combined effects of growth and survival of fish from a period of relatively successful reproduction in the early 1990s."

growth and survival of fish from a period of relatively successful reproduction in the early 1990s.

During the previous two decades beginning in 1970, only two strong year classes, those produced in 1971 and 1978, have been detected. However, length composition data from bottom trawl surveys suggest that one or more above-average year classes which were produced in the mid-1980s recruited to the fishery during the early 1990s. These fish were first detected in the 1991 commercial length composition and appeared in greater numbers as a distinct mode around 25 cm in 1992 and 1993, and they continue to support the fishery.

Estimates of exploitable biomass (ages 5 and older) derived by virtual population analysis or VPA declined by 76%, from 136,000 mt in 1969 to 32,000 mt in 1985. Projections are not available for recent years. Fishing mortality during the 1970s was slightly greater than F_{max} (0.13, 12% exploitation rate) and twice the $F_{0.1}$ level (0.06, 6% exploitation rate). During the late 1970s, the combination of declining stock size and increased fishing effort on the 1971 year class produced fishing mortality rates that were 50 percent greater than F_{max} and three times higher than $F_{0.1}$. Fishing mortality has declined in recent years to a level less than or equal to $F_{0.1}$, and well below

F_{max}. Equilibrium surplus production models have indicated that the long-term potential catch from the stock is about 14,000 mt. Given the low population biomass and poor recruitment during most of the 1980s, surplus production in the near future will remain considerably less than 14,000 mt.

Landings since 1989 have been extremely low (less than 900 mt/yr), reflecting low levels of stock abundance and fishing mortality. Recruitment has been poor throughout the 1970s and 1980s, except for the moderate to strong 1971 and 1978 year classes and some modest recruitment from the mid-1980s. Stock biomass has since increased steadily through the mid-1990s, substantially so based on 1996 observations. However, most of the redfish supporting the recent increase in biomass are small, immature fish produced in the early 1990s, and have yet to realize their full growth and reproductive potential. If fishing mortality on these young fish increases significantly in the near-term, stock biomass may decline to levels observed during the 1980s. To allow recovery to continue, catches must remain low. The stock is considered to be fully exploited at present.

NEFSC scientist Betsy Broughton with basket of redfish

NOAA Fisheries NEFSC photo by Brenda Figuerido

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.

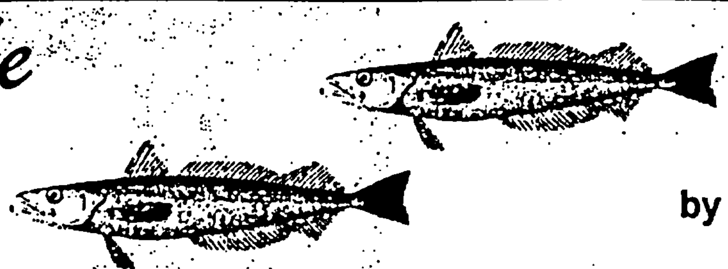
Mayo, R. K., U. B. Dozier, and S. H. Clark. 1983. An assessment of the redfish, Sebastes fasciatus, stock in the Gulf of Maine - Georges Bank region. Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Ref. Doc.* 83-22.

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.

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

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

Silver Hake



by R.K. Mayo

The silver hake or whiting, *Merluccius bilinearis*, is a slender, swiftly swimming fish with a range extending from Newfoundland to South Carolina. Silver hake are important predators, feeding on fish, shrimp, and occasionally squid. In U.S. waters, two stocks have been identified based on morphological differences; the Gulf of Maine-Northern Georges Bank stock, and the Southern Georges Bank-Middle Atlantic stock. Silver hake undertake extensive migrations, moving towards shallow water in the spring, where spawning occurs during late spring and early summer, and returning to deeper areas in autumn. Silver hake from the northern stock overwinter in deeper waters of the Gulf of Maine, while individuals from the southern stock overwinter along the outer continental shelf and slope.

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. Peak spawning occurs earlier in the southern stock (May and June) than in the northern stock (July and August). 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.

Its abundance and availability have made silver hake important to the U.S. and Canada as well as to distant-water fleets. Following entrance of distant-water fleets to the fishery in 1962, nominal catches from both stocks increased rapidly to a peak of over 350,000 mt in 1965, but declined to only 55,000 mt by 1970. Landings then increased to 137,000 mt in 1973 and then declined sharply with inception of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977. Prior to MFCMA, distant-water fleets accounted for about 49% and 87% of total landings for the northern and southern stocks, respectively. Fishing activity by distant-water fleets ceased after 1977 for

Total Landings, All Areas

Silver Hake

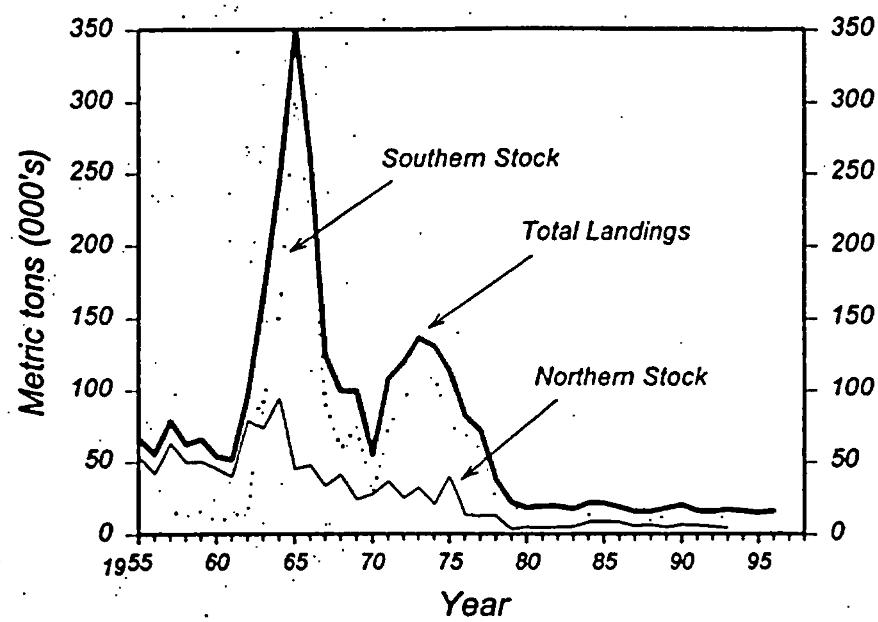


Table 4.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year: 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	18.8	15.7	16.0	17.8	20.0	16.2	15.6	17.2	16.1	14.7	16.2
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	7.7	-	-	-	-	-	-	-	-	-	-
Total nominal catch	26.9	15.7	16.0	17.8	20.0	16.2	15.6	17.2	16.1	14.7	16.2

> **"Recently, a 'juvenile' whiting fishery has developed in response to an export market for small silver hake that have traditionally been discarded."**

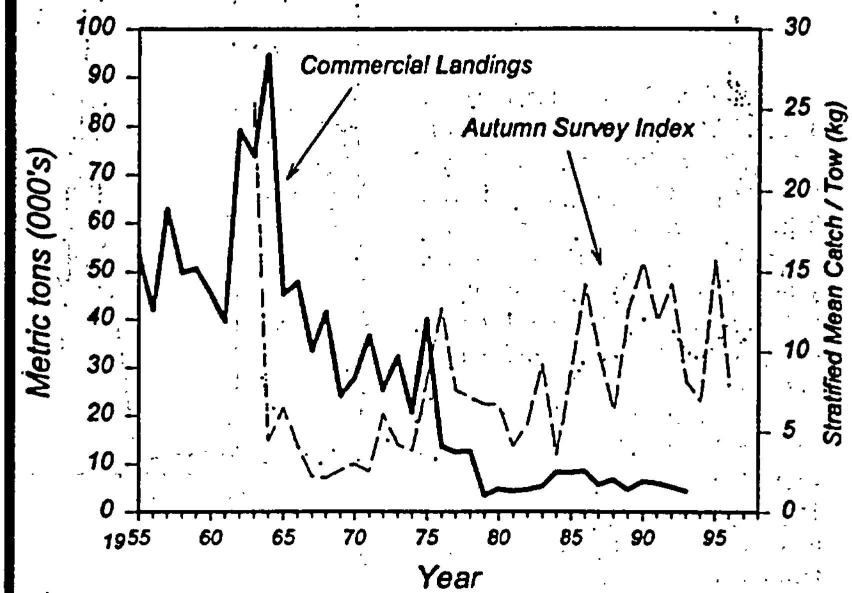
the northern stock, but exploitation of the southern stock by distant water fleets continued until 1987, primarily as bycatch in the squid fishery. U.S. landings during the last decade have remained stable, but low compared to earlier years of the fishery, averaging 16,600 mt per year.

The otter trawl remains the principal gear used in the U.S. fishery. Recreational catches since 1985 have been insignificant. Silver hake are included within the New England Fishery Management Council's Multispecies Fishery Management Plan ("nonregulated multispecies" category).

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

Gulf of Maine-Northern Georges Bank

Silver Hake



Summary Status

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	=	1.7 years (both sexes)
Size at 50% maturity	=	22.3 cm (8.8 in.), males
		23.1 cm (9.1 in.), females
Assessment level	=	Index
Overfishing definition	=	31% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{31\%} = 0.36$

$M = 0.40$ $F_{0.1} = 0.39$ $F_{1996} > 1.0$

Gulf of Maine-Northern Georges Bank

The NEFSC autumn bottom-trawl survey biomass index declined during the period of heavy exploitation by distant-water fleets, reaching a minimum in 1967-68. With the appearance of the strong 1973 and 1974 year classes, biomass indices increased during the mid-1970s, but declined slightly during the late 1970s. Biomass indices have again increased since 1980 and recent recruitment appears to be at or above that of the mid-1970s.

During 1973-1982, fishing mortality rates on fully recruited fish (age 3+) derived from virtual population analysis (VPA) fluctuated between 0.38 and 1.1, and generally increased from 1982 (0.45) through 1988 (0.70). Although VPA fishing mortality estimates are not available for subsequent years, total mortality estimates based on NEFSC survey abundance indices suggest that since 1992 fishing mortality has doubled, from about 0.7 (42% exploitation rate) to 1.4 (65% exploitation rate).

Substantial mortality of age 1 and 2 (<25 cm) fish has occurred through discarding in the large mesh (>5.5 inch mesh) and small mesh (<3.5 inch mesh) otter trawl fisheries and in the northern shrimp fishery.

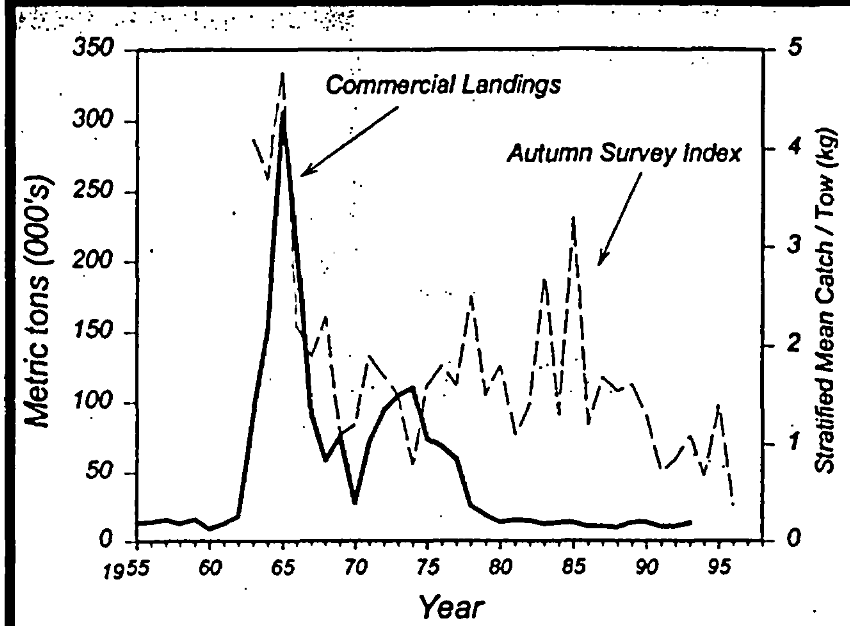
"...high discard mortality on juvenile fish results in substantial losses in long term yield and spawning biomass."

Annual discard estimates over the 1989-1992 period ranged from 1,700 mt to 7,200 mt. In terms of numbers of fish, the quantities of discarded silver hake have been quite large, ranging from 17 million to 76 million fish per year. This high discard mortality on juvenile fish results in substantial losses in long term yield and spawning biomass.

Bottom-trawl survey indices suggest that biomass has remained at or above pre-1975 levels over the past 15 years, but substantial increases in recruitment in recent years have not translated into an increase in mature fish biomass (age 3+). Until this inconsistency is resolved, the precise level of exploitation remains uncertain. However, since it is not likely that fishing mortality will decline substantially in the near future to below the overfishing definition level ($F_{31\%}$ = 0.36, 25% exploitation rate), and given the rapid removal of recruits from the stock in recent years, this stock must be considered overexploited.

Southern Georges Bank - Middle Atlantic

Silver Hake



Summary Status

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Minor
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	1.6 years (both sexes)
Size at 50% maturity	=	22.7 cm (8.9 in.), males 23.2 cm (9.1 in.), females
Assessment level	=	Index
Overfishing definition	=	42% MSP
fishing mortality rate corresponding to overfishing definition	=	$F_{42\%}$ = 0.34

M = 0.40 $F_{0.1}$ = 0.45 F_{1996} > 1.0

Southern Georges Bank - Middle Atlantic

The NEFSC autumn bottom trawl survey biomass index has declined by over 50% since 1985, and survey indices in the past three years have been at or near record lows.

Between 1955 and 1962, fishing mortality was relatively low, ranging from 0.09 to 0.41 (average = 0.24, 18% exploitation rate). With increased effort by distant-water fleets, F rose rapidly and reached 0.98 in 1965. Fishing mortality decreased to 0.5 (33% exploitation rate) during 1978-1980 and then again increased to over 1.0 (54% exploitation rate) during 1983-1987. Although VPA estimates of fishing mortality and stock size are not available from 1988 onward, total mortality estimates based on NEFSC survey data suggest that F has been close to 1.2 (60% exploitation rate) in recent years.

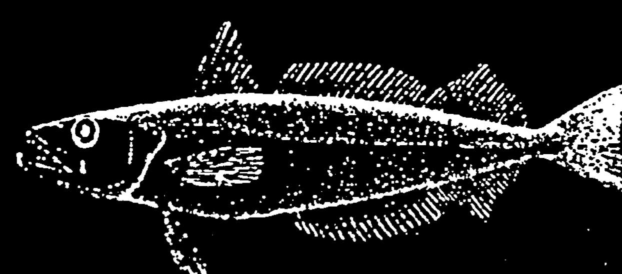
Significant mortality of age 1 and 2 (<25 cm) fish has occurred through discarding in the large mesh (>5.5 inch mesh) and small mesh (<3.5 inch) otter trawl fisheries. Annual discard estimates over the 1989-1992 period ranged from 1,300 mt to 10,000 mt. The estimated numbers of fish discarded have been quite high, ranging from 10 million to 81 million fish per year. This high discard mortality on juvenile fish results in substantial losses in long term yield and spawning biomass.

"The stock is overfished and will remain so until the exploitation pattern is improved (*i.e.*, catches of juveniles are minimized) and fishing mortality is markedly reduced."

NEFSC bottom trawl survey results indicate that stock abundance is low and continues to decline. Age structure of the population is severely truncated, with few fish older than age 4. Although landings are relatively low compared to historical levels, F has steadily increased since 1980, generally exceeding 1.0 during the 1990s. Fishing mortality remains far above the level corresponding to the overfishing definition ($F_{42\%}$ = 0.34, 24% exploitation rate). The stock is overfished and will remain so until the exploitation pattern is improved (i.e., catches of juveniles are minimized), and fishing mortality is markedly reduced.

Silver hake

NOAA Fisheries NEFSC photo by Brenda Figuerido



For further information

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

Helser, T. E., F. P. Almeida, and D. E. Waldron. 1995. Biology and fisheries of Northwest Atlantic hake (Silver hake: *M. bilinearis*), p. 203-237. *In* Alheit, J. and T.J.Pitcher, eds. Hake: fisheries, products and markets, Chapman and Hall, London.

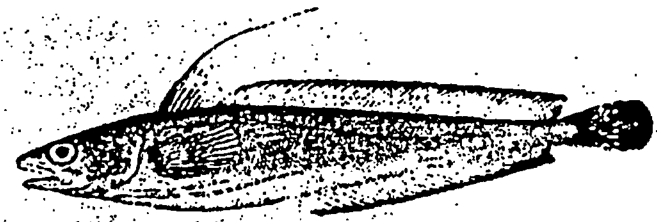
Helser, T. E. 1996. Growth of silver hake within the U.S. continental shelf ecosystem of the Northwest Atlantic Ocean. *J. Fish. Biol.* 48:1059-1073.

Helser, T. E., E. M. Thunberg, and R. K. Mayo. 1996. An age-structured bioeconomic simulation of U.S. silver hake fisheries. *N. Am. J. Fish. Mgt.* 16:783-794.

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

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

Red Hake



by K. Sosebee

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. Red hake undergo extensive seasonal migrations, moving into shallower waters to spawn in spring and summer and offshore to winter in 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 primary spawning areas located on the southwest part of Georges Bank and off southern New England. Red hake feed primarily on crustaceans, but adult red hake also feed extensively on fish. The maximum length attained by red hake is approximately 50 cm (19.7 in.). Maximum age is reported to be about 12 years, but few fish survive beyond 8 years of age. Two stocks have been tentatively identified, a Gulf of Maine-Northern Georges Bank stock and a Southern Georges Bank-Middle Atlantic stock.

Otter trawls are the principal commercial fishing gear used to catch red hake. Recreational catches are of minor importance. Following the arrival of distant-water fleets in the early 1960s, total landings from both stocks peaked at 113,600 mt in 1966. Annual landings declined sharply after 1966, increased again to 76,400 mt in 1972, and then declined steadily with increased restrictions on distant-water fleets.

Prior to implementation of the Magnuson Fisheries Conservation and Management Act (MFCMA) in 1977, approximately 93 and 83 percent of the total landings from the northern and southern stock, respectively, were taken by distant-water fleets. Between

Total Landings, All Areas

Red Hake

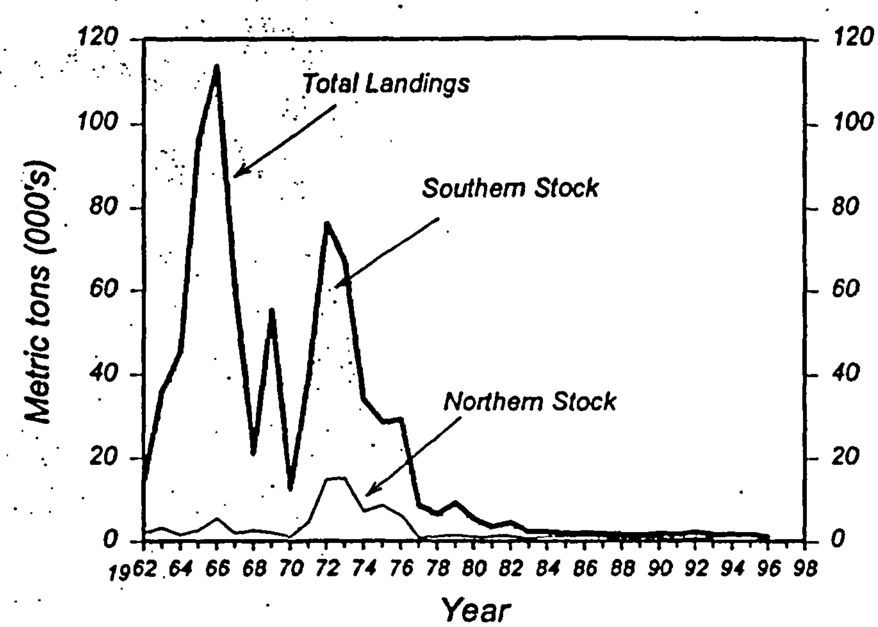
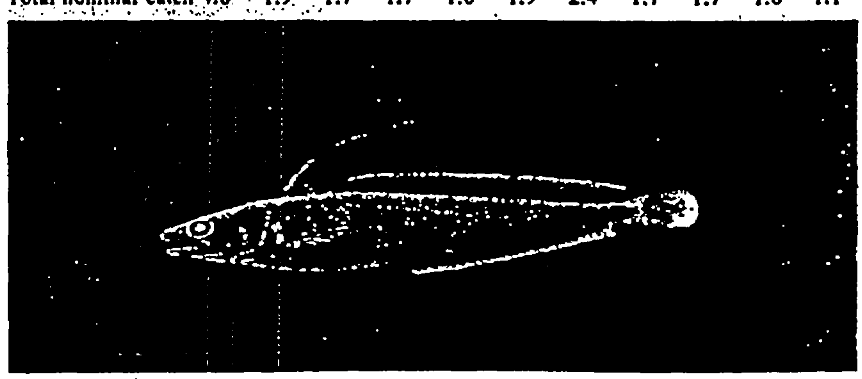


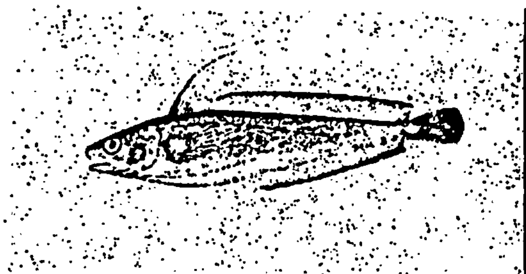
Table 5.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year										
	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	0.2	<0.1	<0.1	<0.1	<0.1	0.2	0.2	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	3.7	1.9	1.7	1.7	1.6	1.7	2.2	1.7	1.7	1.6	1.1
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	0.9	-	-	-	-	-	-	-	-	-	-
Total nominal catch	4.8	1.9	1.7	1.7	1.6	1.9	2.4	1.7	1.7	1.6	1.1



Gulf of Maine-Northern Georges Bank

Red Hake

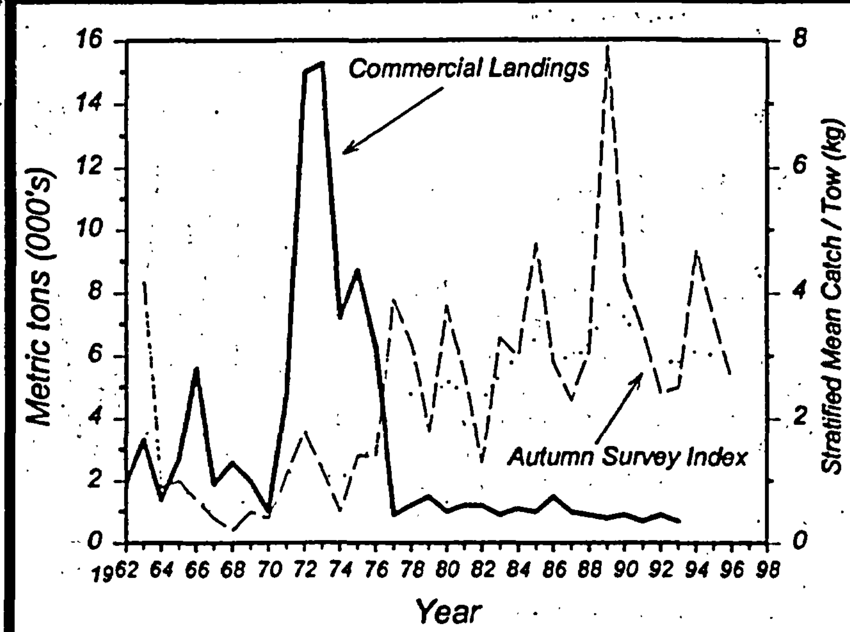


1977 and 1986, landings declined more or less continually due to restrictions placed on foreign fishing; and for more recent years landings have been exclusively domestic. Red hake are included in the New England Fishery Management Council's Multispecies Fishery Management Plan under the "nonregulated multispecies" category. Total commercial landings during the last decade (1987-1996) averaged 1,700 mt annually. In 1996, landings were 35% lower than the 1987-1996 average and remain far below historic levels.

Gulf of Maine - Northern Georges Bank

The NEFSC autumn bottom trawl survey biomass index increased steadily from the early 1970s to a peak in 1989, the highest value in the time series. This index has declined somewhat during the past five years, although values remain high. This decline does not appear to be fishery-related given the low level of landings. Survey data indicate that most year classes of red hake since 1985 have been moderate, but with low landings these year classes have been sufficient to maintain stock biomass at moderate to high levels. This stock is under-exploited and could support substantially higher catches.

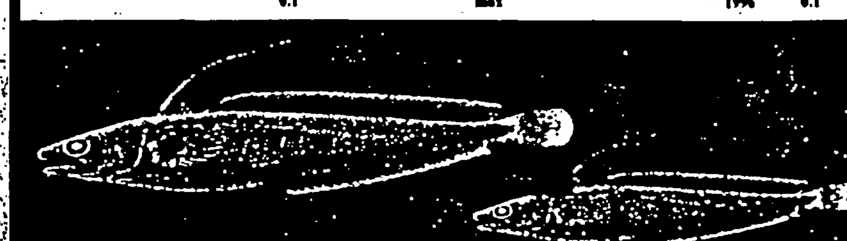
> **"This stock is underexploited and could support substantially higher catches."**



Summary Status

Long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Underexploited
Age at 50% maturity	=	1.4 years, males 1.8 years, females
Size at 50% maturity	=	22 cm (8.7 in.), males 27 cm (10.6 in.), females
Assessment level	=	Yield per recruit
Overfishing definition	=	3-year moving average of NEFSC autumn bottom trawl survey index falls within lowest quartile of the time series
Fishing mortality rate corresponding to overfishing definition	=	N/A

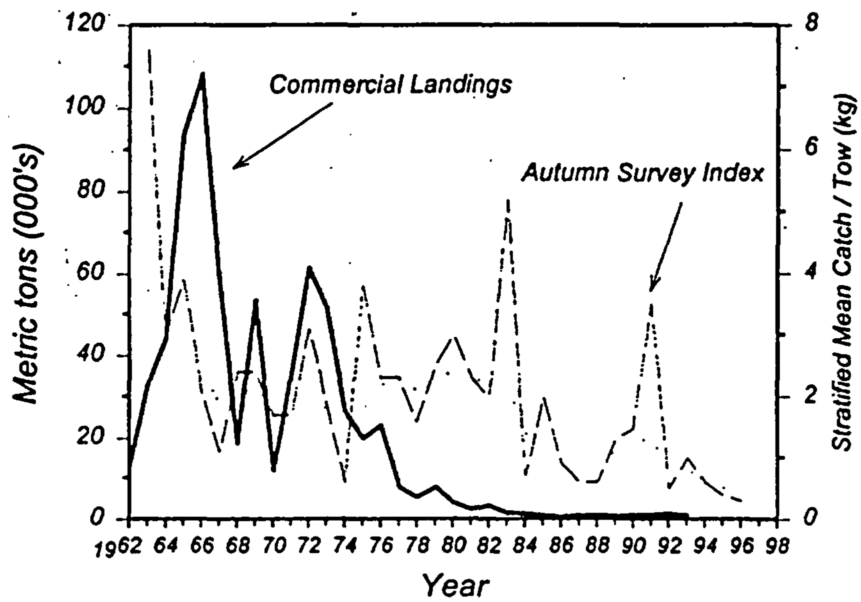
$M = 0.4$ $F_{0.1} = 0.5$ F_{max} = None $F_{1996} < F_{0.1}$



"...this stock is considered to be overexploited according to the existing overfishing definition."

Southern Georges Bank - Middle Atlantic

Red Hake



Summary Status

Long-term potential catch	=	Unknown
Importance of recreational fishery	=	Minor
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	1.8 years, males 1.7 years, females
Size at 50% maturity	=	24 cm (9.5 in.), males 25 cm (9.8 in.), females
Assessment level	=	Yield per recruit
Overfishing definition	=	3-year moving average of NEFSC autumn bottom trawl survey index falls within lowest quartile of the time series
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.4$ $F_{0.1} = 0.5$ F_{max} = None F_{1996} = Unknown

Southern Georges Bank-Middle Atlantic

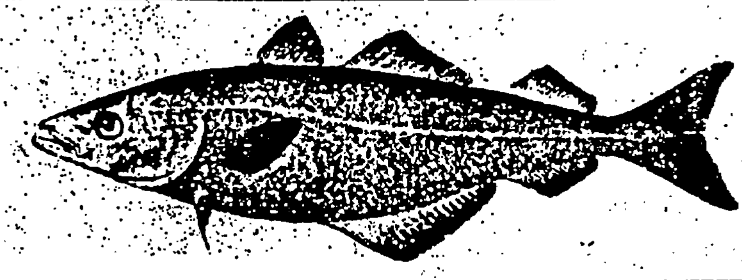
The NEFSC autumn survey biomass index declined from 1963-1967 and was subsequently relatively constant between 1968 and 1982. The index then declined to a record low in 1987. From 1988 to 1991, the survey index increased, but has since dropped sharply to historically low levels. The declining trend in survey values from 1983 onward does not appear to be fishery related; landings during the past decade have been very low (less than 2,000 mt per year) compared with the late 1960s and early 1970s (more than 20,000 mt in most years) when the survey index was stable. However, this stock is considered to be overexploited according to the existing overfishing definition.

For further information

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

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

Pollock



by R.K. Mayo

Pollock, *Pollachius virens*, occur on both sides of the North Atlantic; in the Northwest Atlantic, they are most abundant on the western 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 (Northwest Atlantic Fisheries Organization or NAFO Divs. 4VWX and Subarea 5) continue to be assessed as a unit stock by U.S. scientists.

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

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

Since 1984, the U.S. fishery has been restricted to areas of the Gulf of Maine and Georges Bank west of the

Pollock

NOAA Fisheries
NEFSC photos by Brenda Figuerido

"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."

line delimiting the U.S. and Canadian fishery zones (NAFO Divs. 5Y and 5Z). The Canadian fishery occurs primarily on the Scotian Shelf (NAFO Divs. 4VWX) with some additional landings from Georges Bank east of the line delimiting the U.S. and Canadian fishery zones (NAFO Subdiv. 5Zc). This fishery has shifted westward over time, and the contribution to the total catch from larger, mobile gear vessels has steadily diminished since 1981.

The U.S. portion of the fishery is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan (FMP). Under this FMP pollock are included in a complex of 10 groundfish species which have been managed by time/area closures, gear restrictions, minimum size limits, and, since 1994, direct effort controls including a moratorium on permits and days-at-sea restrictions under Amendments 5 and 7. The ultimate goal of the management program is to reduce fishing mortality to levels which will allow stocks within the complex to rebuild to above minimum spawning biomass thresholds. The Canadian fishery is managed under fleet-specific quotas.

The total nominal catch of pollock in 1996 was 12,300 mt, 54% less than in 1993 (26,800 mt). Most of the recent decrease has been due to sharp reductions in Canadian landings reflecting significantly reduced TACs for the Canadian fishery since 1993. United States commercial landings declined by 47% between 1993 and 1996 (from 5,700 mt to 3,000 mt).

Gulf of Maine, Georges Bank, Scotian Shelf

Pollock

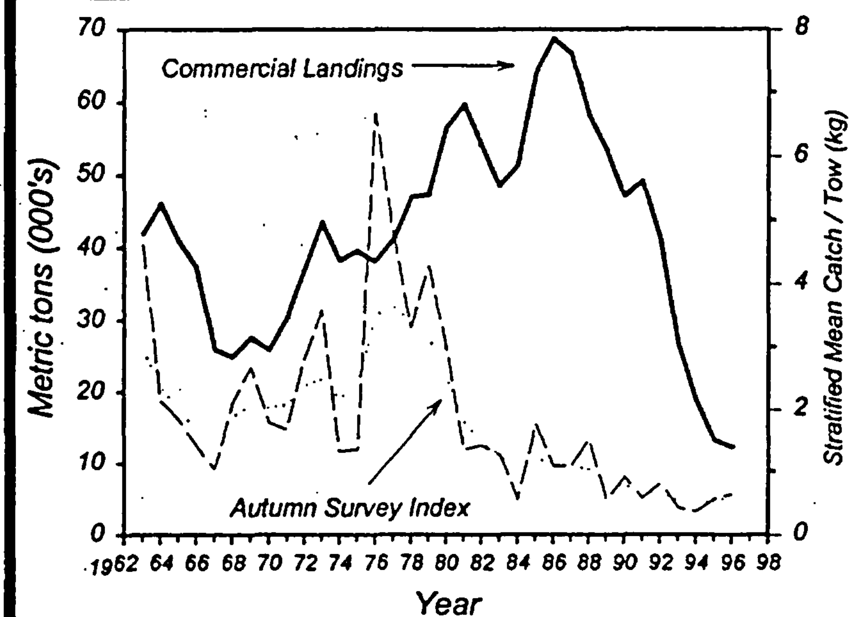


Table 6.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year: 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	0.8[1]	0.1	0.2	0.4	0.1	0.1	<0.1	<0.1	0.2	0.3	0.0
Commercial											
United States	17.3	20.4	15.0	10.6	9.6	7.9	7.2	5.7	3.8	3.4	3.0
Canada	34.8	45.3	41.8	41.0	36.2	37.8	32.1	20.3	15.2	9.8	9.2
Other	0.7	0.8	1.3	1.8	1.3	3.3	2.1	0.8	0.0	0.1	0.1
Total nominal catch	53.6	66.6	58.3	53.8	47.2	49.1	41.4	26.8	19.2	13.6	12.3

[1] 1979-1986

Summary Status

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	=	2.3 years, males 2.0 years, females
Size at 50% maturity	=	41.8 cm (16.5 in.), males 39.1 cm (15.4 in.), females
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%} = 0.65$

$M = 0.20$ $F_{0.1} = 0.20$ $F_{med} = 0.47$ F_{1996} = unknown

Estimated U.S. annual recreational catches have fluctuated between negligable levels and 1,300 mt since 1979. No information is available for the Canadian recreational harvest, although it appears to be of minor importance. The total nominal catch from the stock, including recreational, has been steadily declining since 1986; the 1996 total represents an 82% reduction from 1986.

Nominal commercial catches from the Scotian Shelf, Gulf of Maine, and Georges Bank region increased from an annual average of 38,200 mt during 1972-76 to 68,800 mt in 1986. Canadian landings increased steadily from 24,700 mt in 1977 to an annual average of 43,900 mt during 1985-87, while U.S. landings increased from an average of 9,700 mt during 1973-77 to more than 19,000 mt annually from 1985-1987, peaking at 24,500 mt in 1986. Landings by distant-water fleets declined from an annual average of 9,800 mt during 1970-73 to less than 1,100 mt per year during 1981-88. Distant-water fleet landings increased to 3,300 mt in 1991, but have since declined to negligible levels. Over time, most of the distant water fleet catch has been taken by the USSR/Russian fleet on the Scotian Shelf.

Total stock size estimated from virtual population analysis (VPA) increased continuously throughout the 1970s and early 1980s, declined through the late 1980s, and has since increased slightly. 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, declined sharply during the 1980s, and have remained relatively low since 1989. Indices derived from Canadian bottom trawl surveys conducted on the Scotian Shelf increased during the 1980s but declined sharply during the early 1990s. Commercial catch per unit effort (CPUE) indices for U.S. trawlers fishing predominantly in the Gulf of Maine increased 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 catch per unit effort (CPUE) indices from the Scotian Shelf also increased during the late 1970s to mid-1980s, declined steadily between 1986 and 1994, and increased slightly in 1995 and 1996.

Spawning stock biomass increased from 90,000 mt in 1974 to more than 200,000 mt in 1985. After 1985, however, SSB declined by 39 percent, reaching a low of 122,000 mt in 1991. The increases in stock biomass during the 1970s and early 1980s resulted from recruitment and growth of several relatively strong year classes, notably those of 1971, 1975, and 1979. Recruitment conditions were favorable during this period, with moderate to strong year classes appearing every 3 to 4 years. Year classes produced between 1983 and 1986 were all average or below average, but the 1987 and 1988 year classes were well above the long-term mean. The most recent strong year class was produced in 1988 in the Gulf of Maine and in 1989 on the Scotian Shelf. These year classes were expected to recruit fully to the fishery in 1995 and 1996. The 1990 through 1992 year classes, however, appear to be well below average in size.

High landings during the mid-1980s and later years (in excess of 63,000 mt per year between 1985 and 1987) resulted in relatively high fishing mortality rates ranging from 0.62 (42% exploitation rate) to 0.85 (53% exploitation rate) during the late 1980s and early 1990s. Subsequent projections indicate a substantial reduction in fishing mortality in 1993 to about 0.3-0.4 due to the combined effect of reduced catch and effort in the Canadian sector, and continued recruitment of the 1988 and 1989 year classes. Further reductions in F occurred in 1995 and 1996. The 1991 and 1992 levels of F were well above $F_{0.1}$ (0.20, 17% exploitation rate), substantially greater than F_{med} (0.47, 34% exploitation rate) and slightly above $F_{20\%}$ (0.65, 44% exploitation rate) the level corresponding to the overfishing definition of 20% maximum spawning potential. On the Scotian shelf, F was reduced dramatically in 1995 and 1996 to well below $F_{0.1}$ due to sharp reductions in the Canadian TAC, and adult biomass has increased by about 50% since the early 1990s.

Over the full range of the stock, current fishing mortality appears to be in the range of $F_{0.1}$, and spawning biomass is increasing. Within the Gulf of Maine, however, stock abundance and biomass remain low. Overall the stock is considered 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.

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 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.

Neilson, J., P. Perley, and C. Nelson. 1997. The 1997 assessment of pollock *(Pollachius virens)* in NAFO Divisions 4VWX and Subdivision 5Zc. DFO [Department of Fisheries and Oceans]. *Can. Stock Assess. Sec. Res. Doc.* 97/109.

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

Yellowtail Flounder

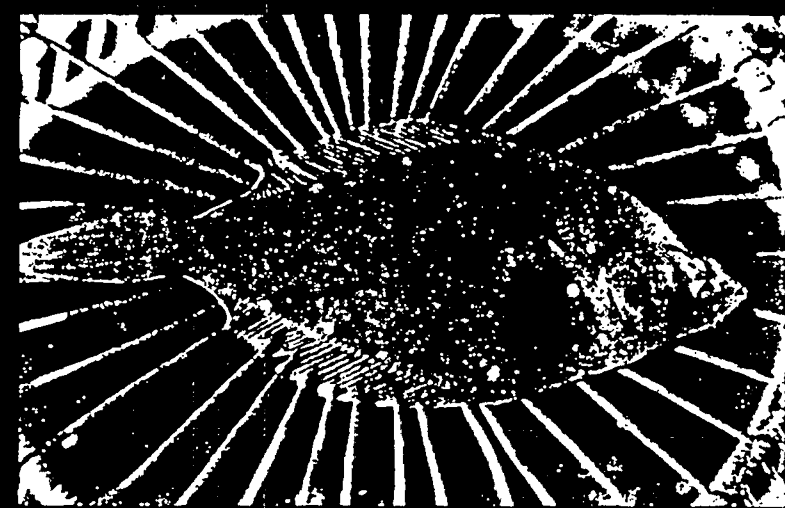
by W. Overholtz
S.X. Cadrin

Yellowtail flounder, *Limanda ferruginea*, range from Labrador to Chesapeake Bay. Off the U.S. coast, commercially important concentrations are found on Georges Bank, off Cape Cod, and off Southern New England, generally at depths between 40 and 70 m (20 to 40 fathoms). Some yellowtail are also taken in the New York Bight and in the Gulf of Maine. Yellowtail grow to 55 cm (22 in.) total length and attain weights of 1.0 kg (2.2 lb), but high rates of fishing mortality have greatly reduced average size and age. 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 develop demersal form and settle to the bottom.

Historical tagging data, larval distributions, geographical patterns of landings and bottom trawl survey data indicate relatively discrete stocks off Southern New England, on Georges Bank, off Cape Cod and in the Middle Atlantic. Intermingling among these groups is probably very limited but has not been quantified.

The principal fishing gear used to catch yellowtail flounder is the otter trawl. Total landings of yellowtail flounder by the U.S. in 1996 were 2,300 mt. These landings were 14% of the 1977-1986 average and 7% of the 1969 historical maximum. An additional 500 mt was taken by Canada on Georges Bank. Recreational landings are negligible.

The U.S. fishery is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan (FMP). Under this FMP yellowtail are included in a complex of 10 groundfish species which have been managed by time/area closures, gear restrictions, minimum size limits, and, since 1994, direct effort controls including a moratorium on permits and days-at-sea restrictions under Amendments 5 and 7. The ultimate goal of the management program is to reduce fishing mortality to levels which will allow stocks within the complex to rebuild to above minimum spawning biomass thresholds. The Canadian fishery on Georges Bank is managed under an individual quota system.



Yellowtail flounder on wire bucket — NOAA Fisheries NEFSC Photo by Brenda Figuerido

Georges Bank

The Georges Bank yellowtail stock has been exploited since the late 1930s. Landings gradually increased to 7,300 mt in 1949, decreased to 1,600 mt in 1956, and subsequently increased again to an average of 13,600 mt during 1962-1976, some of which was taken by distant water fleets. No yellowtail have been taken by distant water fleets since 1977. U.S. landings declined to approximately 6,000 mt between 1978 and 1981 and then rose to over 10,500 mt in 1982-1983 with strong recruitment and intense fishing effort. Landings then fell to a low of 1,100 mt in 1989, averaged 2,200 from 1990 to 1994 and dropped to 300 and 800 mt in 1995 and 1996, respectively. Canadian landings were negligible before 1989, but subsequently increased to 2,100 mt in 1994, exceeding the U.S. total for the first time. In 1995 and 1996, Canada set a total allowable catch (TAC) of 400 mt, and landings totalled under 500 mt.

Abundance indices from NEFSC spring and autumn bottom trawl surveys have declined at average rates of about 10% per year since 1963. Several large year classes have temporarily reversed the overall rate of decline but the general trend has persisted. Between 1963 and 1969,

Georges Bank
Yellowtail flounder

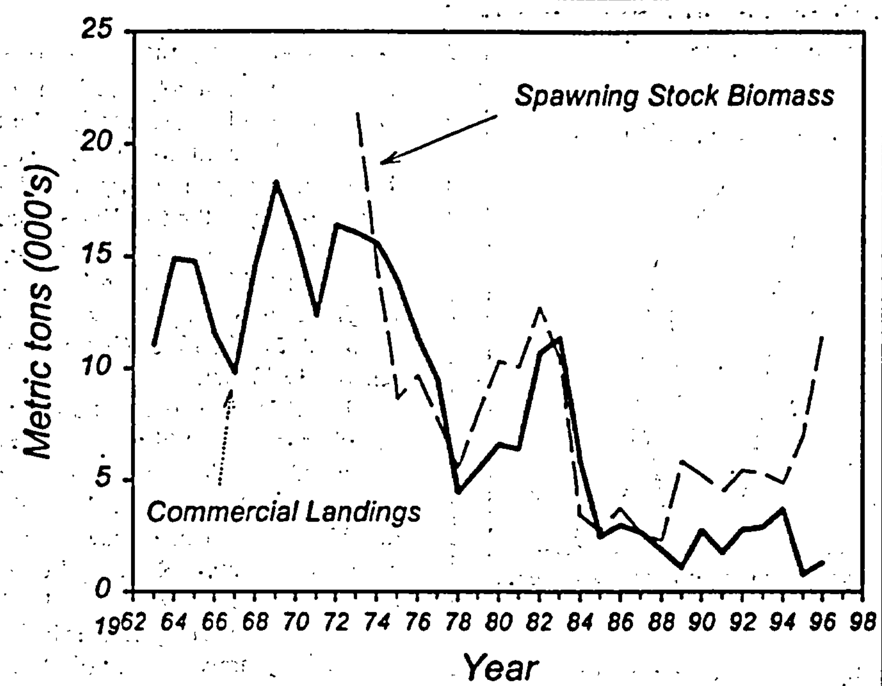


Table 7.1 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	6.6	2.7	1.9	1.1	2.7	1.8	2.9	2.1	1.6	0.3	0.8
Canada	<0.1	-	-	-	-	-	<0.1	0.8	2.1	0.5	0.5
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	6.6	2.7	1.9	1.1	2.7	1.8	2.9	2.9	3.7	0.8	1.3

Summary Status

Long-term potential catch	=	13,000 mt
Biomass for long-term potential catch	=	38,000 mt
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	1.3 years, males 1.8 years, females
Size at 50% maturity	=	21.4 cm (8.4 in.), males 25.8 cm (10.2 in.), females
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%}=0.69$

$M = 0.20$ $F_{0.1} = 0.25$ $F_{max} = 0.63$ $F_{1996} = 0.10$

"...biomass remains low relative to historic levels, but is increasing."

NEFSC autumn survey indices averaged 26 fish per tow; but for the last ten years the average was less than 4 yellowtail per tow. Declines in average weight per tow have been less pronounced but suggest that current biomass levels are about 14% of levels observed in the 1960s.

Recent cooperative assessments with Canada indicate that stock biomass remains low relative to historic levels, but is increasing. Virtual population analysis or VPA indicates that the stock was abundant in the early 1970s and was supported by several strong year-classes. Stock size rapidly declined in the early to mid 1980s from poor recruitment and extremely high fishing mortality, but has since gradually increased to about half the levels observed in the mid-1970s. Fishing mortality was extremely high from 1973 to 1994, but decreased from 1.7 (76% exploitation rate) in 1994 to less than 0.2 (16% exploitation rate) in 1996 and 1997, well below the management target ($F_{0.1}$ = 0.25, 20% exploitation rate) chosen to allow stock rebuilding. Spawning stock biomass declined from 21,400 mt in 1973 to less than 4,000 mt from 1984-1988. Spawning biomass fluctuated below 6,000 mt from 1989 to 1994, and then increased to 15,700 mt in 1997. The stock is considered to be fully exploited and rebuilding from an overfished state.

Southern New England

Landings of yellowtail flounder from the Southern New England stock averaged 20,000 mt during 1963-1968 but declined abruptly after 33,200 mt were landed in 1969. Landings dropped to 8,900 mt in 1971 and have exceeded that level only three times in the past 24 years. Landings increased rapidly between 1981 and 1983 to 17,000 mt due to strong

Southern New England
Yellowtail flounder

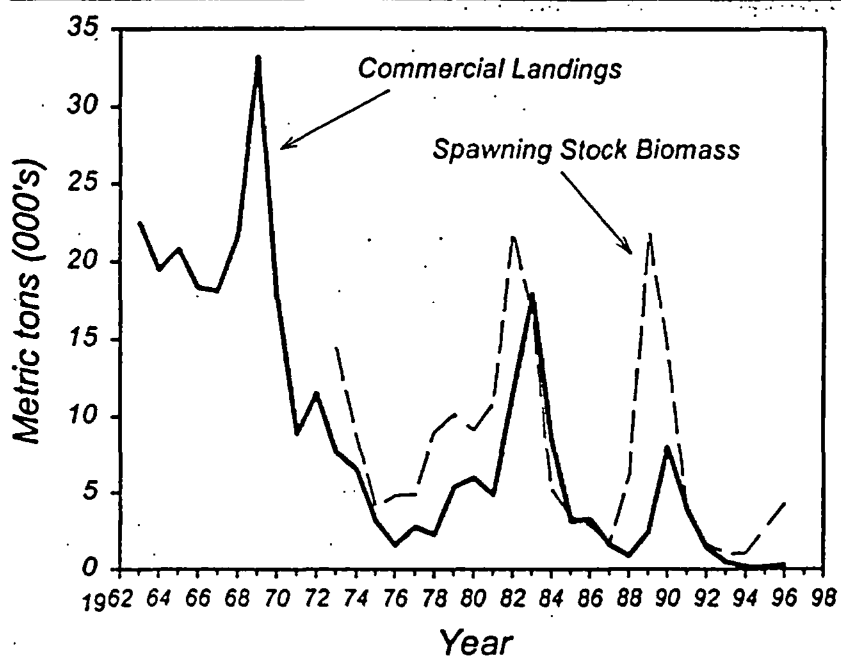


Table 7.2 Recreational catches and commercial landings (thousand metric tons)

Category	Year										
	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	6.6	1.6	0.9	2.5	8.0	3.9	1.5	0.5	0.2	0.2	0.3
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	6.6	1.6	0.9	2.5	8.0	3.9	1.5	0.5	0.2	0.2	0.3

Summary Status

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	=	Fully exploited
Age at 50% maturity	=	1.8 years, males 1.6 years, females
Size at 50% maturity	=	19.6 cm (7.7 in.), males 25.5 cm (10.0 in.), females
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%}$ = 0.94

M = 0.20 $F_{0.1}$ = 0.27 F_{max} > 2.00 F_{1996} = 0.12

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

"...the stock is at low levels, but is increasing slightly."

recruitment of the 1980 year class. Landings subsequently declined to only 900 mt in 1988, rose to 8,000 mt in 1990 with recruitment of the strong 1987 year class, and subsequently declined to only 200 mt in 1994-1995. The apparent recoveries in the early 1980s and 1990 resulted in landings roughly one-half of preceding maximum values. In 1996, landings totalled only 300 mt.

NEFSC autumn bottom trawl survey abundance and biomass indices fluctuated about high levels between 1963 and 1972, but declined sharply in 1973. Since then, survey indices have been augmented briefly by recruitment of the strong 1980 and 1987 year classes, but survey catches in the intervening years were among the lowest on record. By 1993 the NEFSC autumn survey index had fallen to the lowest level in the 30-year series and has since increased only slightly. The average rates of decline in the spring and autumn surveys are similar and indicate an average rate of decline of 11% per year. Current abundance is less than 5% of levels observed in the late 1960s.

A 1997 assessment indicated that the stock is at low levels, but is increasing slightly. Fishing mortality on fully recruited ages fluctuated between 0.6 and 1.1 between 1973 and 1979. Afterwards, F averaged 1.6 per year (74% exploitation rate) until the early 1990s. During these years yellowtail older than age 4 virtually disappeared from both commercial landings and bottom trawl survey catches. Fishing mortality has since declined sharply to 0.12 (10% exploitation rate) in 1996, well below the reference point ($F_{0.1}$ = 0.27, 22% exploitation rate) chosen to allow stock rebuilding. Spawning stock biomass decreased from 21,900 mt in 1989 to only 1,000 mt in 1993, but has since increased to 4,300 mt in 1996. The stock is considered to be fully exploited.

Cape Cod

Traditionally, landings of yellowtail flounder from the Cape Cod stock have been a small fraction of the landings from Southern New England and Georges Bank. Since 1993, however, landings from the Cape Cod stock have exceeded those from Southern New England and, since 1995, have exceeded those from Georges Bank. This situation is more indicative of the degree of decimation of the above stocks than of growth of the Cape Cod stock. Landings of Cape Cod yellowtail fluctuated between 1,500 and 2,000 mt from the mid-1960s to the mid-1970s, increased to a record high of 5,000 mt in 1980, and then declined to only 600 mt in 1993. Landings from 1994-1996 averaged approximately 1,000 mt.

Trends in abundance and biomass for this stock have been monitored by Massachusetts Division of Marine Fisheries and NEFSC bottom trawl surveys. The Massachusetts DMF spring survey biomass index peaked in 1981, but then declined to one-third of peak levels by the late 1980s. Subsequently, stock biomass appears to have increased to one-half of former peak levels. These trends are generally reflected by NEFSC bottom trawl surveys.

Declines in landings and relatively low survey indices (compared to those in the late 1970s) suggest that stock biomass was reduced by the high catches of the late 1970s and early 1980s. Continued recovery will be contingent on maintaining a conservative management program.

Middle Atlantic

Trends for the Mid-Atlantic stock of yellowtail flounder have been generally similar to those observed for the Southern New England stock. Landings declined from more than 8,000 mt in 1972 to less than 1,000 mt between 1976 and 1980. As a result of improved recruitment, landings increased from 300 mt in 1980 to 2,200

Cape Cod
Yellowtail flounder

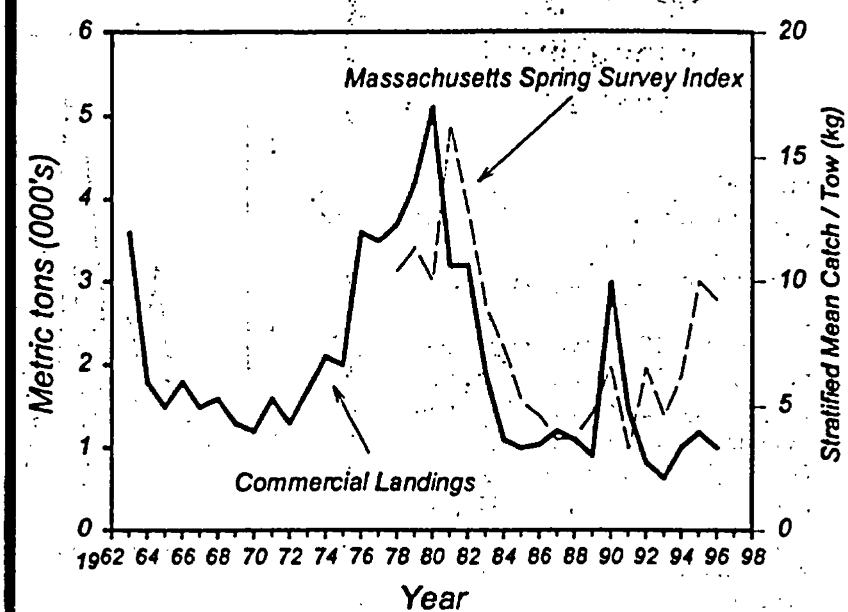


Table 7.3 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	2.8	1.2	1.1	0.9	3.0	1.4	0.8	0.6	0.9	1.2	1.0
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	2.8	1.2	1.1	0.9	3.0	1.4	0.8	0.6	0.9	1.2	1.0

Summary Status

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	=	2.6 years (both sexes)
Size at 50% maturity	=	26.8 cm (10.6 in.), males 27.3 cm (10.8 in.), females
Assessment level	=	Yield per recruit
Overfishing definition	=	None
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.20$ $F_{0.1} = 0.2$ $F_{max} = 0.55$ $F_{1996} =$ Unknown

"Continued recovery will be contingent on maintaining a conservative management program."

mt in 1984. Subsequently, landings declined sharply and have since fluctuated about a low level, averaging 200 mt annually during the last three years.

Prior to 1973, average biomass per tow in NEFSC autumn bottom trawl survey indices in the Mid-Atlantic region was comparable to levels on Georges Bank. Subsequent to the removal of over 8,000 mt in 1972, survey indices fell to very low levels, with only slight increases in 1981-1982 and again in 1989-1990. In 1992, no yellowtail flounder were caught in the NEFSC autumn survey in the mid-Atlantic.

A quantitative assessment is not available for this stock. Qualitatively, survey and catch data suggest continued low abundance. Recovery to former levels will be contingent upon maintaining a conservative management program.

For further information

NEFSC [Northeast Fisheries Science Center]. 1996. [Report of the] 21st Northeast Regional Stock Assessment Workshop (21st SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 96-05d.

NEFSC [Northeast Fisheries Science Center]. 1997. [Report of the] 24th Northeast Regional Stock Assessment Workshop (24th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-12.

Middle Atlantic

Yellowtail flounder

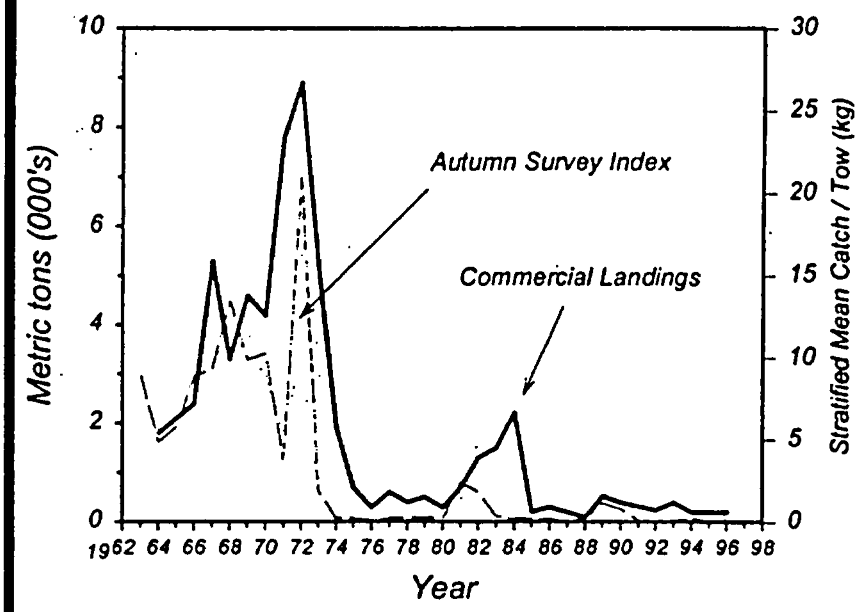


Table 7.4 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	0.8	0.2	<0.1	0.5	0.4	0.3	0.2	0.4	0.2	0.2	0.2
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.8	0.2	<0.1	0.5	0.4	0.3	0.2	0.4	0.2	0.2	0.2

Summary Status

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	=	1.8 years, males[1] 1.6 years, females[1]
Size at 50% maturity	=	19.6 cm (7.7 in.), males[1] 25.5 cm (10.0 in.), females[1]
Assessment level	=	Index
Overfishing definition	=	None
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.20$ $F_{0.1} = 0.21$ $F_{max} = 0.55$ F_{1996} = Unknown

[1]Based on maturity data for southern New England yellowtail

Summer Flounder

by M. Terceiro

The summer flounder or fluke, *Paralichthys dentatus*, occurs from the southern Gulf of Maine to South Carolina. Important commercial and recreational fisheries exist within the Mid-Atlantic Bight (Cape Cod to Cape Hatteras). Summer flounder are concentrated in bays and estuaries from late spring through early autumn, when an offshore migration to the outer continental shelf is undertaken. Spawning occurs during autumn and early winter, and the larvae are transported toward coastal areas by prevailing water currents. Development of post-larvae and juveniles occurs primarily within bays and estuarine areas, notably Pamlico Sound and Chesapeake Bay. Most of the population is sexually mature by age 2. Female summer flounder may live up to 20 years, but males rarely live for more than 7 years. Growth rates differ appreciably between the sexes with females attaining weights up to 11.8 kg (26 lb).

The resource is managed under the Summer Flounder Fishery Management Plan (FMP) as a unit stock from North Carolina to Maine. Amendment 2 to the FMP made several major regulatory changes including annual commercial quotas, recreational harvest limits, a commercial vessel permit moratorium, minimum fish size and gear restrictions, and a recreational fishery possession limit. The amendment also implemented a target fishing mortality rate reduction schedule, which under Amendment 7 to the FMP was as follows: F = 0.41 in 1996, 0.30 in 1997, and 0.23 in 1998 and beyond. Total landings were capped at 8,400 mt (18.51 million lbs) in 1996.

Summer flounder in the shade — NOAA Fisheries NEFSC photo by Brenda Figuerido

Total landings averaged 22,700 mt annually during 1979-1986, peaking at 28,300 mt in 1980. Since 1989, landings have been much lower, ranging between 6,500 and 10,800 mt. Total landings in 1996 were 10,500 mt, 11 percent higher than in 1995.

The principal gear used in commercial fishing for summer flounder is the otter trawl. Commercial landings of summer flounder averaged 13,700 mt during 1979-1986, reaching a high of 17,100 mt in 1984. Commercial landings during 1989-1996 have been markedly lower (4,200 to 8,100 mt per year). In 1996, commercial landings fell to 5,800 mt, 17 percent lower than in 1995.

The recreational fishery for summer flounder harvests a significant proportion of the total catch, and in some years recreational landings have exceeded the commercial total. Recreational landings have historically constituted about 40 percent of the total landings. Recreational landings averaged 9,000 mt during 1979-1986, and peaked at 14,100 mt in 1980. Since 1987, recreational landings have been considerably lower although recent trends have been upwards. In 1996, recreational landings increased to 4,700 mt, the highest level observed since 1988.

Catch curve analyses of NEFSC survey and commercial fishery age composition data for 1976 through 1983 indicated that fishing mortality rates during this period were about 0.6 to 0.7 (41-46% exploitation rates), well in excess of the current overfishing definition for the stock, F_{max} = 0.24 (19% exploitation rate). Recent virtual population analyses (VPA) have used NEFSC survey age composition data, survey age composition data from the states of Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, and North Carolina,

"...about 85% of the spawning stock would be expected to be ages 2 and older if the stock were rebuilt and fished at F_{max}."

and commercial and recreational fishery age composition data to estimate fishing mortality rates and stock sizes. Current VPA results indicate that fishing mortality has been high in recent years, peaking at F = 2.1 (82% exploitation rate) in 1992, and was near 1.0 (58% exploitation rate) in 1996.

Spawning stock biomass declined 75% from 1983 to 1989 (18,900 mt to 5,200 mt), but has since increased to 17,400 mt in 1996. The age structure of the spawning stock has begun to expand, with 34% of the biomass at ages 2 and older in 1996, although about 85% of the spawning stock would be expected to be ages 2 and older if the stock were rebuilt and fished at F_{max}. The 1982 and 1983 year classes were estimated to be the largest in the VPA time series at 76 and 83 million age 0 fish, respectively. Recruitment declined from 1983 to 1988, with the 1988 year class the smallest, at only 13 million fish. The 1995 year class, at about 47 million fish, is of about average strength (1982-1996), but the 1996 year class is estimated to be the poorest since 1988. The summer flounder stock is at an intermediate level of historical (1968-1996) abundance and is overexploited.

For further information

NEFSC [Northeast Fisheries Science Center]. 1997. [Report of the] 25th Northeast Regional Stock Assessment Workshop (25th SAW) Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-14.

Georges Bank-Middle Atlantic

Summer Flounder

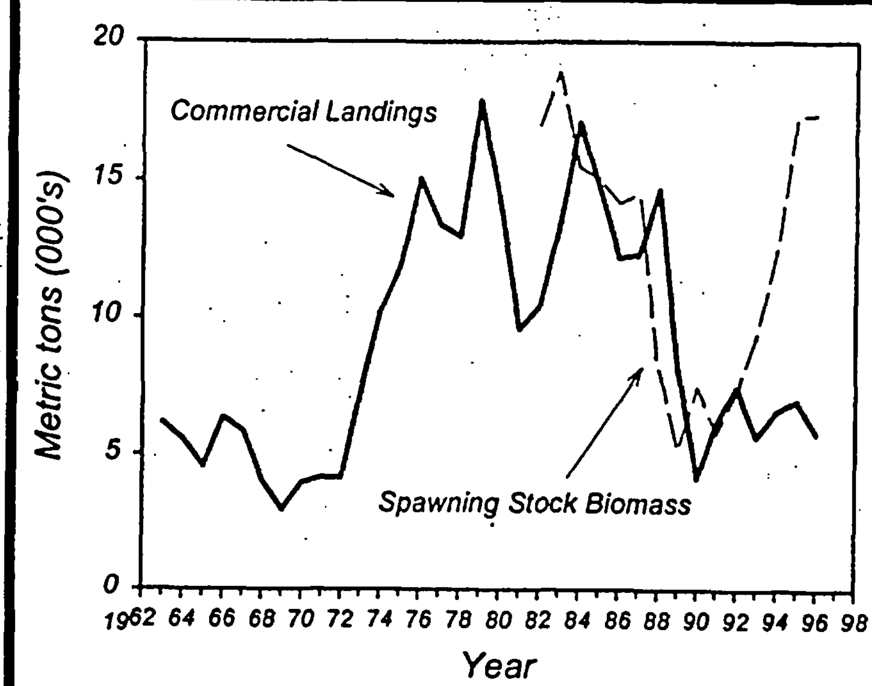


Table 8.1 Recreational and commercial landings (thousand metric tons)

Category	Year 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	9.0[1]	5.5	6.7	1.4	2.3	3.6	3.2	3.5	4.1	2.5	4.7
Commercial											
United States	13.6	12.3	14.7	8.1	4.2	6.2	7.5	5.7	6.6	7.0	5.8
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	22.6	17.8	21.4	9.5	6.5	9.8	10.8	9.2	10.7	9.5	10.5

[1]1979-1986

Summary Status

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	=	1.0 years, males 1.5 years, females
Size at 50% maturity	=	24.9 cm (9.8 in.), males 28.0 cm (11.0 in.), females
Assessment level	=	Age structured
Overfishing definition	=	F_{max}
Fishing mortality rate corresponding to overfishing definition	=	$F_{max} = 0.24$

$M = 0.20$ $F_{0.1} = 0.14$ $F_{1996} = 1.0$

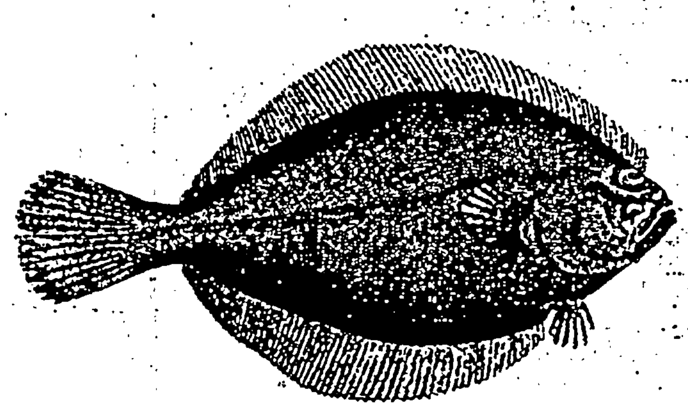
American Plaice

by L. O'Brien

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

The principal commercial fishing gear used to catch American plaice is the otter trawl. Recreational and foreign catches are insignificant. The U.S. fishery is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Management measures include a moratorium on permits, days-at-sea restrictions, time/area closures, gear restrictions, and minimum size limits.

Landings of American plaice increased from an annual average of 2,300 mt during 1972-1976 to an average of 12,700 mt per year during 1979-1984. Subsequently, annual landings declined and since 1991 have ranged between 4,000 mt and 7,000 mt. Total commercial landings in 1996 were 4,400 mt, 5% less than in 1995 (4,700 mt). Between 1960 and 1974, 67% 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. commercial catch per unit effort (CPUE) index was relatively stable between 1964 and 1969, declined in the early 1970s, and then sharply increased to a record high in 1977, when total landings doubled. Subsequently, the index steadily declined, reaching a record low in 1988, and remained relatively stable at a low level through 1993. Values for 1994-1996 are currently unavailable.

Abundance and biomass indices from NEFSC autumn bottom trawl surveys reached record-low values in 1987 but increased through 1990 as the strong 1987 year class recruited to the survey gear. Indices declined in 1991 and 1992, but increased in 1994 due to record high catches of 2-year-old fish from the 1992 year class. Indices remained stable in 1995 but declined in 1996.

A 1992 virtual population analysis indicated that fishing mortality on fully recruited ages (6-9+) more than doubled between 1981 (F =0.36) and 1987 (F=0.87), but declined to F=0.47 in 1990. Fishing mortality in 1991 was estimated to be 0.58, well above F_{max}=0.29 (23% exploitation rate) and the F needed to attain 20% maximum spawning potential ($F_{20\%}$=0.49, 35% exploitation rate), the overfishing definition established for this stock. Subsequent projections indicate that fishing mortality was above 0.70 (46% exploitation rate) during 1992-1995 but declined to about 0.5 in 1996.

Spawning stock biomass declined from 41,400 mt during 1980-1982 to 7,700 mt during 1987-1989. In 1991, spawning stock biomass increased to 13,400 mt as the strong 1987 year class began to recruit to the spawning stock. Projections indicate that spawning stock biomass remained relatively stable during 1992-1993, declined during 1994-1995 and then increased in 1996 as the strong 1992 year class, similar in strength to the 1987 year class, recruited to the spawning stock.

Discard estimates for American plaice indicate that discarding is highest on age 2 and 3 fish in the northern shrimp fishery and on age 3 and 4 fish in the large mesh otter trawl fishery. Estimates for the northern shrimp fishery indicate that by 1991, 40% of the total cumulative catch (in numbers) of the 1987 year class had been discarded. Similarly, in the large mesh fishery, 41% of the total cumulative catch of the 1987 year class is estimated to have been discarded by 1991. Discarding in the shrimp fishery, however, has been reduced following introduction of the Nordmore grate in April of 1992.

"The 1992 and 1993 year classes represent the next opportunity to continue increasing harvestable biomass if fishing mortality and discarding are reduced."

The decline in landings that occurred between 1983 and 1989 reflected a declining trend in harvestable biomass, as indicated by both catch per unit effort and NEFSC survey indices. Although landings increased in 1990-1992, as the 1986 and 1987 year classes recruited to the fishery, landings have since declined through 1996. Stock biomass remains at a medium level. The 1992 and 1993 year classes represent the next opportunity to continue increasing harvestable biomass if fishing mortality and discarding are reduced.

For further information

Mayo, R.K., L. O'Brien, and N. Buxton. 1992. Discard estimates of American plaice in the Gulf of Maine northern shrimp fishery and the Gulf of Maine-Georges Bank large mesh otter trawl fishery. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC SAW Doc.* 14/3.

Northeast Fisheries 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. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC SAW-14/Res. Doc. SAW 14/2.*

Sullivan, L.F. 1982. American plaice, *Hippoglossoides platessoides*, in the Gulf of Maine. University of Rhode Island (Kingston). Master's Thesis.

Gulf of Maine-Georges Bank

American Plaice

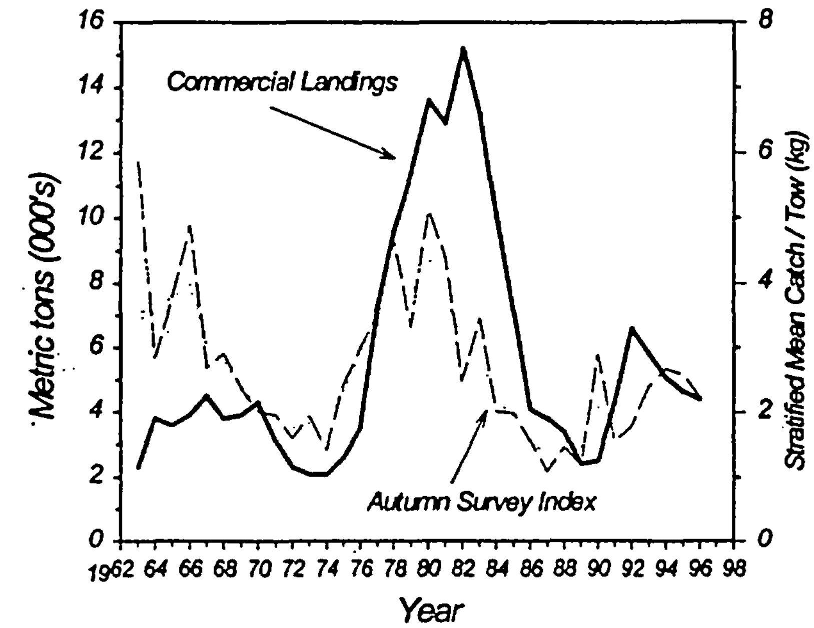


Table 9.1 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	10.4	3.8	3.4	2.4	2.5	4.3	6.6	5.8	5.1	4.7	4.4
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	10.4	3.8	3.5	2.5	2.5	4.3	6.6	5.8	5.1	4.7	4.4

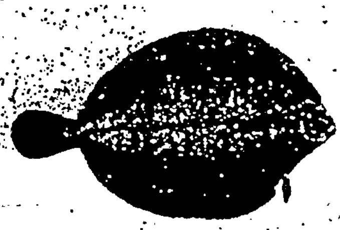
Summary Status

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	=	$F_{20\%} = 0.49$

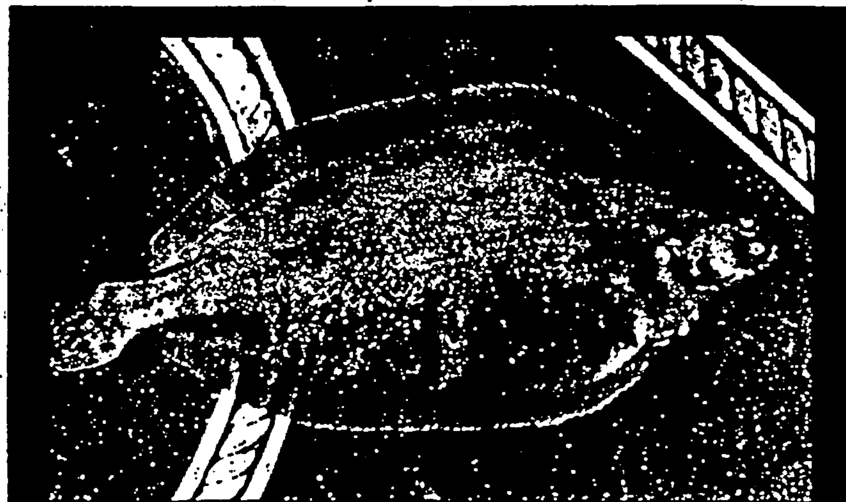
$M = 0.20$ $F_{0.1} = 0.18$ $F_{max} = 0.29$ $F_{1996} \sim 0.50$

[1]Excluding discards

Witch Flounder



by S. Wigley



Witch flounder — NOAA Fisheries NEFSC photo by Brenda Figuerido

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

The principal fishing gear used to catch witch flounder is the otter trawl. Recreational catches are insignificant. The U.S. fishery is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Management measures include a moratorium on permits, days-at-sea restrictions, time/area closures, gear restrictions, and minimum size limits.

Historically, significant proportions of the U.S. nominal catch have been taken both on Georges Bank and in the Gulf of Maine; but in recent years most of the U.S. catch has come from the Gulf of Maine area. Canadian landings from both areas have been minor (never more than 68 mt annually). Distant-water fleet catches averaged 2,700 mt in 1971-1972, but subsequently declined sharply and have been negligible since 1976. Total landings peaked at over 6,000 mt in 1971, declined to an annual average of 2,800 mt during 1973-1981, and then increased sharply to 6,500 mt in 1984. Landings then declined steadily to only 1,500 mt in 1990, the lowest value since 1964. Landings for 1991-1996 averaged 2,300 mt annually. Total landings in 1996 were 2,100 mt, a decrease of 6% from 1995 (2,200 mt).

The NEFSC autumn bottom trawl survey index declined from an average of 3.6 kg per tow in 1966-1970 to 0.9 kg per tow in 1976 following heavy exploitation by distant-water fleets. The index increased in 1977-78 but then declined steadily to the lowest level on record. The 1996 value of 1.0 kg per tow represents an increase over the record low 1992 value of 0.2 kg per tow; however, witch flounder biomass remains at a low level.

Prior to the 1980s, witch flounder was primarily a by-catch species. In the early 1980s, U.S. commercial LPUE (landings per unit effort for all trips landing witch flounder) indices increased and peaked in 1983 as effort became more directed towards witch flounder. As abundance declined, catch rates declined to at or near record lows in the early 1990s.

Between 1982 and 1993, 8.7 million witch flounder were discarded in the northern shrimp fishery and large-mesh otter trawl fisheries. Discards in the northern shrimp fishery consist primarily of ages 1-4 witch flounder, while discards in the large mesh otter trawl fishery are largely comprised of fish age 3 and older. Almost all age 6 and older fish are landed.

Virtual population analyses indicate that fishing mortality on fully-recruited ages (7 to 9+) increased from F=0.19 in 1982 to F=0.55 in 1985, declined to 0.24 in 1990 and 1991 and increased to 0.45 (34% exploitation rate) in 1993, above the overfishing reference level of $F_{30\%}$ = 0.39 (30% exploitation rate).

Since the mid-1980s, the age structure of the stock has become severely truncated. The NEFSC 1980 autumn survey indicated that 34% of the witch flounder population was age 11 or older; for 1984, this figure had declined to 14%, and by 1995, less than 1% of the population was 11 years or older. This trend is also

Gulf of Maine - Georges Bank

Witch Flounder

"The NEFSC 1980 autumn survey indicated that 34% of the witch flounder population was age 11 or older...by 1995, less than 1% of the population was 11 years or older."

reflected in the commercial landings; 16% of witch flounder in 1984 landings were age 11 or older, while by 1993, this figure had dropped to 8 percent.

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

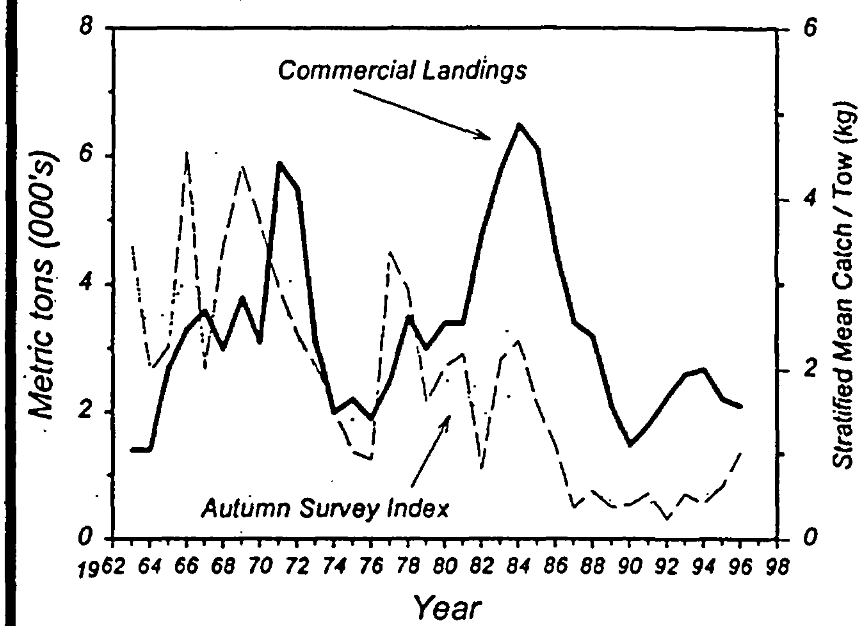


Table 10.1 Recreational and commercial landings (thousand metric tons)

Category	Year										
	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	4.4	3.5	3.2	2.1	1.5	1.8	2.2	2.6	2.7	2.2	2.1
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	4.4	3.5	3.2	2.1	1.5	1.8	2.2	2.6	2.7	2.2	2.1

Summary Status

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

$M = 0.15$ $F_{0.1} = 0.15$ $F_{max} = 0.27$ F_{1996} = Unknown

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.

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

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

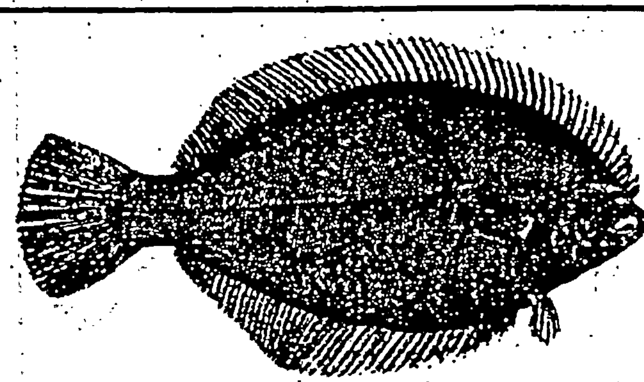
Winter Flounder

by R. Brown
W. Gabriel

The winter flounder, blackback, or lemon sole, *Pseudopleuronectes 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. Winter flounder undertake small-scale migrations into estuaries, embayments, and saltwater ponds in winter to spawn, subsequently moving to deeper water during summer. Winter flounder tend to return to the same spawning locations in consecutive years. Restricted movement patterns, and differences in growth, meristic, and morphometric characteristics suggest that relatively discrete local groups exist.

Tagging and meristic studies indicate separate groups of winter flounder north of Cape Cod, east and south of Cape Cod, and on Georges Bank. Recently, three groups have been recognized for assessment purposes; these being a Gulf of Maine, Southern New England - Middle Atlantic, and a Georges Bank group. 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 is the otter trawl. Recreational catches are significant, especially in the southern parts of the range. U.S. commercial and recreational fisheries are managed under the New England Fishery Management Council's Multispecies Fishery Management Plan (FMP) and the Atlantic States Marine Fisheries Commission's Fishery Management Plan for Inshore Stocks of Winter Flounder. Management measures under the Multispecies FMP include a moratorium on permits, days-at-sea restrictions, time/area closures, gear restrictions, and minimum size limits. Total commercial landings in 1996 (4,800 mt) increased from 1994 and 1995 levels, but remained near a record low.



"Future improvements in the condition of the stock will depend on decreases in exploitation... and on improved recruitment."

Gulf of Maine

Commercial landings from the Gulf of Maine increased from a steady 1,000 mt for the period 1961 to 1975 to nearly 3,000 mt in 1982. Recreational landings estimates, first available in 1979, combined to produce a total catch of 3,400 mt for that year; and combined landings rose to 5,000 mt in 1981 before declining to an average of 2,700 mt during the mid-1980s. Since 1989, landings have continued to trend downward. Combined landings in 1995-1996 were only 700 mt, and were 600 mt in 1994, a record low for the 1979-1996 time series. Estimated recreational catches in 1994-1996 (<100 mt) were the lowest since 1979.

Bottom trawl survey abundance indices from the Massachusetts Division of Marine Fisheries spring survey decreased after 1983, and reached a record-low in 1994. Since 1988, survey indices have remained stable at a low level. Estimates of fishing mortality based on that survey were near or above 1.0 (58% exploitation rate) from 1989-1994. Commercial catch per unit effort (CPUE) indices (for Tonnage Class 2 otter trawlers) peaked in the late 1960s to early 1970s, averaging 3.0 mt per day fished (df) between 1968 and 1971. CPUE has since declined steadily, with 1992-1993 values (0.7 mt per df) being the lowest in the 30-year time series. Estimates from surplus production modeling (ASPIC) suggest that biomass declined from 19,600 mt in 1979 to a low of 6,000 mt in 1991. Biomass has since increased to 8,900 mt in 1997.

The continuing low level of landings, CPUE indices, and survey indi-

Gulf of Maine
Winter Flounder

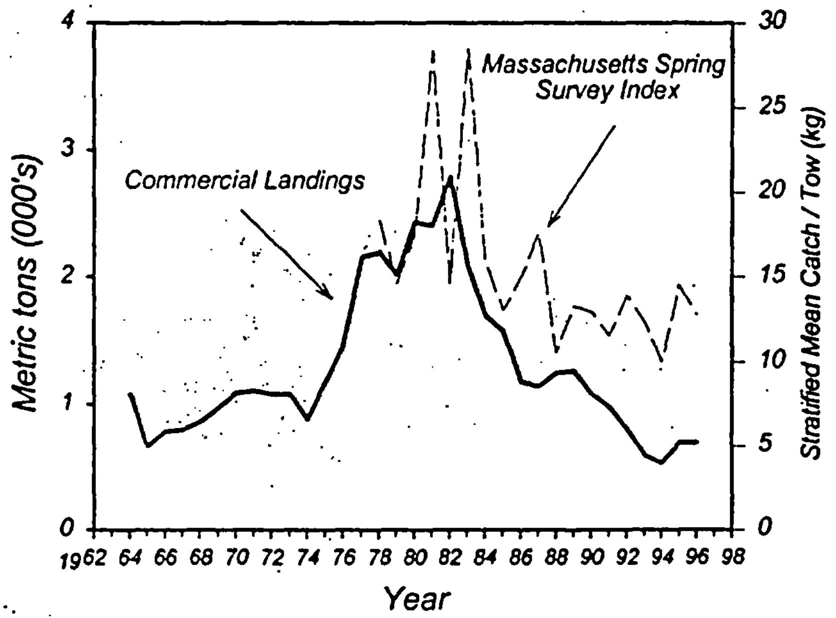


Table 11.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year: 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	1.4[1]	1.7	0.6	0.6	0.4	0.1	0.1	0.1	<0.1	<0.1	<0.1
Commercial											
United States	2.0	1.1	1.3	1.3	1.1	1.0	0.8	0.6	0.5	0.7	0.7
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.5	2.9	1.8	1.9	1.5	1.1	0.9	0.7	0.6	0.7	0.7

[1]1981-1986

Summary Status

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Multispecies FMP FMP for Inshore Stocks of Winter Flounder (ASMFC)
Status of exploitation	=	Overexploited
Age at 50% maturity	=	3.3 years, males 3.5 years, females
Size at 50% maturity	=	27.6 cm (10.9 in.), males 29.7 cm (11.7 in.), females
Assessment level	=	Surplus production model
Overfishing definition	=	20% MSP (NEFMC) 40% MSP (ASMFC)
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = 0.20 $F_{0.1}$ = Unknown F_{max} = Unknown F_{1996} = Unknown

ces suggest that winter flounder abundance in the Gulf of Maine has been reduced substantially. Future improvements in the condition of the stock will depend on decreases in exploitation in both the recreational and commercial fisheries, and on improved recruitment. The stock is at a low biomass level and 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 1980-1984(average of 3,800 mt per yr). Between 1985 and 1988, landings averaged 2,400 mt per yr, but landings then declined steadily to approximately 700 mt in 1995. Landings increased to 1,300 mt in 1996 due to improved recruitment. No recreational catches have been reported from this stock.

The NEFSC autumn bottom trawl survey biomass index declined from the mid-1970s until 1991, when it reached an all-time low of 0.14 kg per tow. Since 1991, indices have increased steadily, reaching 1.76 kg in 1996. However, current survey indices remain significantly below former levels.

"... stock rebuilding has been initiated, [but] stock levels remain well below the historic average."

Available data indicate that the stock declined to record low levels in the early 1990s, and was overexploited. Since 1993, this stock has benefitted from restrictive management measures including direct effort controls along with temporal and spatial expansion of closed areas. Although there is some evidence to suggest that stock rebuilding has been initiated, stock levels remain well below the historic average.

"Strong year classes in 1992 and 1994 have resulted in a gradual rebuilding of stock biomass..."

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 over 11,000 mt in 1981. Recreational catches were not estimated before 1981. Commercial landings have since declined steadily, while recreational catches increased from 1981 to 1985, and then declined. Combined recreational and commercial landings decreased to 2,800 mt in 1994, the lowest in the 1979-1996 time series. Since then, combined landings have increased slightly, to 3,300 mt in 1995-1996.

The NEFSC spring bottom trawl survey biomass index shows trends similar to those for commercial landings since about 1975, increasing through 1981 and thereafter declining. The 1993 survey index value was the lowest in the 29-year time series. The commercial CPUE index (for Tonnage Class 3 otter trawlers) declined from the 1964-1983 average of 2.7 mt per df to only 0.6 mt per df in 1993, the lowest in the 1964-1993 time series.

Fishing mortality estimated from surplus production modelling (ASPIC) averaged 1.2 (65% exploitation rate) from 1984-1995, exceeding fishing mortality rates associated with the overfishing definitions for this stock ($F_{40\%}$ = 0.21, 17% exploitation rate, $F_{20\%}$ = 0.46, 34% exploitation rate). Fishing mortality is estimated to have declined to 0.36 (28% exploitation rate) in 1996.

Stock biomass (age 1+) gradually declined from 39,000 mt in 1981

Georges Bank

Winter Flounder

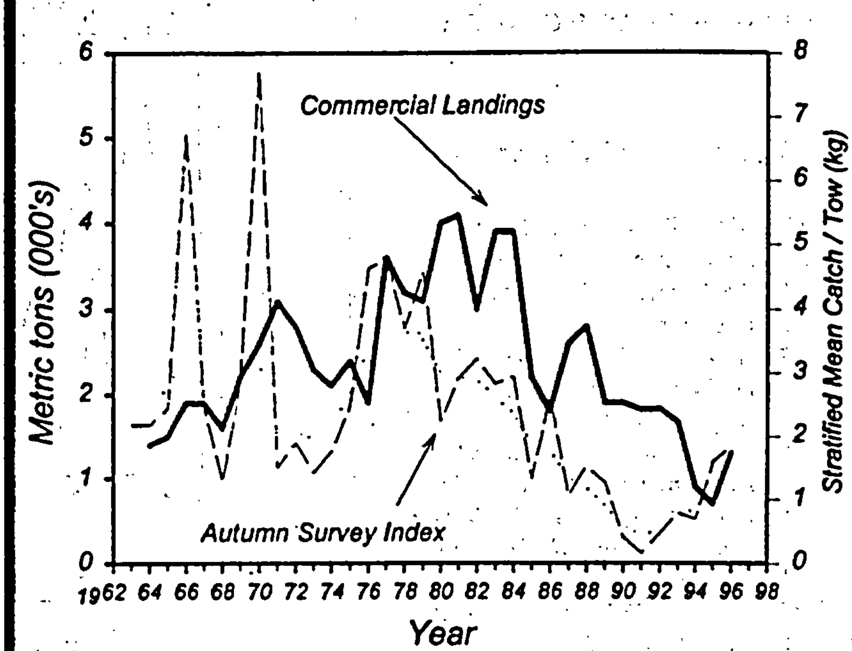


Table 11.2 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	3.3	2.6	2.8	1.9	1.9	1.8	1.8	1.7	0.9	0.7	1.3
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.3	2.6	2.8	1.9	1.9	1.8	1.8	1.7	0.9	0.7	1.3

Summary Status

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 (both sexes)
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	=	$F_{20\%}$ = 0.37

M = 0.20 $F_{0.1}$ = 0.17 F_{max} = 0.36 F_{1996} = Unknown

to a record low level of 8,500 mt in 1992. Strong year classes in 1992 and 1994 have resulted in a gradual re-building of stock biomass to 18,000 mt in 1996. However, stock biomass remains low relative to historic levels and the stock remains overexploited relative to the ASMFC overfishing definition.

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.*

ASMFC Winter Flounder Technical Committee. 1998. Assessment of the Southern New England/Mid-Atlantic and Gulf of Maine winter flounder stocks. *ASMFC Winter Flounder Technical Committee Doc.* 98-01.

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

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

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

NEFSC [Northeast Fisheries Science Center]. 1996. 21st Regional Stock Assessment Workshop (21th SAW) Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 96-05d.

Southern New England - Middle Atlantic

Winter Flounder

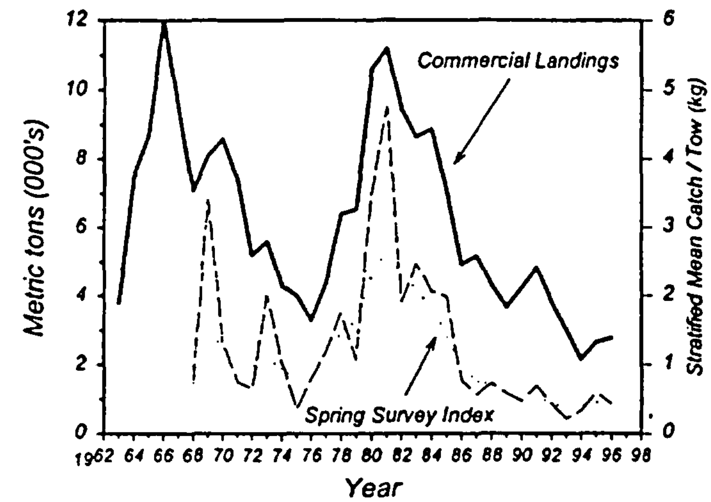


Table 11.3 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	3.8[1]	3.1	3.4	1.8	1.1	1.2	0.4	0.5	0.6	0.7	0.6
Commercial											
United States	7.8	5.2	4.3	3.7	4.2	4.8	3.8	3.0	2.2	2.6	2.8
Canada	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	11.6	8.3	7.8	5.5	5.3	6.0	4.2	3.6	2.8	3.3	3.3

[1] 1981-1986

Summary Status

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Significant
Management	=	Multispecies FMP FMP for Inshore Stocks of Winter Flounder (ASMFC)
Status of exploitation	=	Overexploited
Age at 50% maturity	=	3.3 years, males 3.0 years, females
Size at 50% maturity	=	29.0 cm (11.4 in.), males 27.6 cm (10.9 in.), females
Assessment level	=	Surplus production model
Overfishing definition	=	20% MSP (NEFMC) 40% MSP (ASMFC)
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%}$ = 0.46 (NEFMC) $F_{40\%}$ = 0.21 (ASMFC)

M = 0.20 $F_{0.1}$ = 0.22 F_{max} = 0.54 F_{1996} = 0.36

Windowpane

by L. Hendrickson

Windowpane or sand flounder, *Scophthalmus aquosus*, is a thin-bodied, left-handed flatfish distributed on the northwest Atlantic continental shelf from the Gulf of St. Lawrence to Florida. This species inhabits large estuaries and is also commercially abundant in waters less than 56 m (30 fathoms) on Georges Bank and in Southern New England. Sexual maturity occurs between ages 3 and 4. Spawning occurs from April through December in Mid-Atlantic Bight waters, with peaks in May and October; and during summer on Georges Bank, where peak activity occurs in July and August.

No stock structure information is available. Therefore, a provisional arrangement has been adopted which recognizes two stock areas based on apparent differences in growth, sexual maturity, and abundance trends between fish from Georges Bank and Southern New England. The proportions of total landings contributed by the Gulf of Maine and Mid-Atlantic areas are low (less than 7%), so data from these areas are combined with those from Georges Bank and Southern New England, respectively.

The principal commercial fishing gear for windowpane flounder is the otter trawl. Recreational and foreign catches are insignificant. This species is managed under the New England Fishery Management Council's Multispecies Fishery Management Plan. Management measures include a moratorium on permits, days-at-sea restrictions, time/area closures, and gear restrictions.

Commercial exploitation of windowpane flounder began during 1943-1945, and until 1975, windowpane

Windowpane

NOAA Fisheries
NEFSC Photo Archive

Gulf of Maine - Georges Bank

Windowpane

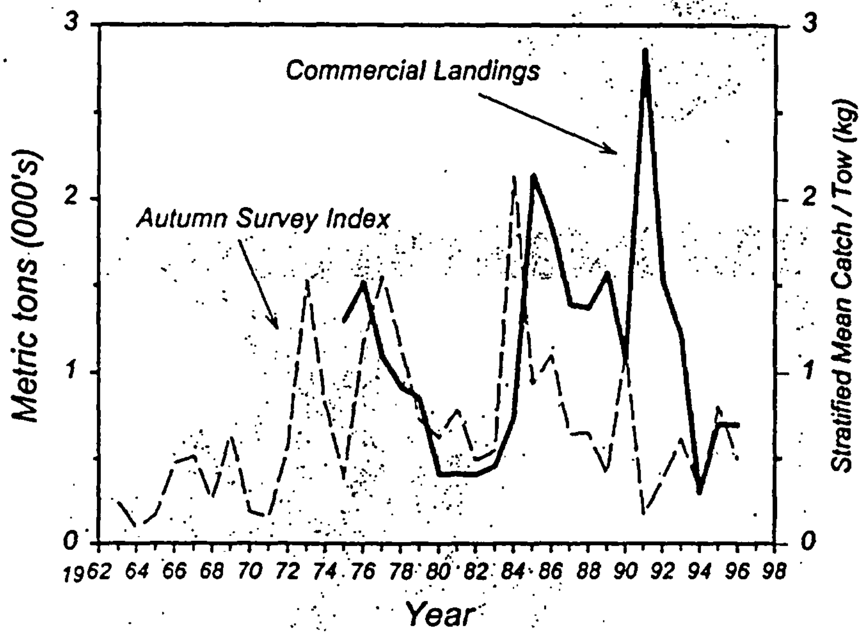


Table 12.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year										
	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial:											
United States	0.9	1.4	1.4	1.6	1.1	2.9	1.5	1.2	0.3	0.7	0.7
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.9	1.4	1.4	1.6	1.1	2.9	1.5	1.2	0.3	0.7	0.7

Summary Status

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	=	3.0 Years
Size at 50% maturity	=	22.2 cm (8.7 in.), males 22.5 cm (8.9 in.), females
Assessment level	=	Index
Overfishing definition	=	3-year moving average of NEFSC autumn bottom trawl survey index falls within the lowest quartile of the time series
Fishing mortality rate corresponding to overfishing definition	=	N/A

M = Unknown **$F_{0.1}$ = Unknown** **F_{max} = Unknown** **F_{1996} = Unknown**

"...until 1975, windowpane was harvested as part of an industrial fishery."

was harvested as part of an industrial fishery. Landings records for this species date back to 1975, at which time landings totalled 2,000 mt. Landings reached a peak of 4,200 mt in 1985 and then fluctuated between 2,000 mt and 3,700 mt during 1987-1991. Subsequently, landings declined sharply and have averaged less than 1,000 mt annually since 1994.

Gulf of Maine-Georges Bank

Since 1991, approximately 75% of the total windowpane landings have been harvested from the Gulf of Maine-Georges Bank area. Following a 1991 record high of 2,900 mt, landings declined to a record low in 1994 (300 mt) and then increased to 700 mt in 1996. High landings during

"NEFSC autumn bottom trawl survey indices, although highly variable, have declined since 1984.

the early 1990s probably reflect an expansion of the fishery to offshore areas, as well as the targeting of windowpane flounder as an alternative to depleted groundfish stocks. NEFSC autumn bottom trawlsurvey indices, although highly variable, have declined since 1984. The stock is considered to be fully exploited and at a medium biomass level.

Southern New England-Middle Atlantic

Windowpane

"During 1991-1993, landings from this area were only 25% of those from the Gulf of Maine-Georges Bank region."

Southern New England-Middle Atlantic

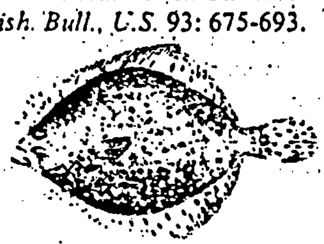
Commercial landings from this region exceeded those from the Gulf of Maine-Georges Bank region during 1980-1984 and reached a record-high of 2,100 mt in 1985. Landings have since declined from 1,200 mt in 1988 to a record low of 100 mt in 1995. During 1991-1993, landings from this area were only 25% of those from the Gulf of Maine-Georges Bank region. NEFSC autumn bottom trawl survey indices have declined since the early 1980s to record low levels. The stock is considered to be overexploited and at a low biomass level.

For further information

Bigelow, H.B.. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. *Fish. Bull.. U.S. Fish. Wildl. Serv.* 74:53.

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.* 11(3):1-79.

Morse, W.W. and K.W.Able. 1995. Distribution and life history of windowpane, *Scophthalmus aquosus*, off the northeastern United States. *Fish. Bull., U.S.* 93: 675-693.



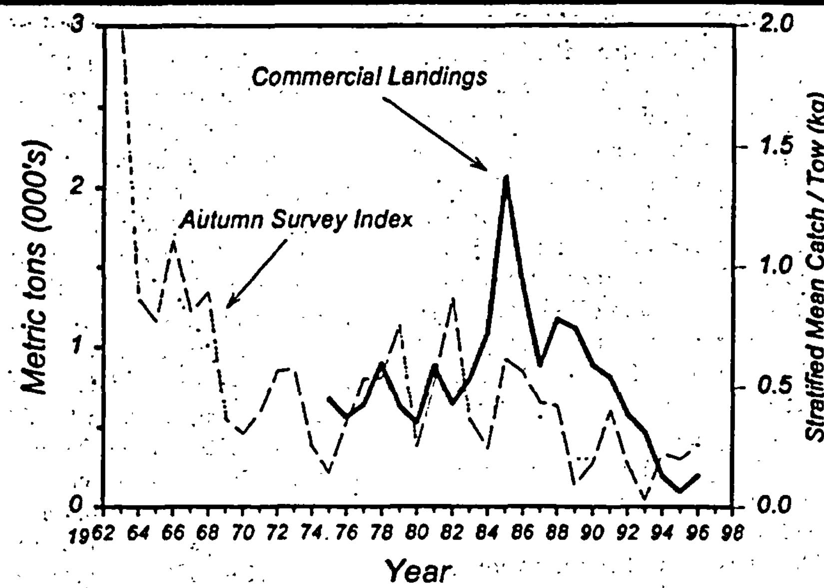


Table 12.2 Recreational catches and commercial landings (thousand metric tons)

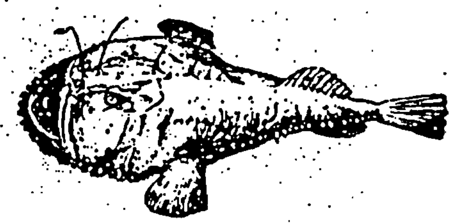
Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	0.9	0.9	1.2	1.1	0.9	0.8	0.6	0.5	0.2	0.1	0.2
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.9	0.9	1.2	1.1	0.9	0.8	0.6	0.5	0.2	0.1	0.2

Summary Status

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	3.0 years
Size at 50% maturity	=	21.5 cm (8.5 in.), males 21.2 cm (8.4 in.), females
Assessment level	=	Index
Overfishing definition	=	3-year moving average of NEFSC autumn bottom trawl survey index falls within the lowest quartile of the time series
Fishing mortality rate corresponding to overfishing definition	=	N/A

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1996} = Unknown

Goosefish



by J. Idoine

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

The goosefish has been described as mostly mouth with a tail attached, and reports of goosefish eating prey almost as big as themselves are common. Growth is fairly rapid and similar for both sexes up to age 4 and lengths of 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 in.). Males have not been found older than age 9, with few older than age 6. Males reach total lengths of approximately 90 cm (35 in.).

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

Data to definitively distinguish separate stock units of goosefish are unavailable. Assessment information is currently summarized for the "Northern Region" (Gulf of Maine and northern Georges Bank) and the "Southern Region" (southern Georges Bank and Middle Atlantic) based on significant differences in recruitment patterns. The species is not under management in federal waters. A management plan is being developed by the New England and Mid-Atlantic Fishery Management Councils.

Total landings (live weight) remained at low levels until the mid-1970s, increasing from a few hundred mt annually to around 6,000 mt in 1978. Landings remained stable at between 8,000 and 10,000 mt until the late 1980s and then increased to a peak level of 26,800 mt in 1995-1996. Landings began to increase in the north (Gulf of Maine and northern Georges Bank) in the mid-1970s and in the south (southern Georges Bank and the Mid-Atlantic) in the late 1970s. Most of the increase in landings in recent years has been from the southern region.

Total landings patterns are driven primarily by landings of goosefish tails. From 1964-1972, the only recorded parts were tails (unclassified). Much of the fish caught went to shack (unreported) until the mid-1970s. From 1964-1975, reported landings of tails rose from 20 mt to 600 mt (landed weight). Landings then increased to 2,300 mt in 1980 and to 6,500 mt in 1996. On a regional basis, most tails were landed from the northern region in the 1960s (75-90%) through to the late 1970s (74% in 1978). From 1979 to 1989, landings of tails were about equal from both regions. In the 1990s, landings from the southern region began to predominate and now provide over 60% of the tails.

Several market categories were added to the system in 1982. Tails were divided into large (> 2.0 lbs), small (0.5-2.0 lbs), and unclassified categories. At the same time, a market developed for livers. In 1989, unclassified round fish were added and in 1991, peewee tails (< 0.5 lbs) and cheeks appeared. Finally, in 1992, belly flaps were also recorded.

The increase in landings of livers is especially notable, increasing steadily from 10 mt in 1982 to 600 mt in 1996. During that time, ex-vessel prices for livers rose from an average of $0.97/lb to over $5.00/lb, with seasonal variations as high as $19.00/lb. For whole or unclassified round fish, landings averaged over 400 mt during 1991-1993. In 1995, preliminary estimates of landings of round fish rose to over 2,600 mt, and then dropped off to a little over 1,000 mt in 1996. The relatively large rise in the tonnage of peewee tails landed is also significant. The increase from 40 mt in 1991 to 400 mt in 1995 (at < 0.5 lb per tail) represents a large increase in numbers of fish landed, most of which are below median length at maturity.

Landings (live wt) from Canadian waters (NAFO Subdiv. 5Zc) are only available from 1986 onwards, but show a rapid rise from about 300 mt in 1986 to a peak of 1,600 mt in 1990. Annual landings have since declined to around 400-500 mt from 1992-1995; and in 1996 Canadian landings dropped to less than 200 mt.

The NEFSC autumn bottom trawl survey biomass index has declined sharply over the last 15 years. The average catch per tow over the last 10 years is 0.78 kg, compared to an average value of 2.24 kg per tow during 1963-1986. Since 1987 the survey index has been less than 1.0 kg per tow and in 1996 was 0.74 kg, the third lowest on record. Additionally, the average size of goosefish caught in the survey has decreased in almost all areas. For both regions, fishing mortality in recent years has exceeded the

> "The relatively large rise in the tonnage of peewee tails landed is also significant ...[and]represents a large increase in numbers of fish landed..."

overfishing definition level, while survey index values fall below levels at which overfishing is defined to occur. This resource is overexploited and at low levels of abundance.

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. Fish. Wildl. Serv.*, 74(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.

NEFSC [Northeast Fisheries Science Center]. 1997. [Report of the] 23rd Northeast Regional Stock Assessment Workshop (23rd SAW) Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-05.

Gulf of Maine - Middle Atlantic

Goosefish

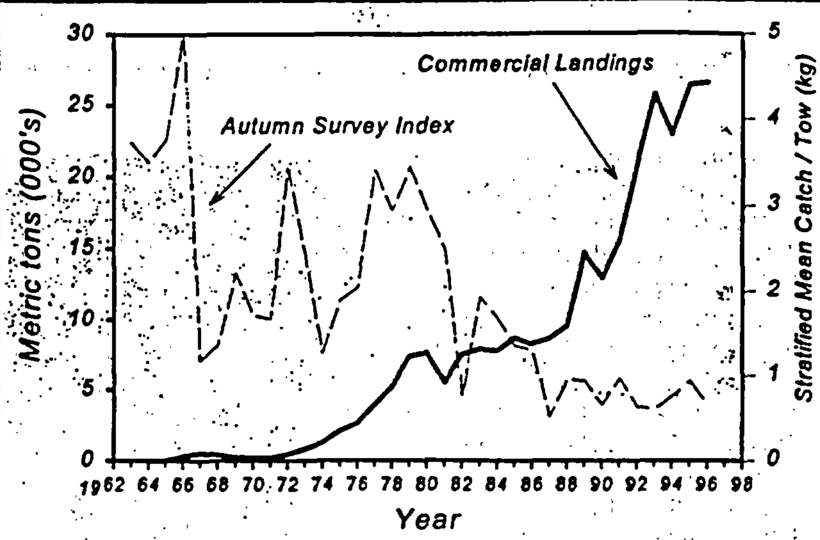


Table 13.1 Recreational catches and commercial landings (thousand metric tons)

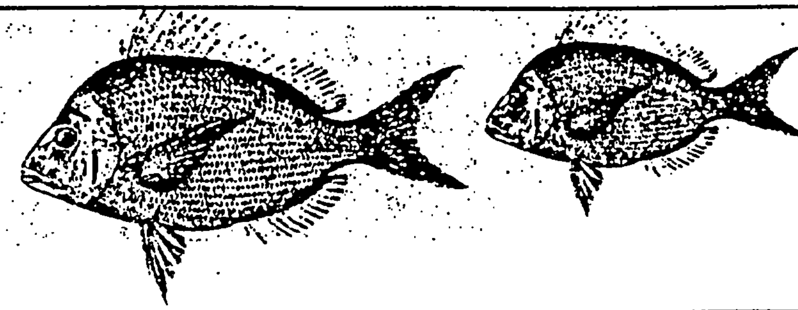
Category	Year 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	7.0	8.7	9.5	14.9	12.9	15.5	20.8	25.7	22.9	26.4	26.6
Canada	<0.1	0.7	0.9	1.2	1.6	1.0	0.5	0.4	0.5	0.4	0.2
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	7.0	9.4	10.4	16.1	14.5	16.5	21.3	26.1	23.4	26.8	26.8

Summary Status

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	FMP under development
Status of exploitation	=	Overexploited
Age at 50% maturity	=	3 years, males 4 years, females
Size at 50% maturity	=	37 cm (14.6 in.), males 49 cm (19.3 in.), females
Assessment level	=	Index
Overfishing definition	=	Three-year moving average autumn survey weight per tow falls below the 33rd percentile of the time series, 1963-1994, or F exceeds $F_{threshold}$
Fishing mortality rate corresponding to overfishing definition	=	$F_{threshold}$ = 0.05 Northern Region $F_{threshold}$ = 0.14 Southern Region

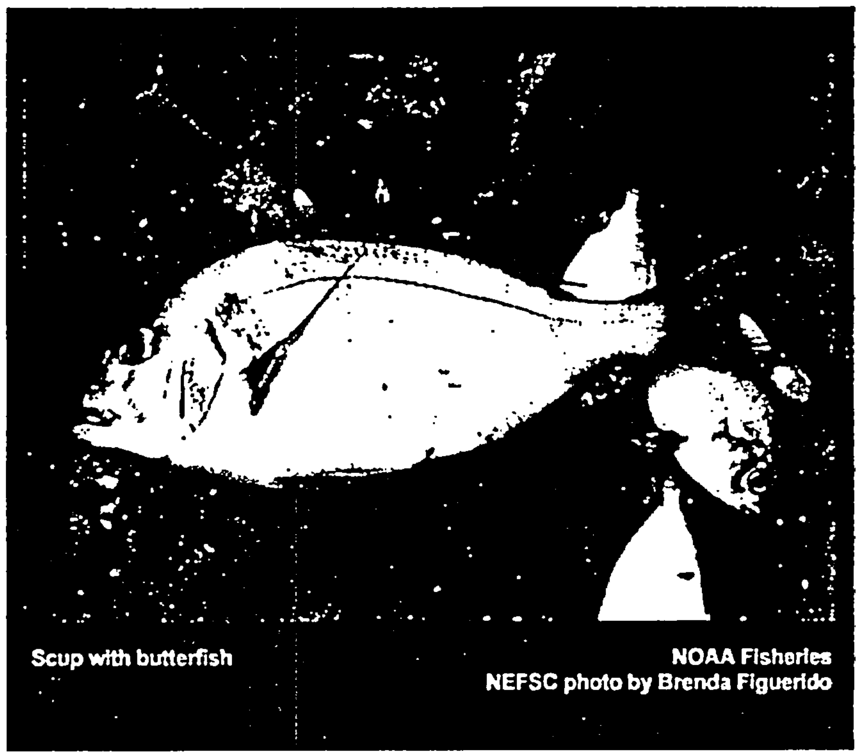
M = 0.20 $F_{0.1}$ = Unknown F_{max} = 0.20 F_{1996} = Unknown

Scup



by W. Gabriel

Scup or porgy, *Stenotomus chrysops*, occur primarily in the Mid-Atlantic Bight from Cape Cod to Cape Hatteras. Seasonal migrations occur during spring and autumn. In summer, scup are common in inshore waters from Massachusetts to Virginia, while in winter, scup are found in offshore waters between Hudson Canyon and Cape Hatteras at depths ranging from 70 to 180 m (38 to 98 fathoms). Sexual maturity is essentially complete by age 3 at a total length of 21 cm (8.3 in.); spawning occurs during summer months. Although ages up to 20 years have been reported, recent catches have consisted of largely immature fish, ages 0-2 (<7 in.) Scup attain a maximum length of about 40 cm (16 in.). Tagging studies have indicated the possibility of two stocks, one in Southern New England waters and the other extending south from New Jersey. However, because the separation of stocks is not well-defined spatially, this separation is not used here.



Scup with butterfish

NOAA Fisheries NEFSC photo by Brenda Figuerido

The principal commercial fishing gear is the otter trawl. Recreational catches are significant. The fishery is now managed under Amendment 8 to the Summer Flounder Fishery Management Plan (now the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan). Management measures include moratorium permits, gear and minimum size restrictions, commercial quotas and recreational harvest limits, and a fishing mortality rate reduction strategy.

Total landings have declined from an annual average of 10,900 mt in 1977-1986 to only 3,500 mt in 1995-1996, with markedly reduced landings reported in both commercial and recreational fisheries. Commercial landings from all countries fluctuated between 18,000 and 27,000 mt annually between 1953 and 1963, but declined to about 4,000 mt during the early 1970s. Landings then steadily increased, reaching a peak of 9,800 mt in 1981 before falling to a record low level (2,500 mt) in 1996. Landings by distant-water fleets peaked at 5,900 mt in 1963, but declined to less than 100 mt per year after 1975.

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

Recreational catches have accounted for 20 - 50% of the annual total during the past ten years. The 1995 recreational catch (600 mt) was the lowest in the 1979-1996 time series and the 1996 catch (1,000 mt) was the second lowest.

Spawning stock biomass has declined since 1990 to a record low in 1995-1996, the lowest observed in a 1984-1996 exploratory age-structured analysis. NEFSC spring and autumn bottom trawl survey biomass index values for recent years are among the lowest on record and indicate substantial declines in abundance from 1970s levels. Recruitment at age 0 also declined to a record low level in

"...the five most recent years include the four lowest values of age 0 abundance in the time series."

1996 in the age-structured analysis; the five most recent years include the four lowest values of age 0 abundance in the time series.

Fishing mortality rates have been very high during the past ten years, above 1.0 (58% exploitation rate) between 1984-1996. These rates are far in excess of the biological reference points and the overfishing definition level (F_{max}=0.24, 19% exploitation rate). The stock is overexploited and at a low biomass level. In the absence of strong year classes, continued high exploitation levels will lead to further declines in SSB.

For further information

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

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

NEFSC [Northeast Fisheries Science Center]. 1995. Report of the 19th Northeast Regional Stock Assessment Workshop (19th SAW) Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 95-08

NEFSC [Northeast Fisheries Science Center]. 1997. [Report of the] 25th Northeast Regional Stock Assessment Workshop (25th SAW). Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-14.

Southern New England - Middle Atlantic

Scup

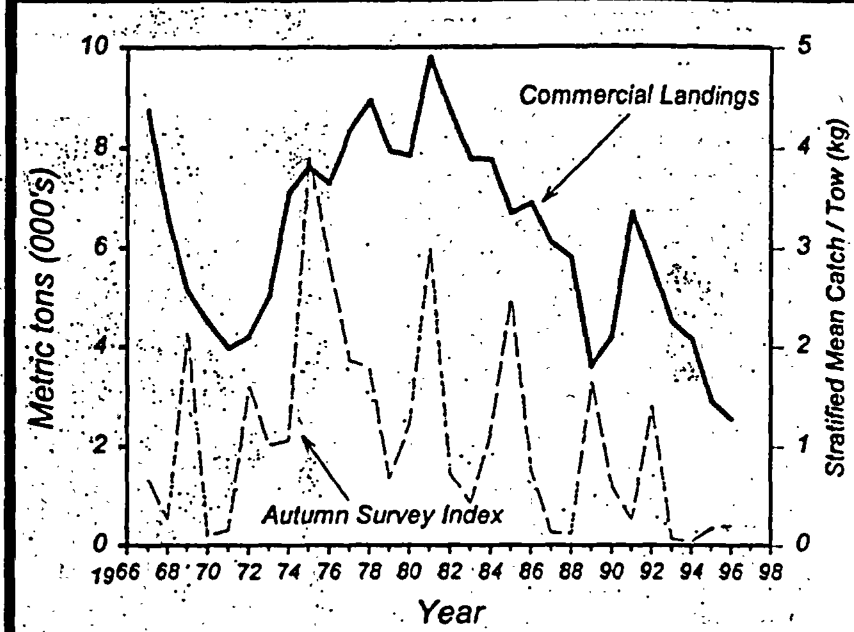


Table 14.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	2.7[1]	2.8	1.9	2.5	1.9	3.7	2.0	1.4	1.2	0.6	1.0
Commercial											
United States	8.2	6.1	5.7	3.7	4.3	6.9	6.0	4.5	4.1	2.9	2.5
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	<0.1	-	-	-	-	-	-	-	-	-	-
Total nominal catch	10.9	8.9	7.6	6.2	6.2	10.6	8.0	5.9	5.3	3.5	3.5

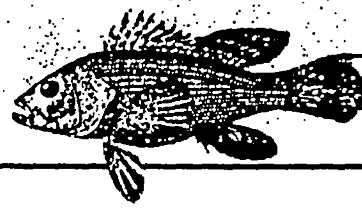
[1] 1979-1986

Summary Status

Long-term potential catch	=	10,000 to 15,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Summer Flounder, Scup and Black Sea Bass FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 years (both sexes)
Size at 50% maturity	=	15.6 cm (6.1 in.), males; 15.5 cm (6.1 in.), females
Assessment level	=	Index
Overfishing definition	=	F_{max}
Fishing mortality rate corresponding to overfishing definition	=	$F_{max} = 0.24$

$M = 0.20$ $F_{0.1} = 0.14$ $F_{20\%} = 0.28$ $F_{1996} > 1.0$

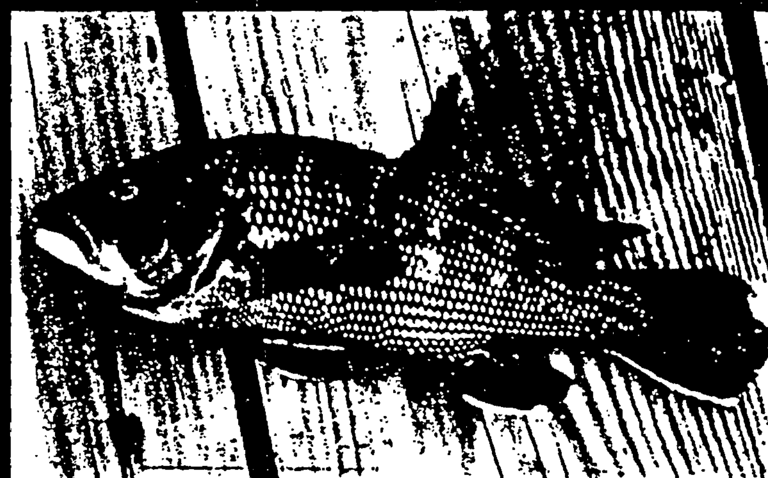
Black Sea Bass



by G. Shepherd

Black sea bass, *Centropristis striata*, occur along the entire U.S. Atlantic coast. Two stocks have been recognized, one north and the other south of Cape Hatteras, North Carolina. The northern group winters along the 100 m (55 fathom) depth contour off Virginia and Maryland, and then migrates north and west into inshore waters, where it becomes 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, and most individuals (both sexes) attain sexual maturity by age 3. 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.



Black sea bass at the pier — NOAA Fisheries NEFSC photo by Brenda Figuerido

The principal commercial fishing gears used to catch black sea bass are otter trawls and fish pots. Recreational fishing is significant. Black sea bass are managed under Amendment 9 to the Summer Flounder Fishery Management Plan or FMP (now known as the Summer Flounder, Scup, and Black Sea Bass FMP) developed in 1996. Management measures under the FMP include a moratorium program, gear restrictions and minimum fish sizes, a coastwide commercial quota and a recreational harvest limit.

Total catch increased in 1996 to 4,100 mt, up from 3,500 mt in 1995. Commercial landings north of Cape Hatteras fluctuated around 2,600 mt from 1887 until 1948, when landings increased to 6,900 mt. Landings peaked at 9,900 mt in 1952, declined steadily to 600 mt in 1971, and then increased to 2,400 mt in 1977. Between 1980 and 1993, commercial landings ranged from 1,100 to 2,000 mt, and averaged 1,500 mt per year. Landings declined to 900 mt in 1994 and 1995 and then rose to 1,500 mt in 1996. There has been no foreign fishing on this stock other than for a reported catch of 1,500 mt by distant-water fleets in 1964.

Estimated recreational landings, occurring primarily in the middle Atlantic states, are comparable in magnitude to those from the commercial fishery. Recreational landings have averaged 2,100 mt per year since 1979, and have accounted for 31-87% of the total annual landings of black sea bass. Recreational landings in 1996 were 2,600 mt, 64% of the 1996 total.

The NEFSC spring bottom trawl survey biomass index increased during the early 1970s, peaking in 1977, but declined sharply between 1979 and 1982 to record-low levels. The index modestly increased during 1985 to 1988, fluctuated around that level until 1993, and then again declined to at or near record lows. Young of year (age 0) indices from the NEFSC autumn bottom trawl survey indicate that above-average year classes occurred

"The index modestly increased during 1985 to 1988, fluctuated around that level until 1993, and then again declined to at or near record lows."

in 1985 and 1986. Index values for 1994 and 1995 were the highest since 1986, but the 1996 value was well below average.

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.

Although definitive estimates of fishing mortality are not available for 1996, it appears to have been greater than 1.0 (58% exploitation rate) in recent years. In addition, recent CPUE indices have been moderate to low, and recent survey index values are among the lowest on record. The stock is overexploited and at a low biomass level.

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.

NEFSC [Northeast Fisheries Science Center]. 1997. [Report of the] 25th Stock Assessment Workshop (25th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-14.

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.

Gulf of Maine - Mid-Atlantic

Black Sea Bass

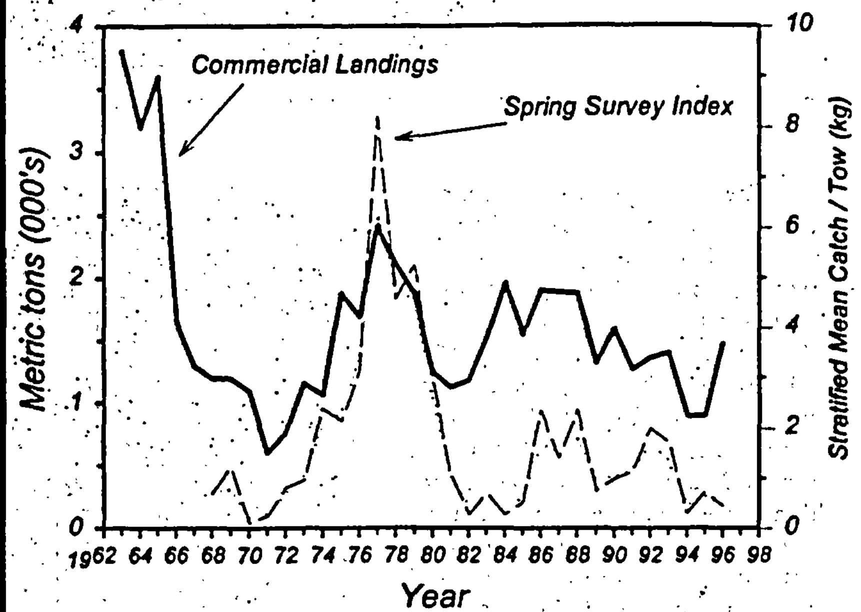


Table 15.1 Recreational and commercial landings (thousand metric tons)

Category	Year: 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	2.1[1]	0.9	1.2	1.5	1.3	1.9	1.2	2.0	1.4	2.6	2.6
Commercial											
United States	1.7	1.9	1.9	1.3	1.6	1.3	1.4	1.4	0.9	0.9	1.5
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	3.8	2.8	3.1	2.8	2.9	3.2	2.6	3.4	2.3	3.5	4.1

[1] 1979-1986

Summary Status

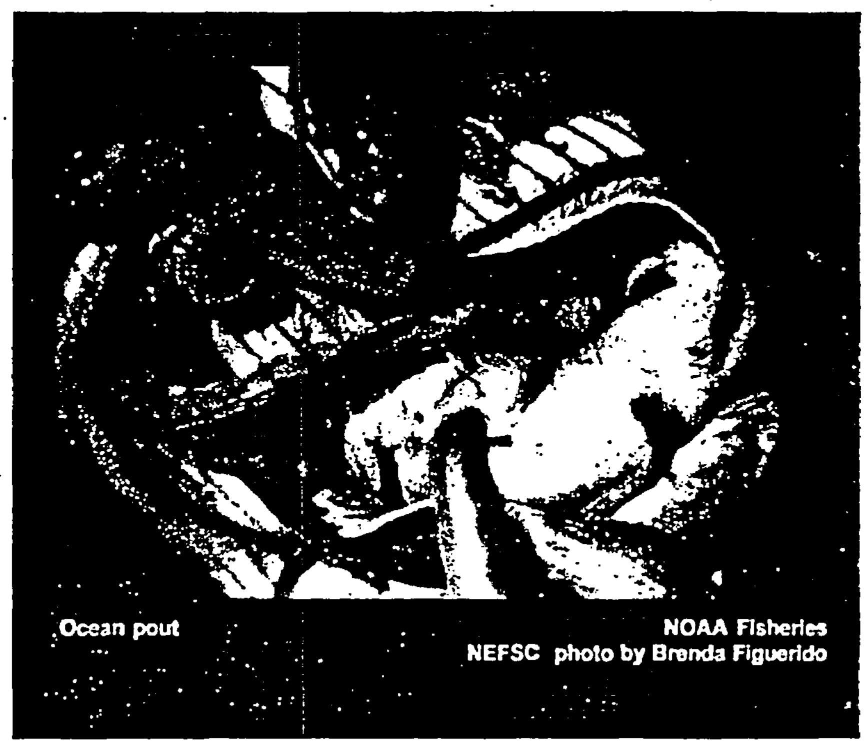
Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Summer Flounder, Scup, and Black Sea Bass FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 years
Size at 50% maturity	=	19.0 cm (7.5 in.), males 19.1 cm (7.5 in.), females
Assessment level	=	Index
Overfishing definition	=	F_{max}
Fishing mortality rate corresponding to overfishing definition	=	$F_{max} = 0.29$

$M = 0.2$ $F_{0.1} = 0.18$ $F_{1996} = >1.0$

Ocean Pout

by S. Wigley

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



Ocean pout — NOAA Fisheries NEFSC photo by Brenda Figuerido

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. Ocean pout are included in the New England Fishery Management Council's Multispecies Fishery Management Plan under the "nonregulated multispecies" category. Total landings in 1996 were only 51 mt, the lowest since 1963.

Commercial interest in ocean pout has fluctuated widely. Ocean pout were marketed as a food fish during World War II, and landings peaked at 2,000 mt in 1944. However, an outbreak of a protozoan parasite that caused lesions on ocean pout eliminated consumer demand for this species. From 1964 to 1974, an industrial fishery developed, and nominal catches by the U.S. fleet averaged 4,700 mt. Distant-water fleets 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 landings 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 have declined more or less continually since 1987 in spite of continued market demand. In recent years, landings from the southern New England/Mid-Atlantic area have continued to dominate the catch, reversing landing patterns observed in 1986-1987 when the Cape Cod Bay fishery was dominant.

From 1968 to 1975 (encompassing peak levels of foreign fishing and the domestic industrial fishery), commercial landings and the NEFSC spring bottom trawl survey biomass

"...landings from the southern New England/Mid-Atlantic area have continued to dominate the catch, reversing landing patterns observed in 1986-1987 when the Cape Cod Bay fishery was dominant."

index followed similar trends; both declined from very high values in 1968-1969 to lows of 300 mt and 1.3 kg per tow, respectively, in 1975. Between 1975 and 1985, survey indices increased to record high levels, peaking in 1981 and 1985. Since 1985, survey catch per tow indices have generally declined, and are presently below the long-term survey average (3.9 kg per tow); the 1996 spring survey index value was 2.1 kg per tow. The population appears to be overexploited and at a low biomass level.

For further information

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

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

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

Gulf of Maine - Mid-Atlantic

Ocean Pout

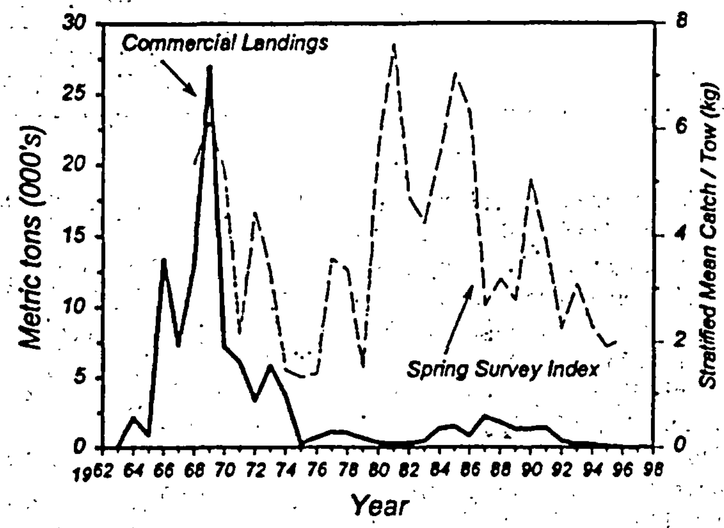


Table 16.1 Recreational and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	0.8	2.2	1.8	1.3	1.3	1.4	0.5	0.2	0.2	0.1	0.1
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	0.8	2.2	1.8	1.3	1.3	1.4	0.5	0.2	0.2	0.1	0.1

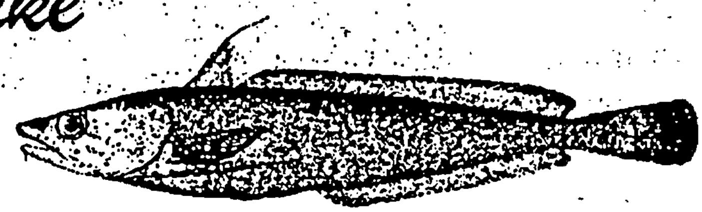
Summary Status

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[1]		
Gulf of Maine	=	30.3 cm (11.9 in.), males 26.2 cm (10.3 in.), females
Southern New England	=	31.9 cm (12.6 in.), males 31.3 cm (12.3 in.), females
Assessment level	=	Index
Overfishing definition	=	3-year moving average of NEFSC spring bottom trawl survey index falls within lowest quartile of the time series
Fishing mortality rate corresponding to overfishing definition	=	Unknown

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1996} = Unknown

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

White Hake



by K. Sosebee

The white hake, *Urophycis tenuis*, occurs from Newfoundland to Southern New England and is common on muddy bottom throughout the Gulf of Maine. Depth distribution of white hake varies by age and season; juveniles typically occupy shallower areas than adults, but individuals of all ages tend to move inshore or shoalward in summer, dispersing to deeper areas in winter. 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) by gillnetting.

White hake — NOAA Fisheries NEFSC photo by Brenda Figuerido

Larval distributions indicate the presence of two spawning groups in the Gulf of Maine, Georges Bank and Scotian Shelf region, one which spawns in deep water on the continental slope in late winter and early spring and a second which spawns on the Scotian Shelf in summertime. Populations in U.S. waters appears to be supported by both spawning events, but individuals are not distinguishable in commercial landings. 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 gears used to catch white hake are otter trawls and gill nets. Recreational and distant-water fleet catches have been insignificant, and Canadian catches have generally been minor. The fishery is managed under the New England Fishery Management Council's Multi-species Fishery Management Plan (FMP). Management measures include a moratorium on permits, days-at-sea restrictions, time/area closures, gear restrictions, and minimum size limits. Total landings in 1996 were 3,700 mt, a 62% decline from 1992.

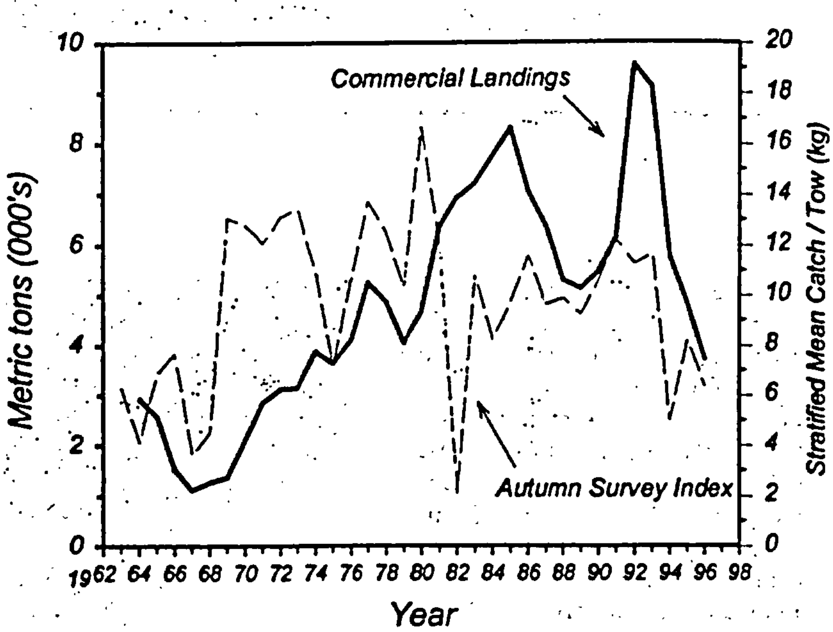
U.S. landings have primarily been taken in the western Gulf of Maine, both incidentally to directed operations for other demersal species and as an intended component in mixed-species fisheries. Since 1968, the U.S. fishery has accounted for approximately 90 percent of the Gulf of Maine-Georges Bank white hake catch. Canadian landings averaged 600 mt from 1977-1991 and then increased to 1,700 mt in 1993, but have since declined to former levels.

Total landings of white hake increased from about 1,000 mt during the late 1960s to 8,300 mt in 1985. Landings then declined to 5,100 mt in 1989, rose sharply to 9,600 mt in 1992, and have since steadily declined to levels not seen since the early 1970s. The increase throughout the 1970s and early 1980s reflects both a general increase in incidental catches associated with expansion of the New England otter trawl fleet and an increase in directed fishing effort. Small white hake are difficult to distinguish from red hake, *Urophycis chuss*, resulting in an unknown (but presumed small) degree of bias in reported nominal catches.

The NEFSC autumn bottom trawl survey biomass index fluctuated about a relatively high level during the 1970s and 1980s but has declined in recent years. The most recent 3-year average of the NEFSC autumn survey biomass index (6.5 kg per tow) is below the current overfishing definition (25th percentile of a 3-year moving average of NEFSC autumn biomass indices:

Gulf of Maine - Georges Bank

White Hake



"Recruitment has varied considerably from 1.9 million fish in 1985 to 9.6 million fish in 1992, with the 1994 level (5.7 million) being about average."

8.3 kg per tow) and is the lowest since 1968. Fishing mortality peaked in 1988 at F=0.56 (39% exploitation rate), declined to 0.34 in 1989, and has since fluctuated around the 1985-1993 average of F=0.40 (30% exploitation rate). Fishing mortality throughout the 1985-1993 period has exceeded F_{max} (F=0.22, 18% exploitation rate). Exploitable biomass has remained relatively stable since 1985, ranging from 11,600 mt in 1987 to a peak of 17,300 mt in 1993. Recruitment has varied considerably from 1.9 million fish in 1985 to 9.6 million fish in 1992, with the 1994 level (5.7 million) being about average.

The Gulf of Maine-Georges Bank white hake stock is at a low biomass level and is overexploited.

For further information

Fahay, M.P. and R.W. Able. 1989. White hake, *Urophycis tenuis*, in the Gulf of Maine: Spawning seasonality, habitat use, and growth in young of the year and relationships to the Scotian Shelf population. *Can. J. Zool.* 67: 1715-1724.

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

Sosebee, K. A., L. O'Brien, and L. C. Hendrickson. 1998. A preliminary analytical assessment for white hake in the Gulf of Maine - Georges Bank region. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 98-05.

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

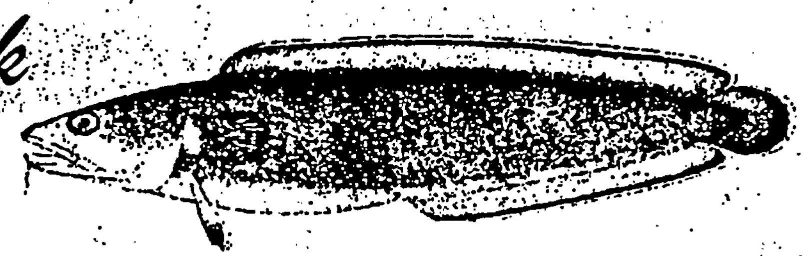
Category	Year										
	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	5.6	5.8	4.8	4.5	4.9	5.6	8.4	7.5	4.8	4.3	3.3
Canada	0.6	0.6	0.5	0.6	0.5	0.6	1.1	1.7	1.0	0.5	0.4
Other	<0.1	<0.1	<0.1	<0.1	-	-	-	-	-	-	-
Total nominal catch	6.2	6.4	5.3	5.1	5.5	6.2	9.6	9.1	5.8	4.8	3.7

Summary Status

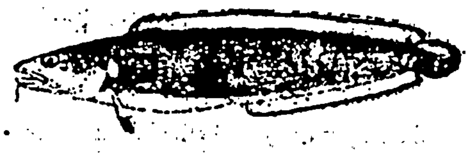
Long-term potential catch	=	7,700 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Multispecies FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	1.4 years (both sexes)
Size at 50% maturity	=	32.7 cm (12.9 in.), males 35.1 cm (13.8 in.), females
Assessment level	=	Size structured (DeLury)
Overfishing definition	=	3-year moving average of NEFSC autumn survey biomass index falls within lowest quartile of the time series

M = 0.20 $F_{0.1}$ = 0.13 F_{max} = 0.22 F_{1996} = Unknown

Cusk



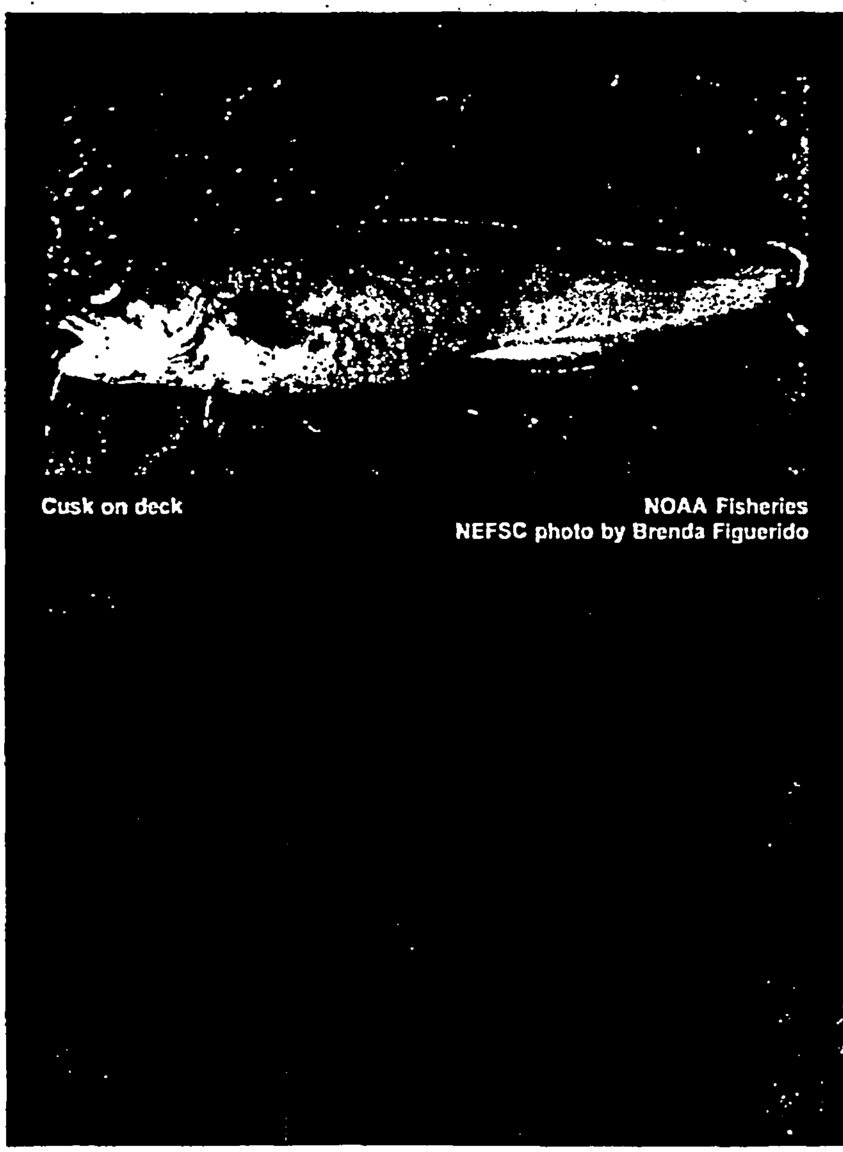
by L. O'Brien



The cusk, *Brosme brosme*, is a deepwater species that is found in rocky, hard bottom areas throughout the Gulf of Maine. Spawning occurs in spring and early summer; eggs rise to the surface where hatching and larval development occur. Juveniles move to the bottom at about 5 cm (2 in.) in length where they become sedentary and rather solitary in habit. Individuals commonly attain lengths up to 90 cm (35 in.) and weights up to 9.0 kg (20 lb). The stock structure of cusk is unknown. Although little information is available for Gulf of Maine fish, cusk from the Scotian Shelf area are relatively slow growing and late maturing. Scotian Shelf cusk reach a maximum age greater than 14 years and attain sexual maturity by ages 5 (males) and 7 (females).

The principal fishing gears used to catch cusk are line trawl, otter trawl, gill net, and longline. Fish caught by these gears range in size from 35 cm (13.8 in.) to 110 cm (43.3 in.). Recreational fishing is insignificant and foreign catches are minor. The fishery is not under management. Total catches in 1996 were 700 mt, 30% less than in 1995, and the lowest in the time series.

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. Landings subsequently declined to 1,500 mt in 1988 and then increased to 2,400 mt in 1992 before again declining to only 700 mt in 1996, a record low. Historically, 60% to 80% of the U.S. catch has been taken from the Gulf of Maine, but since 1993, landings from the Gulf of Maine and Georges Bank have been nearly equal. Almost all Canadian landings have been taken on Georges Bank.



Cusk on deck

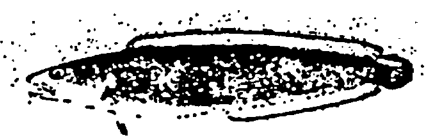
NOAA Fisheries
NEFSC photo by Brenda Figuerido

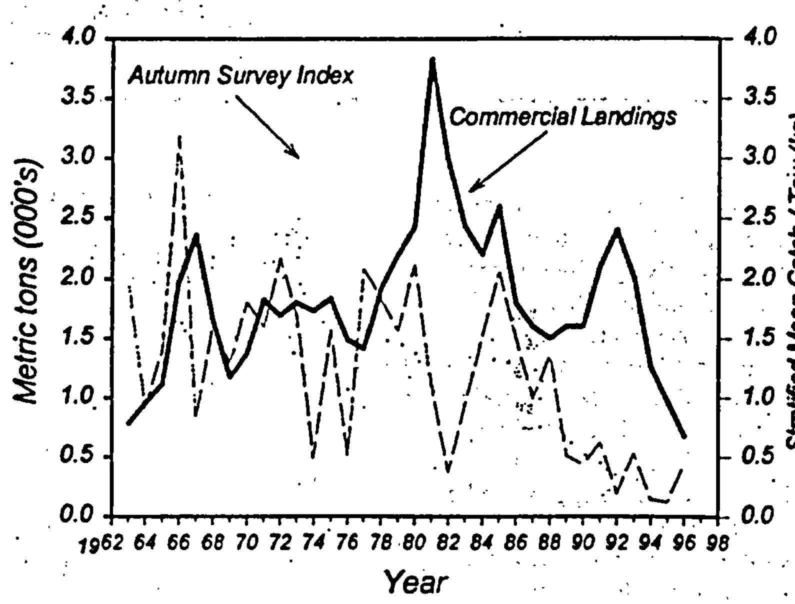
The 1996 U.S. total was 500 mt and accounted for 71% of the total harvest. Canadian landings in 1996 were 200 mt. Historically, otter trawls have accounted for between 50 and 87% of annual U.S. cusk landings. During 1992-1994, the majority of the landings were by bottom long line

Gulf of Maine-Georges Bank

Cusk

"Annual landings have generally declined since 1981, while survey indices of abundance have generally declined since 1985."





gear, also known as line trawls. Otter trawls and line trawls together accounted for most of the landings during 1995-1996.

Although the NEFSC autumn bottom trawl survey biomass index has fluctuated considerably, a declining trend has been evident since the late 1960s. The index fell to a record low in 1995 and has since increased only slightly. The mean length of cusk caught on the survey has also declined, from a long-term average of 61 cm during 1964-1993 to 38 cm during 1994-1996.

Annual landings have generally declined since 1981, while survey indices of abundance have generally declined since 1985. The ratio of landings to survey indices has been increasing since 1986, implying increased exploitation. The stock appears to be overexploited and at a low biomass level.

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

Category	Year 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
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	1.7	1.4	1.1	0.9	1.2	1.5	1.6	1.4	1.1	0.8	0.5
Canada	0.6	0.3	0.4	0.7	0.5	0.6	0.8	0.6	0.2	0.2	0.2
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	2.3	1.7	1.5	1.6	1.7	2.1	2.4	2.0	1.3	1.0	0.7

Summary Status

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

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1996} = Unknown

For further information

Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. *Fish. Bull., U.S. Fish. Wildl. Serv.* 74:53.

Oldham, W.S. 1972. Biology of Scotian Shelf cusk, *Brosme brosme*. *ICNAF Res. Bull.* 9: 85-98.

Atlantic Wolffish

by J. Idoine

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

Wolffish have been taken primarily as bycatch in the otter trawl fishery, although the species may also be an intended component in some mixed fishery situations. Recreational catches are insignificant. The species is unmanaged.

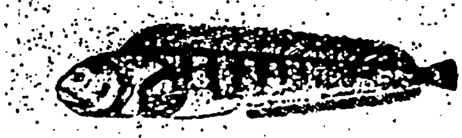
Since 1970, the U.S. nominal commercial catch has been about evenly divided between Georges Bank and the Gulf of Maine. In the last two decades, U.S. vessels have taken more than 85 percent of the total Georges Bank-Gulf of Maine catch; the remainder was taken by Canadian fishermen. Total Georges Bank-Gulf of Maine landings increased from 200 mt in 1970 to approximately 1,200 mt in 1984 and have since declined sharply to an average of 500 mt since 1990. Landings in 1996, 400 mt, are the lowest since the mid-1970s. Canadian landings have been insignificant in recent years.

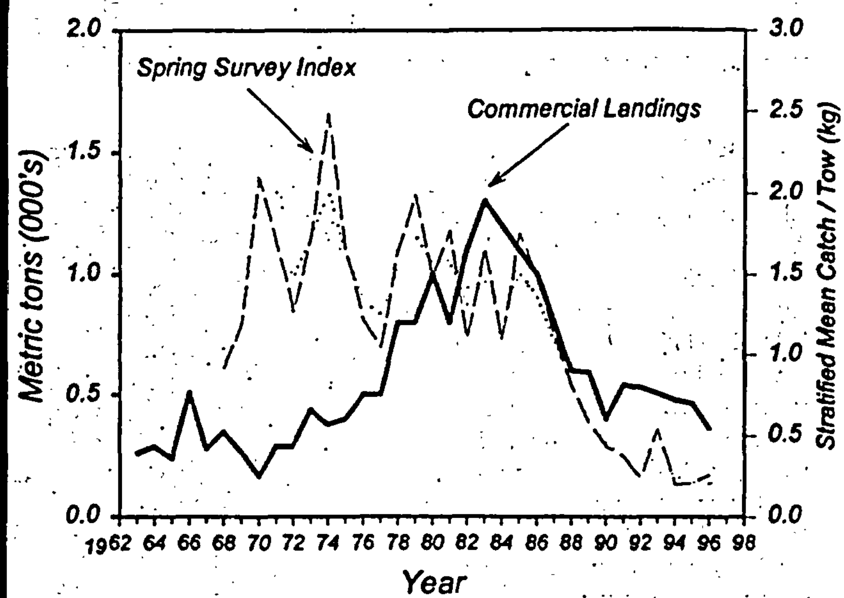
Man with wolffish

NOAA Fisheries
NEFSC Photo Archive

Gulf of Maine - Georges Bank
Atlantic Wolffish

"The decline in landings and in NEFSC trawl survey indices since the mid- 1980s indicate that biomass has been substantially reduced. This stock is clearly overexploited and depleted."





After fluctuating considerably from 1968 to 1985, the NEFSC spring bottom trawl survey biomass index has shown a consistent downward trend; the 1997 index value, 0.13 kg per tow, was the lowest in the time series. The 1990-1996 average (0.32 kg per tow) is approximately 20% of the average for previous years (1.41 kg per tow).

The decline in landings and in NEFSC trawl survey indices since the mid 1980s indicate that biomass has been substantially reduced. This stock is clearly overexploited and depleted.

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

Category	Year 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
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	1.0	0.7	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.4
Canada	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	1.1	0.8	0.6	0.6	0.5	0.6	0.5	0.5	0.5	0.5	0.4

For further information

Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. *Fish. Bull., U.S. Fish. Wildl. Serv.* 74(53).

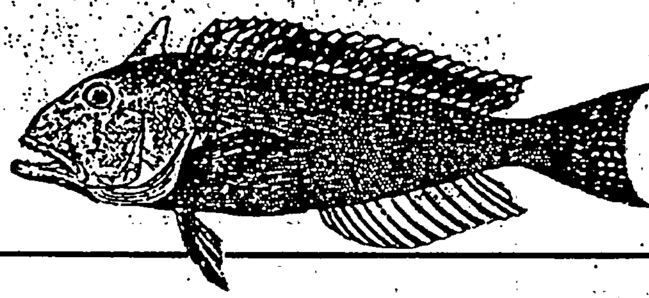
Nelson, G.A., and M.R. Ross. 1992. Distribution, growth and food habits of the Atlantic wolffish (*Anarhichas lupus*) from the Gulf of Maine-Georges Bank region. *J. Northw. Atl. Fish. Sci.* 13:53-61.

Summary Status

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

M = Unknown $F_{0.1}$ = Unknown F_{max} = Unknown F_{1996} = Unknown

Tilefish



by G. Shepherd

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

Nominal catches were first recorded in 1915 (148 mt); a record total of 4,500 mt was taken in 1916, but only 5 mt were reported for 1920. Landings later increased to 1,000 to 1,500 mt during the early 1950s, followed by a decline to 30 mt in 1968-69.

Beginning in the early 1970s, a directed commercial longline fishery expanded rapidly in the Mid-Atlantic and longlines have since been the predominant gear type used. Landings increased to 4,000 mt in 1979 before declining to about 2,000 mt annually from 1982-1986. More recent landings have generally been lower; the 1994-1996 average was 900 mt.

A small recreational fishery developed during the late 1960s in New York and New Jersey but landings never exceeded 100 mt, and recent recreational catches have been negligible.

Men with tilefish

NOAA Fisheries
NEFSC Photo Archive

Catch per unit effort (CPUE) declined from 6.5 mt per standard day fished (df) in 1973 to 1.8 mt in 1982. Since the mid-1980s, CPUE has remained relatively stable about a low level. Estimates of fishing mortality from virtual population analysis or VPA increased from 0.20 (1977) to 0.74 (1981). Estimates are not available for more recent years. Long-term potential catch for tilefish is about 1,200 mt as estimated from a non-equilibrium surplus production model.

Landings and CPUE data indicate that tilefish were overexploited during the height of the longline fishery (between 1977 and 1982). Landings during this period were well above levels corresponding to long-term potential yield, and fishing mortality rates were three times higher than F_{max}. This period was marked by steadily declin-

"Landings and CPUE data indicate that tilefish were overexploited during the height of the longline fishery (between 1977 and 1982)."

ing landings and CPUE, and average size and size at first maturity in males. The stock appears to have been stable about low levels of abundance in recent years.

For further information

Grimes, C.B., C.F. Idelberger, K.W. Able, and S.C. Turner. 1988. The reproductive biology of tilefish, *Lopholatilus chamaeleonticeps* Goode and Bean, from the United States Mid-Atlantic Bight, and the effects of fishing on the breeding system. *Fish. Bull., U.S.* 86(4):745-776.

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

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

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

Georges Bank - Middle Atlantic

Tilefish

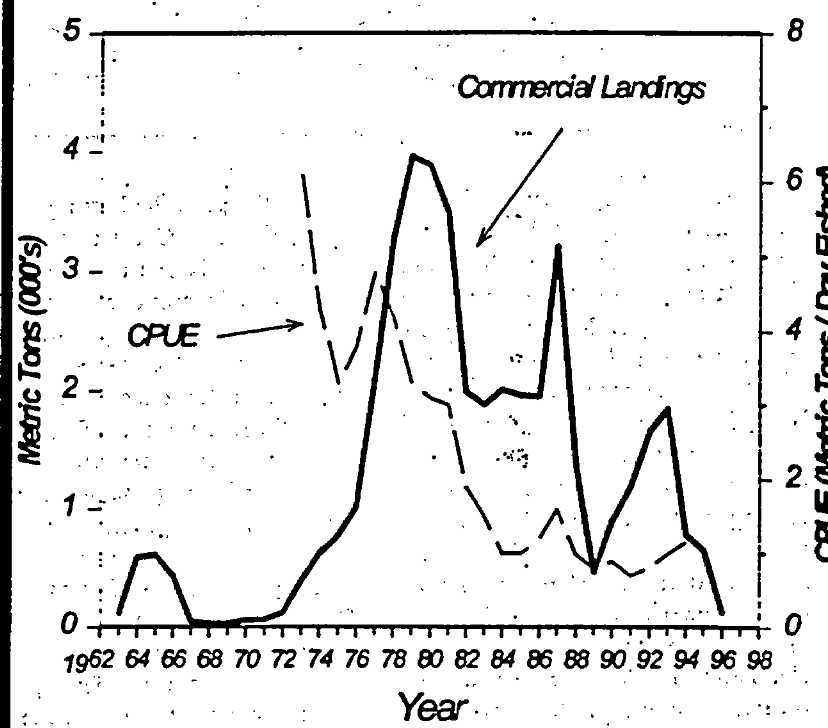


Table 20.1 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Commercial											
United States	2.7	3.2	1.4	0.5	0.9	1.2	1.6	1.8	0.8	0.7	1.1
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	2.7	3.2	1.4	0.5	0.9	1.2	1.6	1.8	0.8	0.7	1.1

Summary Status

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_{1996} = Unknown

Atlantic Herring

by K. Friedland

The Atlantic herring, *Clupea harengus*, is widely distributed in continental shelf waters from Labrador to Cape Hatteras. Important commercial fisheries for juvenile herring (ages 1 to 3) have existed since the last century along the coasts of Maine and New Brunswick. Development of large-scale fisheries for adult herring is comparatively recent, primarily occurring in the western Gulf of Maine, on Georges Bank, and on the Scotian Shelf. Gulf of Maine herring migrate from summer feeding grounds along the Maine coast to southern New England and Mid-Atlantic areas 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 age 4. Age at maturity varies annually and appears to change in response to density dependent effects. Herring eggs are demersal and are typically deposited on gravel substrates. Primary spawning locations off the northeastern United States are located on the Maine coast, Jeffreys Ledge, Nantucket Shoals, and Georges Bank. Incubation is temperature dependent, but usually occurs within 7 to 10 days. Larvae metamorphose by late spring into juvenile brit herring that may form large aggregations in coastal waters during summer. By age 2, juvenile herring are fully vulnerable to coastal fisheries using both fixed and mobile gear.

In the past, the herring resource along the East Coast of the United States was divided into the Gulf of Maine and Georges Bank stocks. There is genetic and tagging evidence that both support and refute this stock division. Of greater concern to those managing the resource is the fact that fishery-independent measures of abundance for herring include contributions of fish originating from both spawning areas. As a consequence, herring from the Gulf of Maine and 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 technical and management challenges.

Total landings for the coastal stock complex have changed substantially since the 1960s. Landings averaged 94,500 mt from 1992 to 1996, whereas three decades ago they exceeded 300,000 mt. Recreational landings have been negligible. Changes in commercial landings trends are best understood by examining changes in 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 79,700 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. However, there have been changes in the distribution of landings between the two principal gear types: mobile and fixed gear. Over the past five years, more than 90 percent of Maine herring landings were taken by mobile gear, compared with less than 50 percent during the 1970s. This shift appears to be related to reduced availability of herring to the fixed-gear fisheries. In addition, mobile gear landings include increasing catches made by mid-water trawlers. Due to recent declines in export markets for adult herring, a significant proportion of the catch has not been used for human consumption.

The herring fishery on Georges Bank was initiated in 1961 by distant-water fleets. Landings peaked in 1968 at 373,600 mt and subsequently declined to only 43,500 mt in 1976 as the fishery collapsed. There has been no directed fishery for Atlantic herring on Georges Bank since that time.

Estimates of stock biomass (all ages) 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 declined to less than 100,000 mt. In the early 1980s, fishing by distant-water fleets ended and the stock complex began to rebuild. Stock biomass has increased significantly in recent years, primarily due to increased spawning first on Nantucket Shoals and later on Georges Bank. The offshore spawning component, which represents the largest historic component of the stock complex, appears to have recovered from its collapse during the early 1970s. Stock biomass is expected to remain high in the near future, as recent recruitment appears to have been strong.

A management plan has been adopted by the Atlantic States Marine Fisheries Commission (ASMFC) which provides guidance on the allocation of herring to internal waters processing operations and regulations concerning spawning closures. A Pre-

"The offshore spawning component, which represents the largest historic component of the stock complex, appears to have recovered from its collapse during the early 1970s."

liminary Management Plan is also in force which provides guidance on the development of joint venture processing in the exclusive economic zone. A Fishery Management Plan is being developed by the New England Fishery Management Council (NEFMC) in coordination with the ASMFC.

For further information

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

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

NEFSC [Northeast Fisheries Science Center]. 1996. [Report of the] 21st Northeast Regional Stock Assessment Workshop (21st SAW) Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 96-05d.

Smith, W.G. and W.W. Morse. 1993. Larval distribution patterns: early signals for the collapse/recovery of Atlantic herring, *Clupea harengus*, in the Georges Bank area. *Fish. Bull., U.S.* 91:338-347.

Coastal Stock Complex

Atlantic Herring

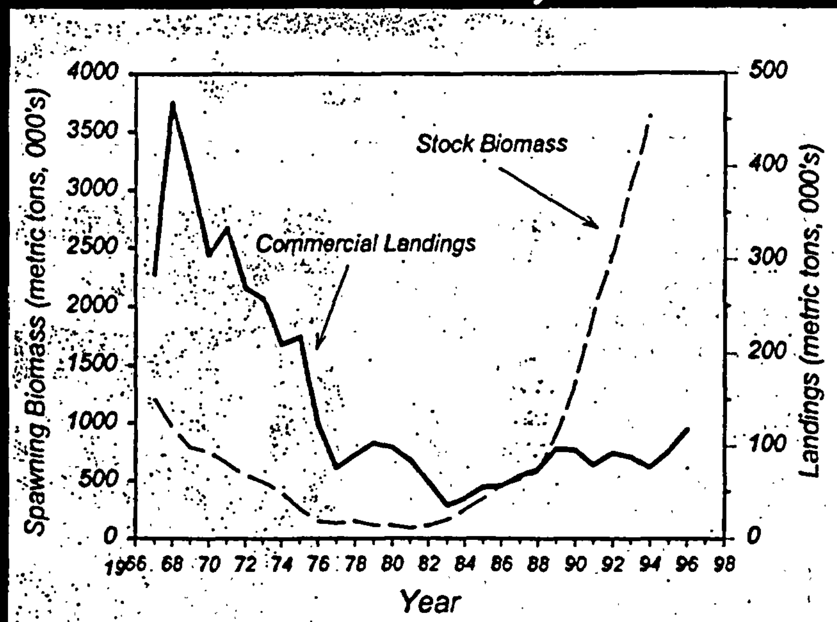


Table 21.1 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	46.4	40.4	41.2	53.1	57.0	55.3	61.2	57.1	54.3	76.1	103.7
Canada	23.5	27.3	33.4	44.1	38.8	24.6	32.0	31.6	22.2	18.2	15.9
Other	1.0	-	-	-	-	-	-	-	-	-	-
Total nominal catch[1]	70.9	67.8	74.7	97.2	95.8	79.9	93.2	88.7	76.6	94.4	119.6

[1]Age groups 1 and older

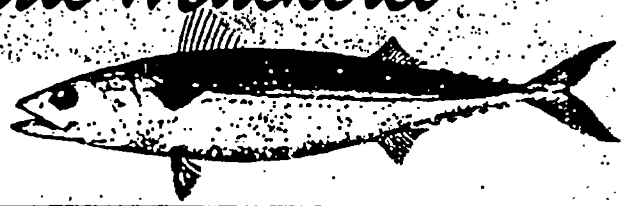
Summary Status

Long-term potential catch[1]	=	285,000 mt
SSB for long-term potential catch[1]	=	619,000 mt
Importance of recreational fishery	=	Insignificant
Management	=	Under ASMFC Plan, PMP
Status of exploitation	=	Underexploited
Age at 50% maturity	=	2.9 years, males 3.0 years, females
Size at 50% maturity	=	25.3 cm (10.0 in.), males 25.4 cm (10.0 in.), females
Assessment level	=	Age structured
Overfishing definition	=	20% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%} = 0.29$

$M = 0.20$ $F_{0.1} = 0.20$ $F_{max} = 0.40$ $F_{1996} =$ Unknown

[1]Estimates from preliminary analysis of MSY

Atlantic Mackerel



by W. Overholtz

The 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. The two groups are managed as a unit stock. Maximum observed size in recent years is about 47 cm (18.5 in) in 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.

Atlantic mackerel — NOAA Fisheries NEFSC photo by Brenda Figuerido

Mackerel are subjected to seasonal fisheries, both commercial and recreational, throughout most of their range. United States commercial landings have been taken primarily between January and May in southern New England and Mid-Atlantic coastal waters and between May and December in the Gulf of Maine. United States recreational catches occur mainly between April and October. Canadian landings have typically been taken from off Nova Scotia and Newfoundland between May and November. The intensive distant-water fishery conducted between 1968 and 1977 occurred mainly between December and April from Georges Bank to Cape Hatteras.

Since April, 1983, the U.S. fishery has been managed under the Mid-Atlantic Fishery Management Council's Atlantic Mackerel, Squid, and Butterfish Plan. Management is based on annual quota specifications. For 1997, domestic annual harvest (DAH) was set at 90,000 mt within an allowable biological catch (ABC) of 383,000 mt.

Mackerel landings increased dramatically as foreign effort intensified in the late 1960s, reaching a peak of roughly 430,000 mt in 1973. Landings subsequently declined to about 30,000 mt in the late 1970s, increased to about 87,000 mt in 1990, and then declined to 27,400 mt in 1995. Increases in landings in the 1980s were due to increased U.S. and foreign joint venture fishing operations. Landings for 1996 totalled 37,600 mt, of which 17,100 mt was taken by the U.S. (15,800 mt commercial, 1,300 mt recreational). Canadian landings increased from 17,700 mt in 1995 to 20,400 mt in 1996. There was a distant-water fleet catch of less than 100 mt in Canadian waters in 1996.

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 was the largest since 1967. The 1984 to 1988, 1991, and 1993 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 stock has since increased to well over 2 million mt. This increase in biomass has been accompanied by decreased growth rates of individual fish. Spawning stock biomass (50% of age 2 fish and 100% of ages 3 and older) increased from about 500,000 mt in 1982 to more than 2.0 million mt in 1994 and has since remained at or above that level.

Rebuilding of the mackerel stock from relatively low levels in the late

> "Rebuilding of the mackerel stock from relatively low levels in the late 1970s and early 1980s has resulted from low catches during 1978-1993 .... as well as improved recruitment."

1970s and early 1980s has resulted from low catches during 1978-1993 (average of 49,400 mt) as well as improved recruitment. Stock biomass levels are now among the highest observed and fishing mortality is substantially below $F_{0.1}$. The resource is underexploited and catches can be increased substantially without adversely affecting spawning stock biomass.

For further information

Anderson, E.D., and A.J. Paciorkowski. 1980. A review of the Northwest Atlantic mackerel fishery. *Rapp. P.-V. Reun. Cons. Int. Explor. Mer* 177:175-211.

Overholtz, W.J., S.A. Murawski, W.L. Michaels, and L.M. Dery. 1988. The effects of density dependent population mechanisms on assessment advice for the northwest Atlantic mackerel stock. *NOAA Tech. Memo. NMFS-F/NEC-62.*

Overholtz, W.J., S.A. Murawski, and W.L. Michaels. 1990. Impact of compensatory responses on assessment advice for the Northwest Atlantic mackerel stock. *Fish. Bull., U.S.* 89:117-128.

NEFSC [Northeast Fisheries Science Center]. 1996. [Report of the] 20th Northeast Regional Stock Assessment Workshop (20th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 95-18.

Labrador to North Carolina

Atlantic Mackerel

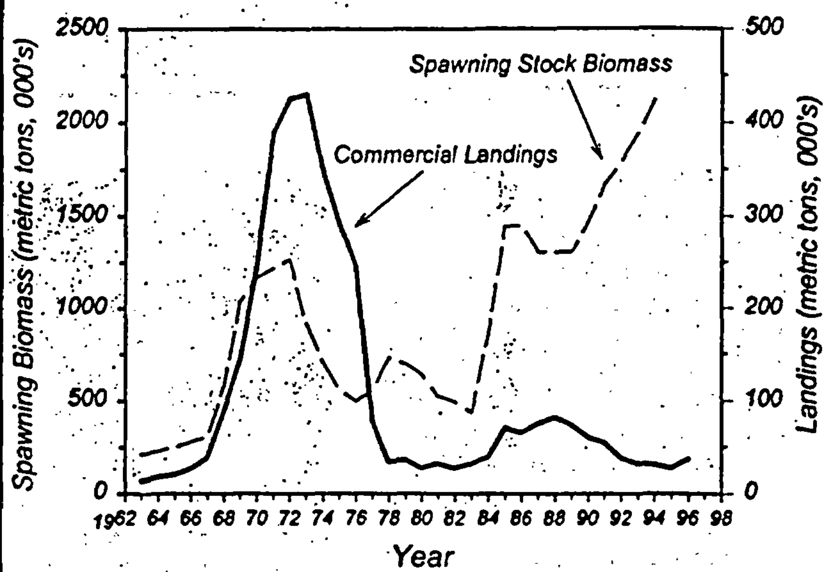


Table 22.1 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	2.7	4.0	3.2	1.8	1.9	2.4	0.3	0.5	1.1	1.2	1.3
Commercial											
United States	4.0	12.3	12.3	14.6	31.3	27.0	11.8	4.7	10.1	8.5	15.8
Canada	23.5	27.6	25.0	21.1	23.0	20.9	24.3	26.1	20.7	17.7	20.4
Other	15.0	36.6	42.9	36.8	30.7	15.7	2.4	0.7	-	-	<0.1
Total nominal catch	45.2	80.5	83.4	74.3	86.9	66.0	38.8	32.0	31.9	27.4	37.6

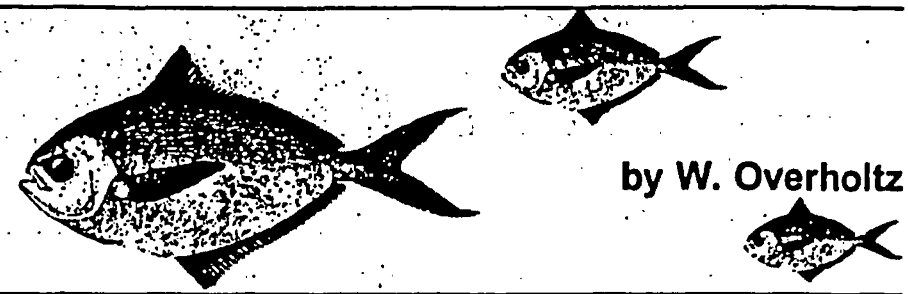
Summary Status

Long-term potential catch	=	134,000[1] mt
SSB for long-term potential catch	=	1.0-1.2 million mt
Importance of recreational fishery	=	Moderate
Management	=	Mackerel, Squid, and Butterfish FMP
Status of exploitation	=	Underexploited
Age at 50% maturity	=	1.9 years (both sexes)
Size at 50% maturity	=	26.0 cm (10.2 in.), males 25.7 cm (10.1 in.), females
Assessment level	=	Age structured
Overfishing definition	=	Minimum SSB of 900,000 mt and $F_{0.1}$ fishing mortality rate
Fishing mortality rate corresponding to overfishing definition	=	Variable

$M = 0.20$ $F_{0.1} = 0.27$ $F_{max} = 0.98$ $F_{1996} = <0.05$

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

Butterfish



by W. Overholtz

The butterfish (*Peprilus triacanthus*) is a small bony foodfish weighing up to 0.5 kg with a thin oval body and delicious oily flesh. Butterfish are short-lived and grow rapidly. Few live to more than 3 years of age, and most are sexually mature at age 1. Butterfish range from Florida to Newfoundland, but are primarily found from Cape Hatteras to the Gulf of Maine where the population is considered to be a unit stock.

The butterfish stock migrates in response to seasonal changes in water temperature. During summer, butterfish move northward and inshore to feed and spawn. Spawning occurs during June to August and peaks progressively later at higher latitudes. During winter, the stock moves southward and offshore to avoid cool waters. Butterfish are primarily pelagic and form loose schools that feed upon small fish, squid, and crustaceans. Butterfish have a high natural mortality rate and are preyed upon by many species including silver hake, bluefish, swordfish, and long-finned squid. During summer, juvenile butterfish associate with jellyfish to avoid predators.

Butterfish — NOAA Fisheries NEFSC photo by Brenda Figuerido

Butterfish have been landed by domestic fishermen since the 1800s. From 1920 to 1962, the annual domestic harvest averaged 3,500 mt. In the 1960s distant water fleets began to exploit butterfish; and from 1965 to 1976, butterfish landings increased to an average of 10,000 mt per year with a peak of 19,500 mt in 1973. During 1977 to 1986 when foreign fishing was being phased out, butterfish landings averaged 6,300 mt. From 1987 to 1995, annual landings averaged 3,000 mt; the 1996 total was 3,600 mt. Otter trawls are the primary fishing gear used to capture butterfish and accounted for 95% of the 1996 landings.

The butterfish stock is managed under provisions of the Mid-Atlantic Fishery Management Council's Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. Management is based on annual quota specifications. For 1997, domestic annual harvest (DAH) was set at 5,900 mt within an allowable biological catch (ABC) of 7,200 mt.

Data from the NEFSC autumn bottom trawl survey indicate that butterfish stock biomass was above its long-term average in 1994. The biom-

Gulf of Maine - Middle Atlantic

Butterfish

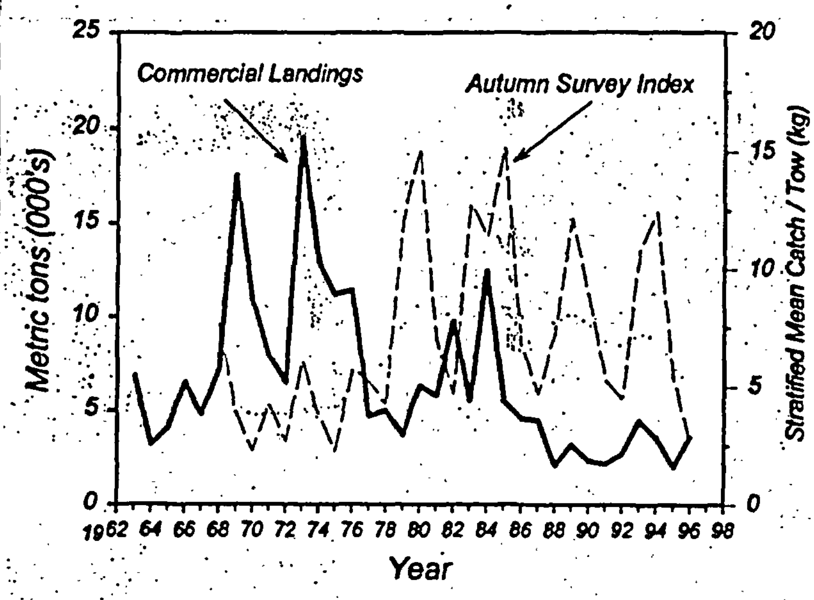


Table 23.1 Recreational and commercial catches (thousand metric tons)

Category	Year										
	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	5.3	4.5	2.1	3.2	2.4	2.2	2.8	4.5	3.6	2.0	3.6
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	1.0	0.0	0.0	<0.1	<0.1	0.0	0.0	0.0	0.0	0.0	0.0
Total nominal catch	6.3	4.5	2.1	3.2	2.4	2.2	2.8	4.5	3.6	2.0	3.6

Summary Status

Long-term potential catch	=	16,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Mackerel, Squid, and Butterfish FMP
Status of exploitation	=	Underexploited
Age at 50% maturity	=	0.9 years (both sexes)
Size at 50% maturity	=	11.4 cm (4.5 in.), males 12.0 cm (4.7 in.), females
Assessment level	=	Yield per recruit
Overfishing definition	=	3-year moving average of autumn prerecruit index falls within lowest quartile of the time series

M = 0.80 $F_{0.1}$ = 1.60 F_{max} > 2.50 F_{1996} = Unknown

"Data collected at sea by fishery observers suggest that much of the fishing-induced mortality of butterfish is attributable to discarding at sea, and discarding may be a factor in the recent low levels of yield."

ass index (total weight for all ages) declined to about 25% of this level in 1996.

Butterfish landings have averaged less than 30% of the DAH since 1987, and recent yields from this stock are well below historical yields. Data collected at sea by fishery observers suggest that much of the fishing-induced mortality of butterfish is attributable to discarding at sea, and discarding may be a factor in the recent low levels of yield. Demand for Atlantic butterfish exports in the important Japanese market has also decreased in recent years. This has probably had a negative impact on the fishery.

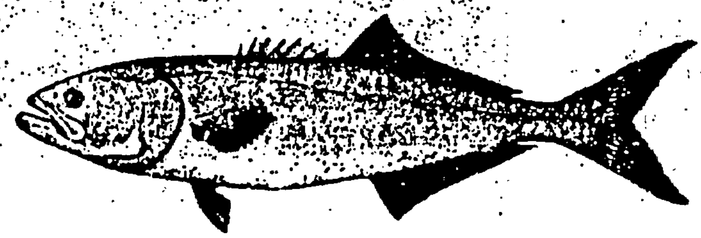
Overall, it appears that the butterfish stock is underexploited and at a medium abundance level.

For further information

Murawski, S. and G. Waring. 1979. A population assessment of butterfish, *Peprilus triacanthus*, in the Northwest Atlantic Ocean. *Trans. Am. Fish. Soc.* 108:427-439.

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

Bluefish



by M. Terceiro

The bluefish, *Pomatomus saltatrix*, is a migratory, pelagic species found throughout the world in most temperate coastal regions, except the eastern Pacific. Along the U.S. Atlantic coast, bluefish are found from Maine to Florida, migrating northward in the spring and southward in the fall. Bluefish are voracious predators that feed on a wide variety of fish and invertebrates. They may reach ages of about 12 years and sizes in excess of 100 cm (39 in.) and 14 kg (31 lb).

Atlantic coast bluefish spawn mainly in the spring in the South Atlantic Bight and during summer in the Middle Atlantic Bight. Fish from the two spawning seasons mix extensively on the fishing grounds and probably comprise a single genetic stock. A unit stock of bluefish along the Atlantic coast is assumed for management purposes. Bluefish are managed under a fishery management plan developed by the Mid-Atlantic Fishery Management Council and the Atlantic States Marine Fisheries Commission.

Total landings from Maine to Florida peaked in 1981 at an estimated 51,400 mt.. Landings have since declined substantially; the 1994-1996 average (11,400 mt) was only 27% of the 1977-1986 average (41,600 mt). The recreational component of the fishery, which has historically constituted 80-90% of the total catch, peaked in 1981 at nearly 44,000 mt. Most of the recreational catch of bluefish is taken in the Middle Atlantic states (New York to Virginia). The 1996 recreational catch of 7,400 mt accounted for 65% of the total catch. There is no foreign fishery.

The principal commercial fishing gears used to catch bluefish are otter trawls and gill nets. Commercial landings peaked in 1981 at 7,500 mt. Commercial landings averaged 6,200 mt annually from 1987-1991 and have since declined; the 1996 figure was 3,900 mt, 35% of the total.

Bluefish

NOAA Fisheries
NEFSC photo by Brenda Figuerido

In early 1998, Atlantic coast bluefish were assessed using a surplus production model that provided estimates of the fishing mortality rate (F_{MSY}) and stock biomass (B_{MSY}) required to produce maximum sustain-

Atlantic Coast

Bluefish

"Bluefish have been overexploited since 1979 and the stock is currently well below levels needed to produce MSY."

able yield (MSY) for bluefish, as well as estimates of stock biomass and fishing mortality through 1997. The analysis indicated that MSY of 42,700 mt can be produced by the Atlantic coast bluefish stock when biomass is approximately at B_{MSY} = 107,500 mt and fishing mortality on total stock biomass is F_{MSY} = 0.40. Bluefish stock biomass approached B_{MSY} during 1980-1981, but has since declined. Average stock biomass in 1997 was estimated at 22,700 mt, about 21% of B_{MSY}, and fishing mortality for 1997 was estimated at 0.51, about 25% higher than F_{MSY}. Bluefish have been overexploited since 1979 and the stock is currently well below levels needed to produce MSY.

For further information

Chiarella, L.A., and D.O. Conover. 1990. Spawning season and first-year growth of adult bluefish from the New York Bight. *Trans. Am. Fish. Soc.* 119:455-462.

Graves, J.E., J.R. McDowell, A.M. Beardsley, and D.R. Scoles. 1992. Stock structure of the bluefish *Pomatomus saltatrix* along the mid-Atlantic coast. *Fish. Bull., U.S.* 90:703-710.

Gibson, M.R., and N. Lazar. 1998. Assessment and projection of the Atlantic coast bluefish using a biomass dynamic model. A report to the ASMFC Bluefish Technical Committee and MAFMC Scientific and Statistical Committee.

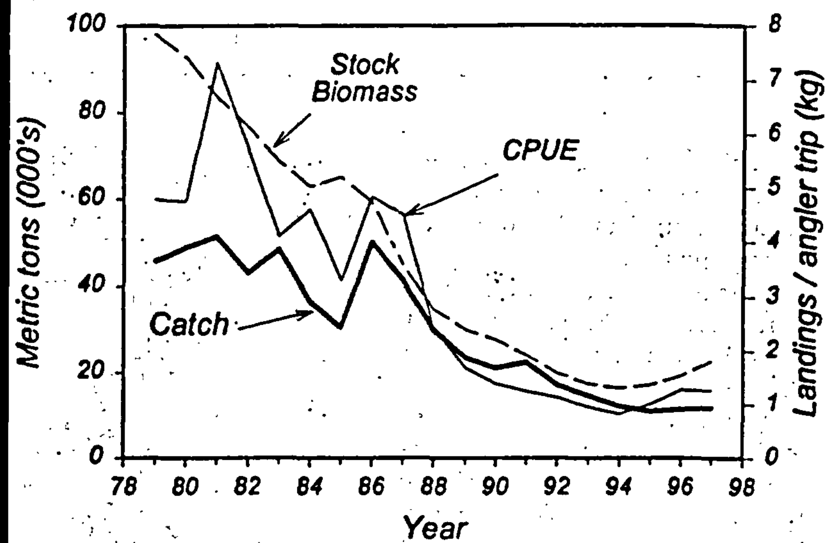


Table 24.1 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational[1]	35.4	35.0	22.9	18.7	14.8	16.2	12.0	10.0	7.9	7.2	7.4
Commercial											
United States	6.2	6.6	7.2	4.7	6.2	6.2	5.2	4.7	4.3	3.6	3.9
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	41.6	41.5	30.1	23.4	21.0	22.4	17.2	14.7	12.2	10.8	11.3

[1]Landings and estimated discard mortality

Summary Status

Long-term potential catch (MSY)	=	42,700 mt
Biomass for long-term potential catch	=	107,500 mt
Importance of recreational fishery	=	Major
Management	=	Bluefish FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	1 year
Size at 50% maturity	=	35 cm (13.8 in.)
Assessment level	=	Surplus Production
Overfishing definition	=	F_{msy}
Fishing mortality rate corresponding to overfishing definition	=	F_{msy} = 0.40

$M = 0.25$ $F_{0.1} = 0.36$ $F_{1997} = 0.51$

Spiny Dogfish

by K. Sosebee

Spiny dogfish, *Squalus acanthias*, are distributed in the western North Atlantic from Labrador to Florida. During spring and autumn, they are found in coastal waters between North Carolina and Southern New England. Dogfish migrate from the edge of the continental shelf to the Gulf of Maine-Georges Bank region in summer. They tend to school by size and, when mature, by sex. Dogfish are known to feed on many species of fish and crustaceans, but generally target the most abundant species. In the Northwest Atlantic, maximum ages reported for males and females are 35 and 40 years, respectively. The species bears live young, with a gestation period of about 18 to 22 months, producing 2 to 15 pups with an average of 6.

Dogfish haul, Georges Bank — NOAA Fisheries NEFSC photo by Brenda Figuerido

The principal commercial fishing gears used for catching dogfish are otter trawls and sink gillnets. Dogfish are frequently caught as bycatch and discarded during groundfish operations, particularly in the Mid-Atlantic - Southern New England area. Recreational and foreign fishing are of minor importance. The fishery is now unmanaged; a fishery management plan is under development by the Mid-Atlantic and New England fishery management councils.

Total landings peaked at 24,700 mt in 1974, declined sharply to a fairly stable average of about 5,900 mt per year during 1977-1989, and then increased sharply to over 17,000 mt in 1990; landings have since increased further to a record high of 28,000 mt in 1996. Distant water fleets accounted for virtually all of the reported total from 1966 to 1977. United States commercial landings during 1979-1989 averaged 3,600 mt per year, but then climbed sharply to 14,700 mt in 1990 and to 27,200 mt in 1996. Catches in the U.S. recreational fishery increased from about 800 mt per year in 1981-1984 to about 1,400 mt from 1987-1993, but subsequently declined to 400 mt in 1996. Quantitative estimates of discards are unavailable except for 1993 (13,500 mt), but may have been at least as high as reported landings. Discards have reportedly declined with increases in directed effort and landings in recent years.

The U.S. fishery for dogfish is similar to European fisheries in being selective for large individuals [larger than 2.3 kg (5.1 lb) in weight, and 83 cm (33 in.) in length], which are primarily mature females, to meet processing and marketing requirements. However, smaller individuals, consisting of both mature and immature males as well as immature females, are also taken as bycatch and discarded.

Minimum swept-area total biomass estimates of spiny dogfish based on NEFSC spring bottom trawl survey catches increased steadily from about 150,000 mt in 1968 to about 600,000 mt in 1990 and have since been stable. However, estimates of fishable biomass (80 cm) peaked at about 300,000 mt in 1989 and have since declined to about 150,000 mt in 1997. Absolute estimates of fishing mortality are not available, but relative rates have increased five-fold since the late 1980s.

Declining abundance as evidenced by trends in commercial catch per unit effort and research vessel survey indices, apparent increases in fishing mortality and declines in average length in commercial landings, all suggest that this stock is overexploited. Since this species bears small numbers of live young and has a protracted gestation period, directed fisheries for mature females may impact significantly upon recruitment. The poten-

"The U.S. fishery for dogfish is similar to European fisheries in being selective for large individuals ...which are primarily mature females, to meet processing and marketing requirements."

tial for rapid overexploitation of sharks has been widely noted.

For further information

Brodziak, J., P.J. Rago, and K. Sosebee. 1994. Application of a biomass dynamics model to the spiny dogfish stock in the Northwest Atlantic. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-18.

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

Rago, P.J., K. Sosebee, J. Brodziak, and E.D. Anderson. 1994. Distribution and dynamics of Northwest Atlantic spiny dogfish (*Squalus acanthias*). Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-19.

NEFSC [Northeast Fisheries Science Center]. 1998. [Report of the] 26th Northeast Regional Stock Assessment Workshop (26th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 98-03.

Labrador - North Carolina

Spiny Dogfish

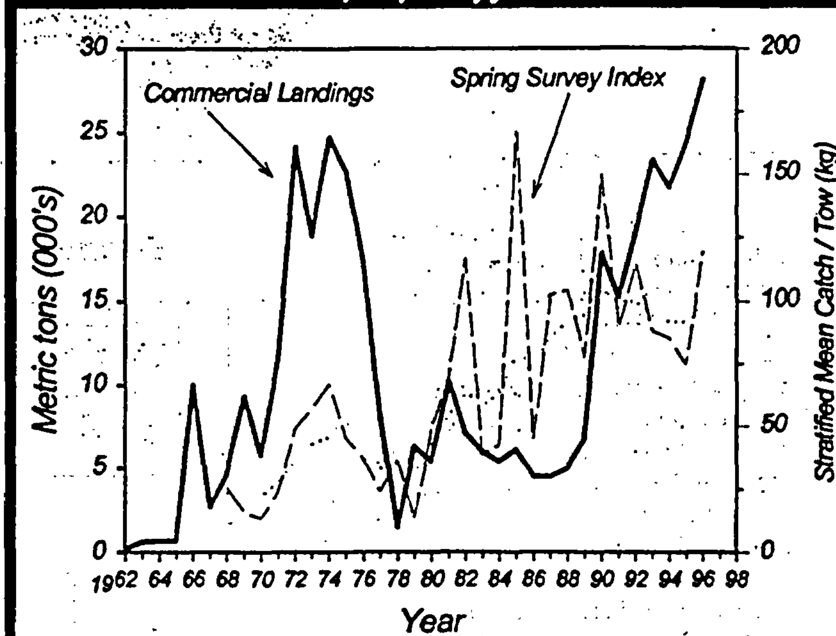


Table 25.1 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	1.0[1]	1.4	1.2	1.8	1.3	1.5	1.2	1.2	1.1	0.7	0.4
Commercial											
United States	3.9	2.7	3.1	4.5	14.7	13.2	16.9	20.6	18.8	22.7	27.2
Canada	0.4	0.3	-	0.2	1.3	0.3	0.8	1.4	1.8	1.0	0.4
Other	1.2	0.1	0.6	0.3	0.4	0.2	0.1	-	-	-	-
Total nominal catch	6.5	4.5	5.0	6.7	17.8	15.2	19.0	23.3	21.7	24.4	28.1

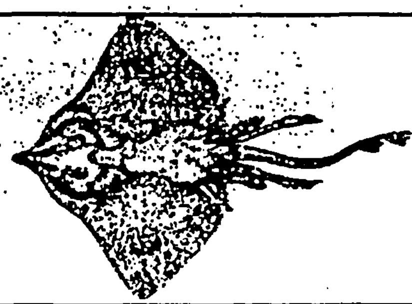
[1]1981-1986 average

Summary Status

Long-term potential catch	=	<10,000 mt
SSB for long-term potential catch	=	200,000 mt
Importance of recreational fishery	=	Low
Management	=	Pending
Status of exploitation	=	Over exploited
Age at 50% maturity	=	6 years, males 12 years, females
Size at 50% maturity	=	60 cm (23 in.), males 80 cm (30 in.), females
Assessment level	=	Size-based
Overfishing definition	=	<100,000 mt Female spawner biomass
Fishing mortality rate corresponding to overfishing definition	=	$F_{THRESHOLD} = 0.11$ at 70 cm entry

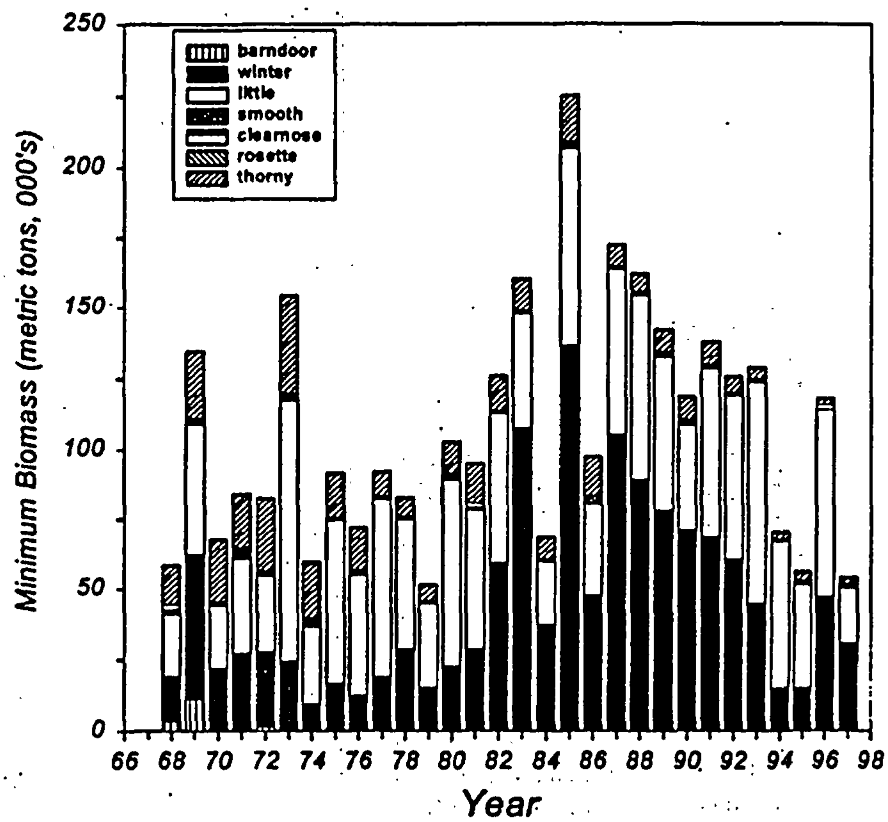
M = 0.09 F_{max} = .08 (at 70 cm entry) F_{1996} = 0.3

Skates



by K. Sosebee

Skates
Spring Survey Species Composition



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*), clearnose skate (*R. eglanteria*), rosette skate (*R. garmani*) and smooth skate (*R. senta*).

The center of distribution for the little and winter skates is Georges Bank and Southern New England. The thorny, barndoor, and smooth skates are commonly found in the Gulf of Maine. The clearnose and rosette skates are southern species, located primarily in the Chesapeake Bight and Southern New England. Skates are not known to undertake large-scale migrations, but they do move seasonally in response to changes in water temperature, generally offshore in summer and early autumn and *vice-versa* during winter and spring.

The principal commercial fishing method used to catch skates is otter trawling. Skates are frequently taken as bycatch during ground fishing operations and discarded. Recreational and foreign landings are insignificant. There are currently no regulations governing the harvesting of skates in U.S. waters.

Skates have been reported in New England fishery landings since the late 1800s. However, landings (primarily from off Rhode Island) never exceeded several hundred metric tons until the advent of distant-water fleets during the 1960s. Skate landings peaked in 1969 at 9,500 mt, but declined quickly during the 1970s and bottomed out at 500 mt in 1981. Landings have since increased substantially, partially in response to increased demand for lobster bait, and, more significantly, to the increased export market for skate wings. Wings are taken from winter and thorny skates, the two species currently known to be used for human consumption. Bait landings appear to be primarily from little skate, based on areas fished and known species distribution patterns. Landings increased to 12,900 mt in 1993 and then declined somewhat to 7,200 mt in 1995; however, the 1996 total was 14,200, the highest on record.

Minimum biomass estimates have been developed from NEFSC spring bottom trawl survey data by area-swept calculations, smoothed to better reflect resource trends. From 1968 to 1980, estimates were relatively constant, at around 80,000 mt, and then increased significantly to peak levels in the mid-to late 1980s. Since 1988, estimates have steadily declined to former levels.

"Skates have a limited reproductive capacity, and stock size could be quickly reduced through intensive exploitation."

Recent increases in skate landings and the potential for rapidly expanding export markets bring into question the level at which sustainable fisheries for these species can be maintained. Skates have a limited reproductive capacity, and stock size could be quickly reduced through intensive exploitation. In areas of the world where skates are more fully utilized, their numbers have been reduced to extremely low levels (*e.g.*, Irish Sea). Abundance of winter skate and thorny skate has declined in recent years.

For further information

Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. *Fish. Bull., U.S. Fish. Wildl. Serv.* 74(53).

Holden, M.J. 1973. Are long-term sustainable fisheries for elasmobranchs possible? *Rapp. P.-V. Reun. Cons. Int. Explor. Mer* 164:360-367.

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

Waring, G.T. 1984. Age, growth and mortality of the little skate off the northeast coast of the United States. *Trans. Amer. Fish. Soc.* 113:314-321.

Gulf of Maine - Middle Atlantic

Skates

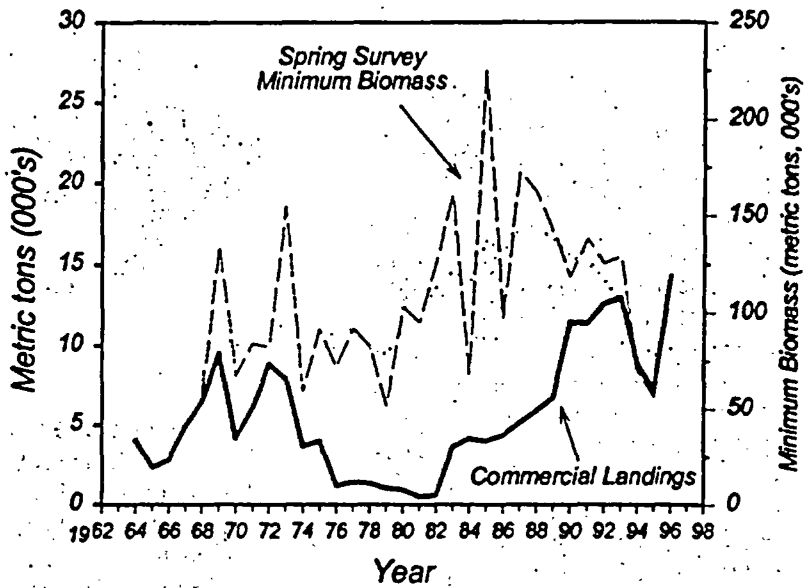


Table 26.1 . Recreational catches and commercial landings (thousand metric tons)

Category	Year 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.6	5.1	5.9	6.7	11.4	11.3	12.5	12.9	8.8	7.2	14.2
Canada	<0.1	-	<0.1	<0.1	-	-	-	-	-	-	-
Other	0.6	0.1	-	-	-	-	-	-	-	-	-
Total nominal catch	2.2	5.1	5.9	6.7	11.4	11.3	12.5	12.9	8.8	7.2	14.2

Summary Status

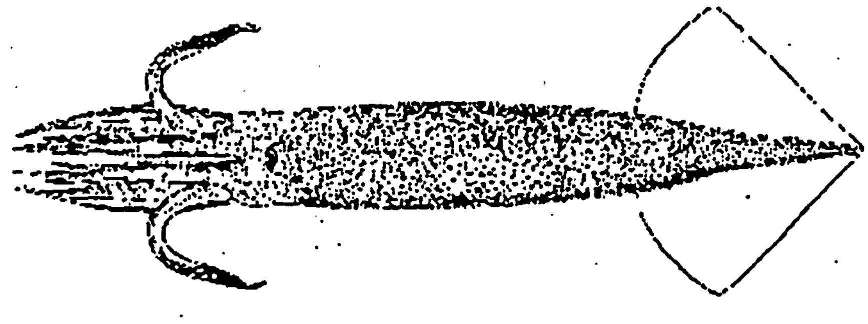
Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational catch	=	Insignificant
Management	=	None
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	4 years[1]
Size at 50% maturity	=	40 cm (15.8 in.)[1]
Assessment level	=	Index
Overfishing definition	=	None
Fishing mortality rate corresponding to overfishing definition	=	Unknown

$M = 0.4$[1] $F_{0.1} = 0.49$[1] $F_{max} = 1.0$[1] F_{1996} = Unknown

[1]Pertains to little skate

Northern Shortfin Squid

by L. Hendrickson



The northern shortfin squid, *Illex illecebrosus,* is a highly migratory ommastrephid which is distributed in the western Atlantic from Florida to Labrador; primarily in offshore continental shelf and slope waters. From Cape Hatteras to Newfoundland, throughout its range of commercial exploitation, the species is considered to be a unit stock.

Although overlapping seasonal cohorts have been identified, peak spawning occurs during winter. During autumn, individuals from as far north as Newfoundland undergo a lengthy spawning migration to warmer waters south of Cape Hatteras. Larvae and juveniles are transported northward in the warm waters of the Gulf Stream and growth is rapid during the first few months. Squid spawned during winter migrate onto the continental shelf during late spring.

This species may attain dorsal mantle lengths of up to 35 cm, although individuals harvested in the commercial fishery are generally less than 25 cm in length. The species lives for up to one year.

In the U.S. Exclusive Economic Zone (EEZ), shortfin squid are targeted primarily during June-September, by small-mesh otter trawl fisheries near the edge of the continental shelf. The U.S. squid fishery originated in the late 1800s, primarily as a source of bait, and from 1928-1967 U.S. landings (including longfin inshore squid, *Loligo pealeii*) ranged between 500-2,000 mt annually. International effort intensified first off the U.S. coast from 1968-1975 and then in Canadian waters (Northwest Atlantic Fisheries Organization or NAFO Subareas 2-4) from 1976-1981. Total landings rose from 1,600 mt in 1969 to 179,300 mt in 1979, of which 162,100 mt was taken in NAFO Subareas 2-4. Following this period of high landings in the early 1980s, the stock shifted to a low productivity regime. The fishery in NAFO Subareas 2-4 collapsed in 1983; landings in that region declined to only 100 mt in 1986, and have since exceeded 10,000 mt only twice (in 1990 and 1997). Landings in the U.S. EEZ peaked during 1976-1977 at a much lower level (about 25,000 mt). Since 1982, total landings have been taken primarily by the U.S. fishery. There has been no foreign fishery in U.S. waters since 1986. Landings by the U.S. were 14,000 mt in 1995 and 17,000 mt in 1996, representing 93% and 66% of the total landings, respectively.

The U.S. fishery is managed by the Mid-Atlantic Fishery Management Council (MAFMC), under provisions of the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. Management measures for shortfin squid include use of moratorium permits, annual quota specifications, and trip limits once 95% of the annual quota is reached. Domestic annual harvest (DAH) for 1997 was set at 19,000 mt, the allowable biological catch (ABC) level. The fishery in Canadian waters is managed under a Total Allowable Catch (TAC) established by NAFO. Since 1980, the TAC has been 150,000 mt.

Since shortfin squid are highly migratory, an unknown fraction of the stock may reside offshore and outside of the area exploited by the fishery or sampled during NEFSC bottom trawl surveys at any given time. Also, distribution is strongly influenced by oceanographic factors. For these reasons, monitoring of this resource can be problematical.

Standardized landings per unit effort (LPUE) data for the U.S. fishery from 1982-1993 have been used in a surplus production model to estimate fishing mortality rates, stock biomass, and maximum sustainable yield (MSY). A new overfishing definition of $F_{20\%}$ (0.28, 21% exploitation rate) and a target of $F_{50\%}$ (0.11, 9% exploitation rate) have recently been adopted to account for the one-year life cycle of this species, and to minimize the risk of recruitment overfishing.

Monthly fishing mortality rates increased during 1988-1993, from 0.01 to 0.12, just above the $F_{50\%}$ target. Stock biomass has generally decreased since 1989 and is now at a medium level. Estimates of median long-term potential yields for $F_{20\%}$ and $F_{50\%}$ are 21,300 mt and 14,600 mt, respectively. However, recruitment is highly variable and yields may vary depending

"A new overfishing definition...and target...exploitation rate have recently been adopted to account for the one-year life cycle of this species..."

on environmental conditions. In 1996, U.S. landings were above the target yield. This stock appears to be fully exploited.

For further information

Dawe E.G., and P.C. Beck. 1997. Population structure, growth, and sexual maturation of short-finned squid (*Illex illecebrosus*) at Newfoundland. *Can. J. Fish. Aquat. Sci.* 54:137-146.

Dawe, E.G., and L.C. Hendrickson. 1998. A review of the biology, population dynamics and exploitation of shortfin squid in the northwest Atlantic Ocean in relation to assessment and management of the resource. *NAFO SCR Doc.* 98/59.

Hendrickson, L.C., J. Brodziak, M. Basson, and P. Rago. 1996. Stock assessment of northern shortfin squid in the Northwest Atlantic during 1993. NOAA/NMFS/NEFSC: Woods Hole, MA. *NEFSC Ref. Doc.* 96-05g.

Lange, A.M.T., and M.P. Sissenwine. 1980. Biological considerations relevant to the management of squid *Loligo pealei* and *Illex illecebrosus*. *Mar. Fish. Rev. 42(7-8)*: 23-28.

NEFSC [Northeast Fisheries Science Center]. 1996. [Report of the] 21st Northeast Regional Stock Assessment Workshop (21st SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. NOAA/NMFS/NEFSC: Woods Hole, MA. *NEFSC Ref. Doc.* 96-05d.

Gulf of Maine - Middle Atlantic

Northern Shortfin Squid

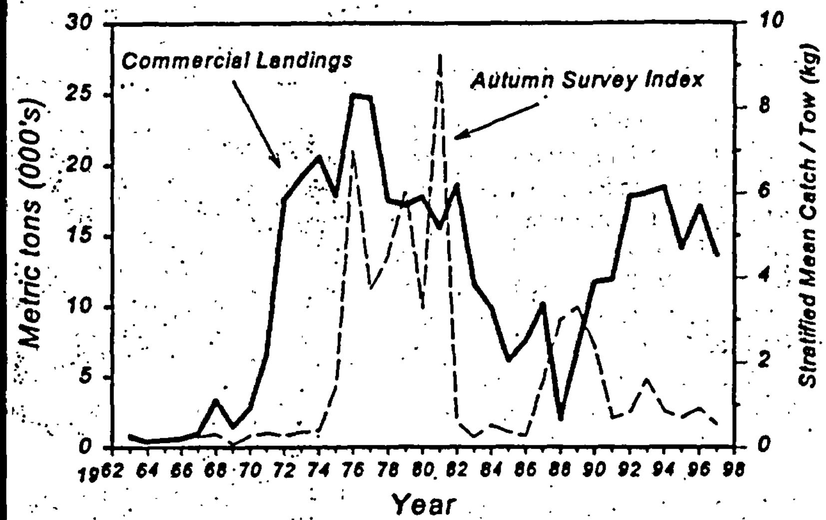


Table 27.1 Commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	4.0	10.1	2.0	6.8	11.7	11.9	17.8	18.0	18.3	14.0	17.0
Canada	<0.1	-	-	-	-	-	-	-	-	-	-
Other	10.6	-	-	-	-	-	-	-	-	-	-
Total US EEZ[1]	14.6	10.1	2.0	6.8	11.7	11.9	17.8	18.0	18.3	14.0	17.0
NAFO SA 2-4	45.7	0.6	0.8	7.0	11.0	4.0	2.0	2.7	6.0	1.0	8.7
Total nominal catch	60.3	10.7	2.8	13.8	22.7	15.9	19.8	20.7	24.3	15.0	25.7

[1]Does not include unidentified squid species

Summary Status

Long-term potential catch	=	14,600 mt[1]
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Mackerel, Squid, and Butterfish FMP
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	<1.0 year
Size at 50% maturity	=	200-215 mm dorsal-mantle length, males
Assessment level	=	Surplus production
Overfishing definition	=	$F_{20\%}$
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%} = 0.28$[2]

M = 0.30[2] $F_{50\%}$ = 0.11[2] F_{1996} = Unknown

[1]Revision based on target of $F_{50\%}$
[2]Monthly mortality rate

Longfin Inshore Squid

by S.X. Cadrin

Longfin inshore squid (*Loligo pealeii*) school in continental shelf and slope waters from Newfoundland to the Gulf of Venezuela. Within its range of commercial exploitation (Georges Bank to Cape Hatteras) longfin squid comprise a unit stock. North of Cape Hatteras, individuals migrate seasonally, moving offshore during late autumn to overwinter in warmer waters along the edge of the continental shelf and inshore during the spring and early summer. Longfin squid live for less than one year, grow rapidly, and spawn year-round. Individuals hatched in summer grow more rapidly than those hatched in winter. The species is sexually dimorphic, with males growing faster and attaining larger sizes than females. Some males attain dorsal mantle lengths of more than 40 cm (16 in.), although most squid harvested in the commercial fishery are less than 30 cm (12 in.) long.

The U.S. squid fishery began in the late 1800s as a source of bait, and from 1928 to 1967, annual squid landings from Maine to North Carolina (including northern shortfin squid, *Illex illecebrosus* landings) ranged from 500-2,000 mt. A directed foreign fishery developed in the late 1960s, and distant water fleets exploited longfin squid throughout the 1970s and early 1980s. Landings fluctuate widely, because generations have minimal overlap and seasonal dynamics are sensitive to environmental factors. Annual landings averaged 19,900 mt from 1967 to 1986 with a maximum of 37,600 mt taken in 1973. Since 1986 there have been no allocations to foreign nationals, and foreign landings have been negligible. From 1987-1996, U.S. landings have averaged 18,200 mt annually. In 1996, landings totalled 12,500 mt.

Longfin squid on butterfish & sand lance

NOAA Fisheries NEFSC photo by Brenda Figuerido

Most landings are taken from Southern New England and Mid-Atlantic waters. Fishing patterns reflect seasonal distribution; most effort is directed offshore from October to March and inshore from April to September. The fishery is dominated by small-mesh otter trawlers, but substantial landings are also taken from pound nets and fish traps in spring and summer. Since 1987, winter fishing effort has increased, and offshore landings have generally been three-fold greater than inshore landings.

The longfin squid stock is managed by the Mid-Atlantic Fishery Management Council under the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan. Management measures include use of moratorium permits, annual quota specifications and gear restrictions.

In 1996, management targets for the longfin squid stock were reevaluated to reflect recent research on its life history. The estimated long-term potential total yield (LPTY) is 21,000 mt, corresponding to a target fishing mortality rate of $F_{50\%}$=0.13 and 0.14 (11% exploitation rate) for winter and summer hatched squid, respectively. This level of exploitation is based on maintaining 50% of potential spawning stock biomass per recruit to en-

> **"Landings fluctuate widely, because generations have minimal overlap and seasonal dynamics are sensitive to environmental factors."**

hance the probability of sustainable yields. The overfishing threshold of maximum yield per recruit (F_{max}) was determined to be 0.38-0.36 (28-26% exploitation rate). For 1997, domestic annual harvest (DAH) was set at 21,000 mt, the allowable biological catch (ABC) level, established at LPTY.

Indices of abundance from the NEFSC autumn bottom trawl survey are highly variable. The survey index was below average in 1995 and 1996.

The short lifespan of longfin squid combined with their rapid growth and capacity to spawn year-round leads to a seasonally dynamic resource. The potential for recruitment overfishing of the stock is substantial because longfin squid recruit to the fishery and to the spawning stock in the same year. This resource is considered to be fully exploited.

For further information

Brodziak, J.K.T., and W.K. Macy, III. 1996. Growth of long-finned squid, *Loligo pealeii*, in the northwest Atlantic. *Fish. Bull., U.S.* 94:212-236.

NEFSC [Northeast Fisheries Science Center]. 1996. [Report of the] 21st Northeast Regional Stock Assessment Workshop (21st SAW). Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 96-05d.

Gulf of Maine-Middle Atlantic

Longfin Inshore Squid

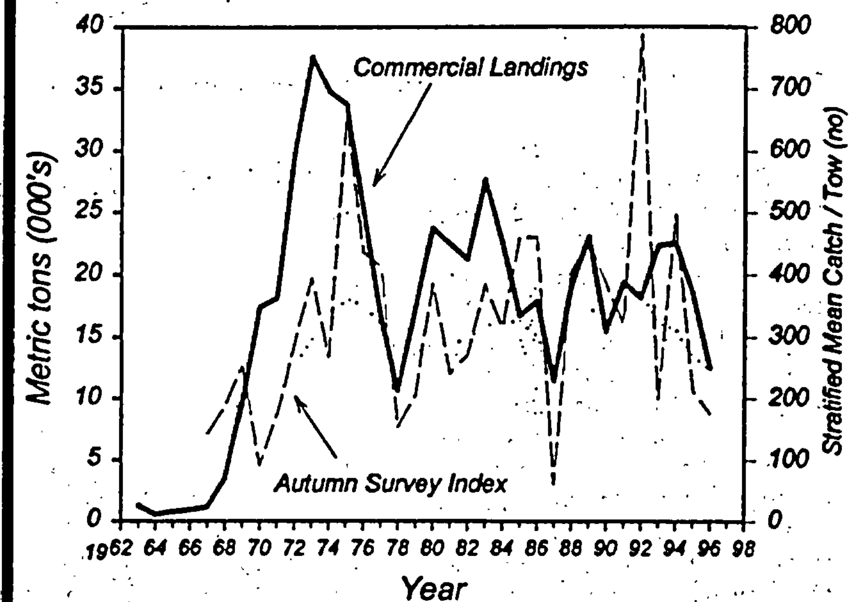


Table 28.1 Recreational catches and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	6.9	11.5	19.1	23.0	15.5	19.4	18.2	22.3	22.5	18.0	12.5
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	12.8	<0.1	<0.1	<0.1	-	-	-	-	-	-	-
Total nominal catch	19.7	11.5	19.1	23.0	15.5	19.4	18.2	22.3	22.5	18.0	12.5

Summary Status

Long-term potential catch	=	21,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Mackerel, Squid and Butterfish FMP
Status of exploitation	=	Fully exploited
Age at 50% maturity	=	6-8 months
Size at 50% maturity	=	16 cm dorsal-mantle length
Assessment level	=	Index
Overfishing definition	=	F_{max}
Fishing mortality rate corresponding to overfishing definition	=	F_{max} = 0.38[1] (winter cohort) F_{max} = 0.36[1] (summer cohort)

Winter cohort	M = .30[1]	$F_{50\%}$ = 0.13[1]	F_{1996} = Unknown
Summer cohort	M = .30[1]	$F_{50\%}$ = 0.14[1]	F_{1996} = Unknown

[1]Monthly mortality rate

American Lobster

by J. Idoine

The American lobster, *Homarus americanus*, is distributed in the Northwest Atlantic from Labrador to Cape Hatteras, from coastal regions out to depths of 700 m (400 fathoms). Lobsters are locally abundant in coastal regions within the Gulf of Maine and off southern New England. Coastal lobsters are concentrated in rocky areas where shelter is readily available, although occasional high densities occur in mud substrates suitable for burrowing. Offshore populations are most abundant in the vicinity of submarine canyons along the continental shelf edge. Tagging experiments in coastal waters suggest that small lobsters undertake rather limited movement, although larger individuals may travel extensively. In contrast, offshore lobsters show well-defined shoalward migrations during the spring, traveling as much as 300 km (186 mi), regularly 80 km (50 mi). Lateral movements along the shelf edge have been demonstrated as well. For assessment purposes, three stock areas- the Gulf of Maine, Georges Bank and South, and South of Cape Cod to Long Island Sound-have been recognized, based on differences in biological attributes and exploitation patterns.

Lobsters exhibit a complex life cycle in which mating occurs following molting of the female. Eggs (7,000 to 80,000) are extruded and carried under the female's abdomen during a 9 to 11 month incubation period. The eggs hatch during late spring or early summer and the pelagic larvae undergo four molts before attaining adult characteristics and settling to the bottom. Lobsters molt approximately 20 times (in 5 to 8 years) before reaching minimum legal size. A significant

Man with two lobsters, circa 1965

NOAA Fisheries NEFSC Photo Archive

"In both inshore and offshore fisheries, the great majority of lobsters landed are within one molt of the minimum size, representative of a continuing dependency on newly recruited animals ..."

Summary Status

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Minor
Management	=	American Lobster FMP/NEFMC Interstate FMP for American Lobster (ASMFC)
Status of exploitation	=	Overexploited
Size at 50% maturity	=	7.8-10 cm (3.1 - 3.9 in.) carapace length
Assessment level	=	Size structured (DeLury)
Overfishing definition	=	10% egg production per recruit
Fishing mortality rate corresponding to overfishing definition	=	$F_{10\%} = 0.32$[1] $F_{10\%} = 0.36$[2] $F_{10\%} = 0.44$[3]

$M = 0.10$	F_{max} (females) $= 0.24$[1]	$F_{1989\text{-}1991} = 0.62$[1]
	$= 0.15$[2]	$F_{1988\text{-}1990} = 0.50$[2]
	$= 0.33$[3]	$F_{1989\text{-}1991} = 1.21$[3]

[1]Gulf of Maine
[2]Georges Bank and South
[3]Southern Cape Cod - Long Island Sound

proportion of the female lobsters caught in inshore areas are not sexually mature.

The principal fishing gear used to catch lobsters is the trap. Lobsters are also taken as bycatch with otter trawls. Recreational fishing occurs in coastal waters, but estimates of the catch are not available. Foreign fishing is insignificant. The offshore fishery is managed under the New England Fishery Management Council's Lobster Fishery Management Plan, while fisheries within 3 mi of shore are managed by the various states under the Atlantic States Marine Fisheries Commission's Interstate Fishery Management Plan for American Lobster. Primary regulatory measures include carapace length (CL) limits, protection of ovigerous females, and gear restrictions and nominal effort control measures.

Total landings averaged 17,600 mt from 1977-1986 and then increased to 28,900 mt in 1991 before declining slightly in 1992-1993. Landings for 1995 and 1996 were 31,900 mt and 32,600 mt, respectively.

Landings in the U.S. inshore fishery were relatively stable from 1965 to 1975, ranging from 10,300 to 12,200 mt, and averaging 11,100 mt. Landings then rose steadily from 12,900 mt in 1978 to a record 24,000 mt in 1991. After declining somewhat in 1992-1993, the upward trend continued, with landings reaching 29,200 mt in 1996. This increase can be attributed both to increased abundance and a continuing increase in effort, especially in the number of pots and extent of area fished.

Prior to 1950, lobsters were taken offshore primarily as incidental trawl catches in demersal fisheries. Reported offshore lobster landings increased dramatically from about 400 mt during the 1950s to an average of more than 2,000 mt in the 1960s. In 1969, technological advances permitted the introduction of trap fishing to 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. At the same time, trawl landings decreased from a peak of 3,200 mt in 1971 to 500 mt in 1984. In subsequent years the trawl component of the fishery has averaged a little over 300 mt. Total offshore landings rose to an average of around 3,200 mt in the late 1980s, peaked at 5,000 mt in 1990 and have since declined to 3,200 mt in 1996, 10 percent of the U.S. total. Offshore landings have never comprised more than 20 percent of U.S. total landings.

In both inshore and offshore fisheries, the great majority of lobsters landed are within one molt of the minimum size, representative of a continuing dependency on newly recruited animals (i.e., those lobsters that have just grown into legal size). Even on Georges Bank in recent years, over 80% of the females are within this newly recruited category. These animals are not even 50% mature at these sizes, and therefore have not, on average, had a chance to reproduce.

In Canada, the Scotia-Fundy region has experienced similar trends in landings over the past decade.

The NEFSC autumn bottom trawl survey biomass index declined from 1.3 kg per tow in 1964 to an average of about 0.6 kg from 1970 -1975. The index then increased to an average of 0.8 kg per tow from 1979-1984. Since then, the index declined somewhat in the late 1980s, but then increased to 1.3 kg per tow in 1996. These trends in biomass indices and offshore landings are consistent in indicating a reduction in stock biomass following the development of the offshore fishery, followed by stabilization of the stock and subsequent increases in abundance. In recent years, other evidence of increases in abundance have been seen throughout the lobster's range.

During the past decade, areal expansion of the lobster fishery, landings from both inshore and offshore and the continued intense inshore fishery have called into question the relationship between animals in these areas. If consistent recruitment in coastal areas depends on egg production from offshore, heavy exploitation of offshore populations could impact all fisheries. It would be prudent to view lobsters from both areas as a unit resource.

The overfishing definition adopted by the New England Fishery Management Council refers only to females, based on maximum spawning potential expressed in terms of egg production. Assessment results indicate that all three stock areas are overexploited. This conclusion is supported not only by estimates of fishing mortality and associated egg production, but other population metrics. The proportion of landings that are new recruits (i.e., just molted into legal size) has ranged from around 80% for the Georges Bank and South region to 90% in the Gulf of Maine and nearly 98% in the South of Cape Cod to Long Island Sound area. The effectiveness of current management measures has been reduced by high mortality rates and the resultant severely truncated size composition. Any change in environmental conditions that would cause a major disruption in a year's molt, or worse, a reduction in spawning or survival from egg to adult stage, could have serious consequences for the resource. Substantial immediate reductions in effort and the initiation of other management measures are required to rebuild stock biomass and size/age composition so as to lessen dependence of the population and the fishery on incoming recruitment.

Gulf of Maine - Middle Atlantic

American Lobster

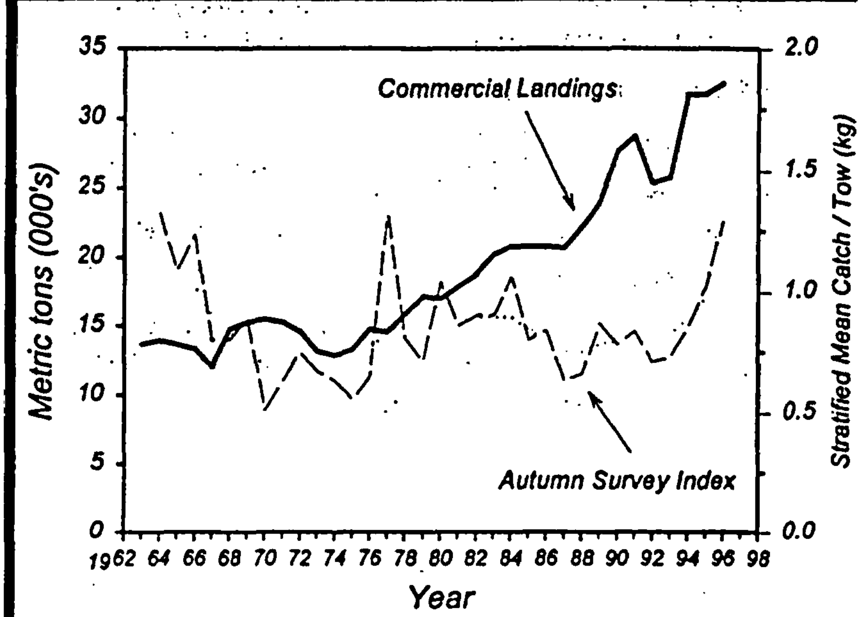


Table 29.1 Commercial and recreational landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational[1]	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States											
Offshore[2]	2.9	3.3	3.0	3.3	5.0	4.7	4.4	3.5	3.8	4.4	3.2
Inshore[3]	14.5	17.3	19.2	20.7	22.6	24.0	20.9	22.1	27.9	27.3	29.2
Canada-Georges Bank	0.2	<0.1	<0.1	<0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1
Total nominal catch	17.6	20.7	22.2	24.0	27.7	28.9	25.5	25.8	31.9	31.9	32.6

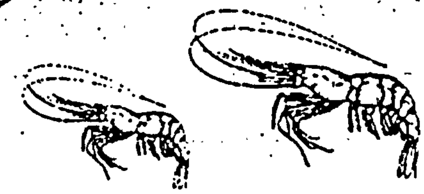
[1]Recreational catches unknown
[2]Includes trawl and offshore trap catches
[3]Inshore trap catches

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]. 1996. [Report of the] 22nd Northeast Regional Stock Assessment Workshop (22nd SAW), Stock Assessment Review Committee (SARC), consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 96-13.

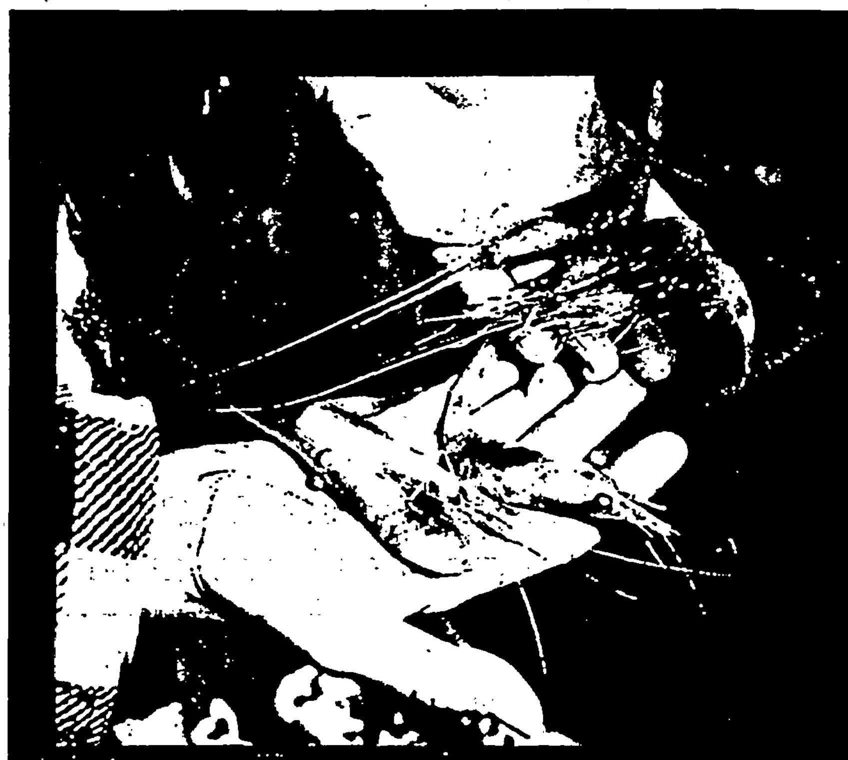
Northern Shrimp



by S.X. Cadrin

Northern or pink shrimp, *Pandalus borealis*, are distributed discontinuously throughout boreal waters of the North Atlantic, North Pacific and Arctic Oceans. In the Gulf of Maine, northern shrimp are considered to comprise a unit stock. They inhabit soft mud bottom at depths of approximately 10 to 300 m (2-165 fathoms), most commonly in the cold waters of the southwest Gulf of Maine. The Gulf of Maine is the southern limit of the species' distribution in the North Atlantic, and temperature is an important factor in ontogenetic rates and reproductive success for this stock.

Northern shrimp are protandrous hermaphrodites. In the Gulf of Maine, they generally spawn as males in their third summer; they subsequently undergo transition and become mature females in their fourth year. After spawning and egg extrusion in summer, ovigerous females move to coastal waters in late autumn, where eggs hatch in wintertime. Juveniles remain inshore for over a year and then migrate offshore as they begin to mature.



Northern shrimp

NOAA Fisheries
NEFSC Photo Archive

A directed otter trawl fishery for northern shrimp began in coastal waters of the Gulf of Maine during the winter months in the 1930s. In the 1960s, landings rose rapidly to a peak of 12,800 mt in 1969 with the expansion of an offshore, year-round fishery; and approximately 11,000 mt were landed annually from 1970-1972. After 1972, landings declined rapidly, leading to increasingly restrictive management measures and closure of the fishery in 1978. The fishery reopened in 1979 and landings increased gradually to 5,000 mt for 1987; the 1988-1994 annual average was 3,400 mt. Landings then increased to 6,800 mt in 1995 and to 9,100 mt in 1996. The latter figure has been exceeded only during the five years prior to the 1970s stock collapse. The 1997 total was 6,300 mt. Nominal fishing effort increased in the late 1960s to average 16,000 trips for the 1970-1972 fishing seasons. Effort decreased rapidly in the 1970s, but has increased considerably since the 1978 closure. The number of trips peaked at about 12,000 in 1987, decreased to 6,000 in 1994, and again increased to 12,000 trips in 1996. The fishery is managed via gear restrictions and seasonal limits (set within a 183-day "window" from December through May) under the authority of the Atlantic States Marine Fisheries Commission (ASMFC).

Stock biomass is currently monitored by the NEFSC autumn bottom trawl survey and the ASMFC summer shrimp survey. The NEFSC autumn survey biomass index declined to very low levels during the late 1970s and has since increased somewhat. However, stock biomass is now below average and fishing mortality appears to

Gulf of Maine
Northern Shrimp

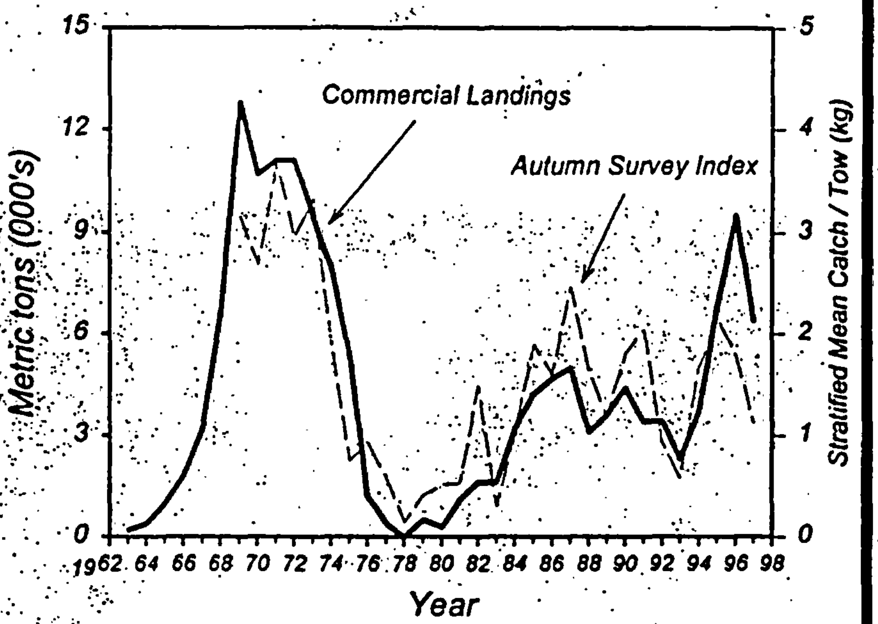


Table 30.1 Recreational catches and commercial landings (thousand metric tons)

Category	Year 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.8	5.0	3.1	3.6	4.4	3.4	3.4	2.3	3.7	6.8	9.1
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	1.8	5.0	3.1	3.6	4.4	3.4	3.4	2.3	3.7	6.8	9.1

Summary Status

Long-term potential catch	=	5,000 mt
Stock Biomass for long-term potential catch	=	31,000 mt
Importance of recreational fishery	=	Insignificant
Management	=	Interstate FMP for northern shrimp(ASMFC)
Status of exploitation	=	Overexploited
Age at 50% maturity (females)	=	3½ years
Size at 50% maturity (females)	=	26mm carapace length (1.0 in.)
Assessment level	=	Stage-structured (DeLury)
Overfishing definition	=	None
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.25$ $F_{0.1} = 0.46$ $F_{max} = 0.77$ $F_{1996} = 0.90$

"Continued high exploitation rates will increase the potential for overfishing and resultant stock collapse."

be high. Abundance of large shrimp at the end of the 1996 fishing season was the lowest since the early 1980s. Exploitation rates increased from 11-29% from 1985-1995 to 53% in 1996. Exploitation rates at or near this level were associated with stock collapse in the mid-1970s. Continued high exploitation rates will increase the potential for overfishing and resultant stock collapse.

For further information

Apollonio, S., D.K. Stevenson, and E.E. Dunton,Jr. 1986. Effects of temperature on the biology of the northern shrimp, *Pandalus borealis*, in the Gulf of Maine. *NOAA Tech. Rept. NMFS* 42.

Cadrin, S.X., D.F. Schick, D. McCarron, S.H. Clark, M.P. Armstrong, B. Smith, and J.B. O'Gorman. 1998. Gulf of Maine northern shrimp stock assessment. NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 98-07.

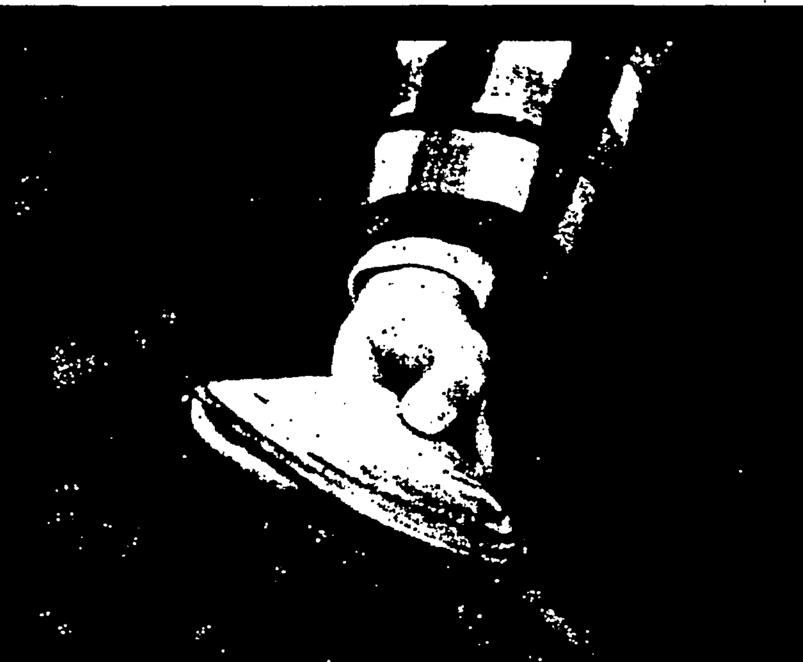
NEFSC [Northeast Fisheries Science Center]. 1997. [Report of the] 25th Northeast Regional Stock Assessment Workshop (25th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-14.

McInnes, D. 1986. Interstate fishery management plan for the northern shrimp (*Pandalus borealis* Kroyer) fishery in the western Gulf of Maine. Atlantic States Marine Fisheries Commission, Washington. *ASMFC Spec. Rept.* No. 9.

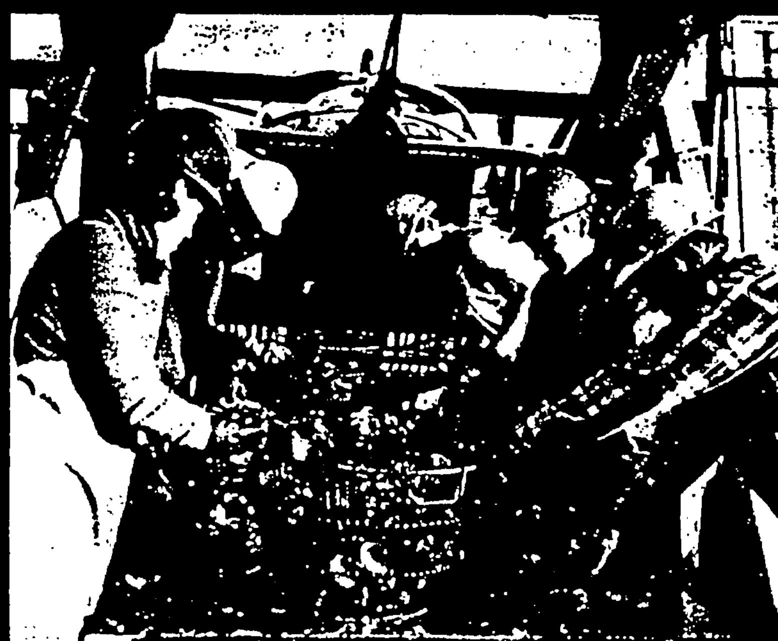
Atlantic Surfclam

by J. Weinberg

Atlantic 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 commercial quantities also 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 years. Maximum size is about 22.5 cm (8.9 in.), but clams larger than 20 cm (7.9 in.) are rare. Surfclams are capable of reproduction in their first year of life, although full maturity may not be reached until the 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.



Atlantic surfclam NOAA Fisheries NEFSC Photo Archive



Sorting surfclam and ocean quahog research survey dredge haul NOAA Fisheries NEFSC Photo Archive

The principal fishing gear for surfclam is the hydraulic clam dredge. Recreational and foreign fishing are insignificant. The Exclusive Economic Zone (EEZ) fishery is managed under the Surfclam-Ocean Quahog Fishery Management Plan (FMP) of the Mid-Atlantic Fishery Management Council, primarily by a total allowable catch (TAC) limit. In 1995 and 1996, EEZ landings totalled 19,600 mt and 19,800 mt (meats) under a TAC of 19,800 mt.

Total landings of surfclams averaged roughly 20,000 mt in the early 1960s, increased to over 40,000 mt by 1974, and then decreased by 1979 to well below the earlier average of 20,000 mt. Landings have subsequently increased, especially in the

"Resources off New Jersey and the Delmarva Peninsula appear sufficient to sustain the fishery during the next several years."

EEZ. The 1987-1996 average was 30,300 mt, of which 21,700 mt was taken in the EEZ. Landings from inshore (state) waters rose from 5,400 mt in 1987 to over 11,000 mt in 1992-1993 and have since averaged about 9,000 mt, reflecting increased landings from inshore New York and New Jersey. Total landings from EEZ and state waters were 28,700 and 28,800 mt for 1995 and 1996, respectively.

The principal management objective under Amendments 1 through 7 of the FMP was to rebuild depleted stocks. Under Amendment 8, an ITQ (individual transferable quota) system was established in 1990, whereby the annual quota was allocated among participating vessels, based on vessel size and performance history. This system is intended to address economic inefficiencies resulting from the intensive regulatory scheme used to promote rebuilding. Trading of vessel allocations is permitted, which is intended to reduce vessel overcapitalization and to result in more efficient use of harvest sector capital.

In 1990, 128 vessels participated in the Mid-Atlantic EEZ fishery. With the adoption of Amendment 8, the number of vessels in the fishery declined to 75 in 1991, and to 37 by 1995. Two management areas, New England and the Mid-Atlantic, were formerly identified, but have been combined in Amendment 8. A single annual TAC applies to both areas. Currently, the Georges Bank region remains closed to the harvesting of surfclams, due to the presence of paralytic shellfish poisoning toxins.

New England-Middle Atlantic

Atlantic Surfclam

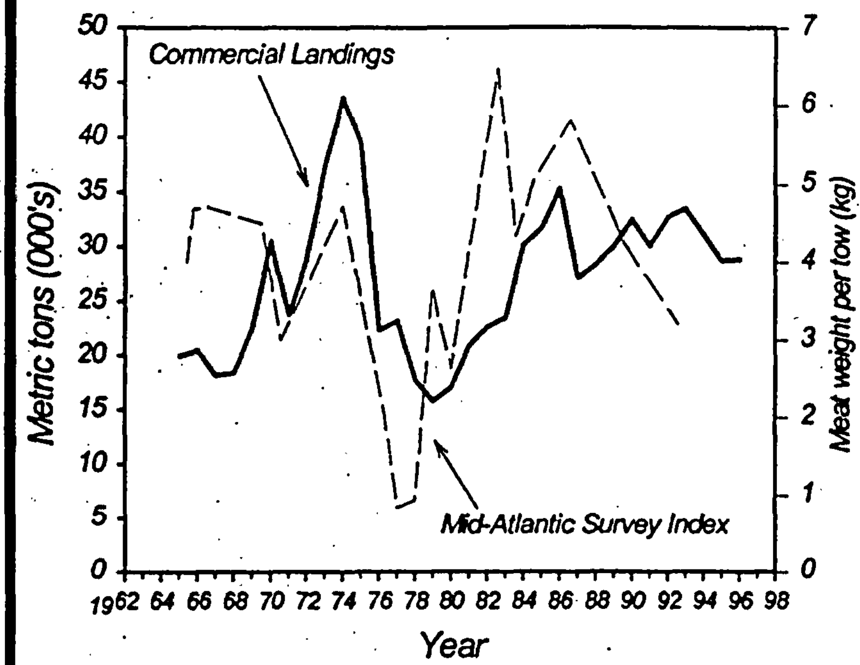


Table 31.1 Recreational catches and commercial landings (thousand metric tons, meats)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
						Year					
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States											
EEZ	19.0	21.7	23.4	21.9	24.0	20.6	21.7	21.9	21.9	19.6	19.8
State waters	5.3	5.4	4.9	8.1	8.5	9.4	11.0	11.6	9.1	9.1	9.0
Canada	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	24.3	27.1	28.3	30.0	32.5	30.0	32.7	33.5	31.1	28.7	28.8

Summary Status

Long-term potential catch	=	14,260 to 26,210 mt
SSB for Long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Surfclam and Ocean Quahog FMP
Status of exploitation	=	Fully exploited (New Jersey) Underexploited overall
Age at 50% maturity	=	1 year
Size at 50% maturity	=	<4 cm (<1.6 in.) shell length
Assessment level	=	Size structured (DeLury)
Overfishing definition	=	$F_{20\%}$
Fishing mortality rate corresponding to overfishing definition	=	$F_{20\%} = 0.18$

M = 0.02 - 0.08 $F_{0.1} = 0.07$ F_{max} = 0.19 F_{1997} = <0.05

Intensive fishing for surfclams was initiated after World War II, primarily off Long Island and northern New Jersey. Extensive offshore beds were discovered and exploited 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, and with the discovery of extensive beds off southern Virginia and North Carolina, total landings rose to an average of 40,100 mt (meats) for 1973-1975, 50 percent higher than the 1965-1977 average (27,000 mt). The southern Virginia-North Carolina fishery collapsed during 1976, and most participating vessels returned to more northern areas.

Biomass indices from research vessel surveys employing hydraulic dredge gear have loosely paralleled trends in landings. For example, 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 substantial recruitment by the 1976 year class in the area subjected to the clam kill. Growth of this year class resulted in an increasing proportion of total Mid-Atlantic landings from off northern New Jersey. Almost all of the 1976 year class is now larger than 12 cm. This was the minimum legal size until 1991. The limit was suspended for the 1991 fishing season due to the relatively low abundance of prerecruit-sized clams and the likely incentive under Amendment 8 to target beds of larger surfclams. Recruitment has taken place during the 1980s and 1990s, although no cohort has dominated the population in the manner that the 1976 cohort did.

Biomass off the Delmarva Peninsula remained 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 a decline in harvestable biomass. However, recent surveys indicate that the abundance of clams in Delmarva waters has remained relatively high. These clams have grown at substantially slower rates than those off New Jersey, due to high density and perhaps other factors.

Research vessel survey data indicate adequate surfclam resources to support the Middle Atlantic EEZ fishery at or near current levels (18,000 to 23,000 mt of meats) for the next few years. Closure of the Georges Bank fishery implies that biomass will likely accumulate there due to the low natural mortality rate of surfclams. However, information about this area is limited and current biomass levels and future prospects are uncertain.

Landings from the EEZ continue to be relatively stable due to the large standing stock relative to the annual quota. In the last several years, fishing has been concentrated off Atlantic City, New Jersey. Catch per unit effort (bushels per hour fished) for the New Jersey area has declined slowly throughout the 1990s. Resources off New Jersey and the Delmarva Peninsula appear sufficient to sustain the fishery during the next several years.

For further information

Chintala, M.M., and J.P. Grassle. 1995. Early gametogenesis and spawning in "juvenile" Atlantic surfclams, *Spisula solidissima* (Dillwyn, 1819), *J. Shellf. Res.* 14(2): 301-306.

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.

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

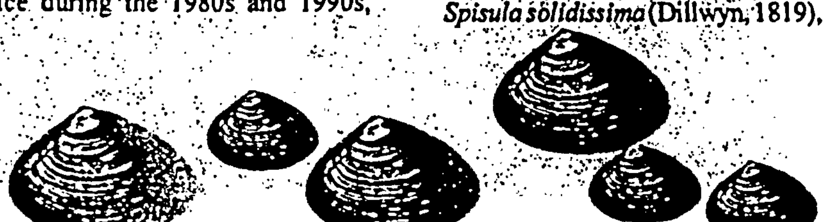
NEFSC [Northeast Fisheries Science Center]. 1995. Report of the 19th Northeast Regional Stock Assessment Workshop (19th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 95-08.

NEFSC [Northeast Fisheries Science Center]. 1996. [Report of the] 22nd Northeast Regional Stock Assessment Workshop (22nd SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 96-13.

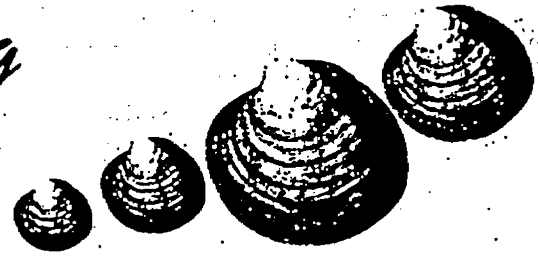
NEFSC [Northeast Fisheries Science Center]. 1998. [Report of the] 26th Northeast Regional Stock Assessment Workshop (26th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 98-03.

Weinberg, J.R., and T.E. Helser. 1996. Growth of the Atlanticsurfclam, *Spisula solidissima*, from Georges Bank to the Delmarva peninsula, USA. *Mar. Biol.* 126: 663-674.

Weinberg, J.R. 1998. Density-dependent growth in the Atlantic surfclam, *Spisula solidissima*, off the coast of the Delmarva Peninsula, USA. *Mar. Biol.* 130:621-630.



Ocean Quahog



by J. Weinberg

The ocean quahog, *Arctica islandica*, is a bivalve mollusk found in temperate and boreal waters on both sides of the North Atlantic. Distribution in the western Atlantic ranges from Newfoundland to Cape Hatteras in depths from 8 to 256 m. Quahogs are rarely found where bottom water temperatures exceed 16°, 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), composed of smaller (about 50 mm shell length) individuals, seem to have had greater recruitment in recent years. Growth rates of ocean quahog are lower in the Gulf of Maine than in Middle Atlantic areas. Results of mark-recapture, shell banding, and length frequency studies indicate that the ocean quahog has a longevity of more than 100 years, and that after age 20 growth is exceedingly slow. Spawning apparently occurs over a protracted interval from summer through autumn. Free-floating larvae develop slowly (more than 30 days until settling), and thus may drift far from their parents.

The principal gear used in the fishery is the hydraulic clam dredge, and until the early 1990s, most ocean quahogs were caught off New Jersey and the Delmarva peninsula. The fish-

Quahogs in wire basket

NOAA Fisheries
NEFSC photo by Brenda Figuerido

New England-Middle Atlantic

Ocean Quahogs

"Commercial catch rates in this region [Mid-Atlantic] have declined since 1987. . . although values have risen in 1995 and 1996"

ery has been moving north for several years and significant catches are now taken off Long Island and southern New England. Recreational and foreign fishing in the Exclusive Economic Zone (EEZ) are insignificant. The Mid-Atlantic EEZ fishery is managed under the Surf Clam-Ocean Quahog Fishery Management Plan (FMP) of the Mid-Atlantic Fishery Management Council. Provisions of Amendment 8 of the Surf Clam-Ocean Quahog FMP, approved in 1990, instituted 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 (typically 20,000 to 25,000 mt of shucked meats), vessel allocations, and reporting requirements for both processors and fishing vessels.

Ocean quahogs were first harvested commercially during World War II off Rhode Island. Total landings, however, never exceeded 2,000 mt of shucked meats until 1976 when offshore exploitation began off New Jersey and Maryland. Steady declines in offshore Mid-Atlantic surfclam stocks combined with the massive kill of surfclams off New Jersey in 1976 stimulated fishing for the deeper-dwelling ocean quahog. Total ocean quahog landings increased dramatically between 1976 and 1979, from 2,500 to 15,800 mt of meats per year.

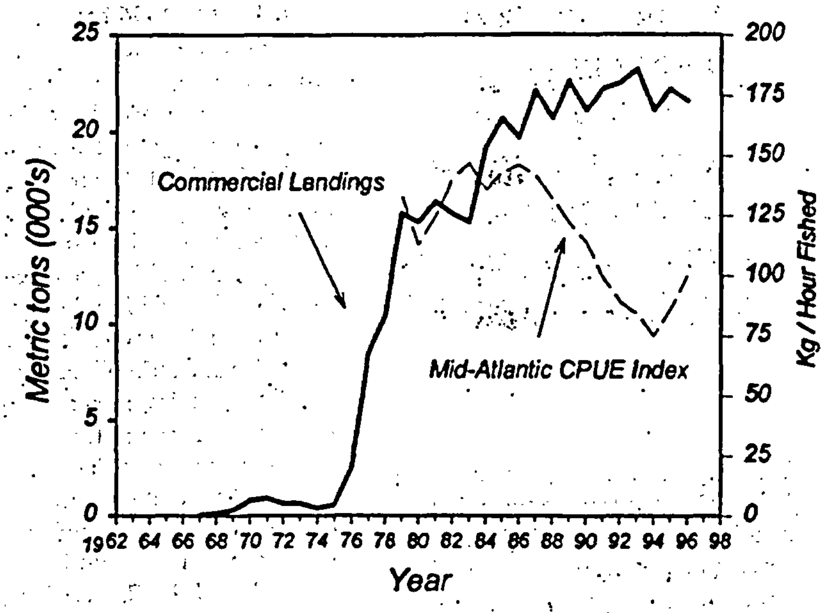


Table 32.1 Recreational catches and commercial landings (thousand metric tons, meats)

Category	Year: 1977-86[1] Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States											
EEZ	14.8	21.5	20.3	22.3	21.0	22.1	22.5	21.9	21.0	21.2	20.0
State	0.8	0.6	0.4	0.2	0.1	0.1	<0.1	1.3	0.1	1.1	1.6
Canada	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	15.7	22.1	20.7	22.6	21.1	22.2	22.5	23.2	21.1	22.2	21.6

[1] EEZ Fishery Initiated in 1976

Summary Status

Long-term potential catch	=	18,140 - 27,200 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
Age at 50% Maturity	=	8 years, males 11 years, females
Size at 50% maturity	=	55 mm (2.1 in.) shell length
Assessment level	=	DeLury depletion model
Overfishing definition	=	$F_{25\%}$
Fishing mortality rate corresponding to overfishing definition	=	$F_{25\%} = 0.04$

M = 0.01-0.03 $F_{0.1}$ = 0.023 F_{max} = 0.068 F_{1996} = <0.1

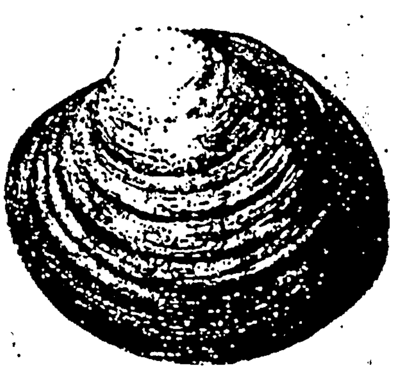
"Although annual landings are approximately only 2 percent of the total estimated stock, greater landings are probably not warranted due to extremely slow growth rates and low annual recruitment. "

Landings in 1995 (22,200 mt) and in 1996 (21,600 mt) were typical of annual landings since 1987. Most of the landings are currently derived from EEZ waters off Long Island, New Jersey, and southern New England. Quahogs are also taken in the EEZ off Maine, and inshore (state waters) off Rhode Island and Massachusetts. The Gulf of Maine fishery has been designated as an experimental one to provide information on abundance, distribution, and biological characteristics of the resource. It has not been subject to ITQ regulations for several years. 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, and juices.)

Resource surveys for ocean quahog have been conducted by the NEFSC in the Georges Bank-Cape Hatteras region since 1965. Swept-area calculations indicate a stock biomass (meat weight) of about 1.0 million mt. Sources of uncertainty in these calculations include the fraction of clams assumed to be collected by the survey dredge and the fraction of the regions sampled consisting of actual ocean quahog habitat, rather than rocks or sands. Of this total biomass, approximately 6 percent is found off Delmarva, 13 percent off New Jersey, 22 percent off Long Island, 31 percent off Southern New England, and 28 percent on Georges Bank.

Trends in fishery performance from 1979 to 1996 have been documented using catch and effort data from mandatory logbook submissions. Mid-Atlantic (New Jersey and Delmarva) landings have declined, especially after 1991. Commercial catch rates in this region have declined since 1987 (after an initial fishery development period), although values have risen in 1995 and 1996. In the absence of substantial new recruitment (as indicated from NEFSC surveys), this trend toward lower performance is likely to continue in the New Jersey and Delmarva areas. The fishery has expanded spatially as catch rates declined in heavily fished areas off Delmarva and southern New Jersey. In 1991 and 1992, the fishery expanded to the Long Island area, a region heretofore unexploited. Continued expansion of the Mid-Atlantic fishery to the north and east is anticipated. Although a substantial ocean quahog resource exists on Georges Bank, it has been subject to fishery closure since 1990 due to the presence of paralytic shellfish poisoning toxins. Fishery-wide CPUE has held steady due to relocation of the fishery over time.

Although annual landings are approximately only 2 percent of the total estimated stock, greater landings are probably not warranted due to extremely slow growth rates and low annual recruitment. Once an area is depleted, recovery time would be expected to be extremely long.



For further information

Leavitt, D.F., J. McDowell Capuzzo, and J.R. Weinberg. 1995. Shellfish resources and their management, p. 185-193. *In*: Colgan, C.S. (ed.). Sustaining coastal resources: economics and the natural sciences. Univ. of S. Maine, Portland.

Mann, R. 1985. Seasonal changes in the depth-distribution of bivalve larvae on the southern New England shelf. *J. Shellfish Res.* 5(2):57-64.

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.

NEFC [Northeast Fisheries Center]. 1990. Report of the Spring 1990 NEFC Stock Assessment Workshop (Tenth SAW). Woods Hole, MA: NOAA/NMFS/NEFC. *NEFC Ref. Doc.* 90-07.

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

NEFSC [Northeast Fisheries Science Center]. 1995. Report of the 19th Northeast Regional Stock Assessment Workshop (19th SAW), Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 95-08.

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.

Sea Scallop

by H.Lai
P. Rago

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 are normally 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 inshore waters of the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic offshore region. Recreational fishing is insignificant, occurring primarily in Maine where shallow-water scallop beds most commonly occur.

Scallops grow rapidly during the first several years of life. Between ages 3 and 5, scallops commonly increase 50 to 80% in shell height and quadruple their 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.) shell height, but scallops larger than 17 cm (6.7 in.) are rare. Sexual maturity commences at age 2, but scallops younger than age 4 probably contribute little to total egg production. Spawning occurs in late summer and early autumn; spring spawning may also occur in the Mid-Atlantic region. 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

Gulf of Maine, Georges Bank, and Middle Atlantic

Sea Scallop

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

Category	Year 1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
Gulf of Maine											
United States[1]	0.7	0.4	0.5	0.6	0.6	0.6	0.7	0.8	0.5	0.6	0.7
Canada	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total	0.7	0.4	0.5	0.7	0.6	0.6	0.7	0.8	0.5	0.6	0.7
Georges Bank											
United States[1]	5.4	4.9	6.1	5.8	10.1	9.4	8.5	3.7	1.1	1.0	2.2
Canada	6.5	6.8	4.4	4.7	5.2	5.8	6.1	6.2	5.0	2.0	3.0
Total	11.9	11.7	10.5	10.5	15.3	15.2	14.6	9.9	6.1	3.0	5.2
Mid-Atlantic											
United States	4.5	7.9	6.5	8.3	6.6	7.0	5.0	2.8	5.9	6.1	4.7
Total nominal catch	17.1	20.0	17.5	19.5	22.5	22.8	20.3	13.5	12.5	9.8	10.6

[1]Includes Southern New England

Summary Status

Long-term potential catch		
Gulf of Maine	=	300 mt (territorial waters)
Georges Bank	=	10,000 mt
Mid-Atlantic	=	3,000 mt
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	NEFMC Sea Scallop FMP
Status of exploitation	=	Overexploited
Age at 50% maturity	=	2 to 4 yrs (GB and MA)
Size at 50% maturity	=	60 mm (2.4 in.) to 90 mm (3.5 in.) shell height (GB and MA)
Assessment level	=	Size structured (DeLury)
Overfishing definition	=	5% MSP
Fishing mortality rate corresponding to overfishing definition	=	$F_{5\%} = 0.71$

$M = 0.10$ $F_{0.1} = 0.12$ $F_{max} = 0.23$ $F_{1995} = 0.41$ (Georges Bank) $= 0.85$ (Middle Atlantic)

"More than 80% of the 1996 total catch was from state territorial waters indicating continued dependence of the fishery on inshore scallop beds."

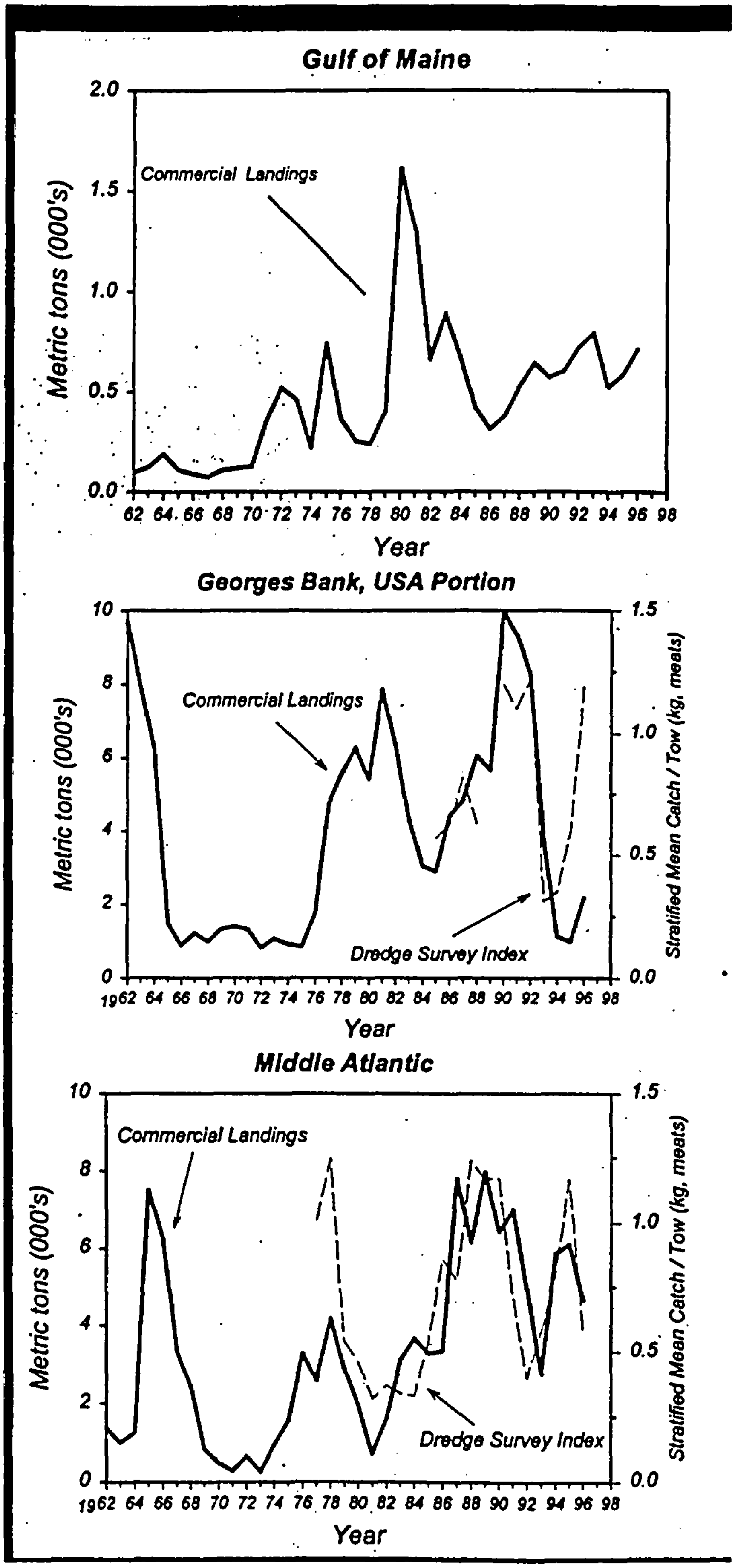
Management Council's Fishery Management Plan for Atlantic Sea Scallops (*Placopecten magellanicus*). Management measures include a moratorium on permits, days-at-sea restrictions, closed areas, and restrictions on gear and crew size. The total nominal catch (U.S. and Canada) averaged 20,400 mt (meats) from 1987-1992 but has since declined sharply; 1995 and 1996 landings were 9,800 mt and 10,600 mt, respectively.

Gulf of Maine

Since 1987, landings have been relatively constant about an average of 600 mt; the 1996 total was 700 mt (meats). More than 80% of the 1996 total catch was from state territorial waters indicating continued dependence of the fishery on inshore scallop beds.

Georges Bank

Total (U.S. and Canadian) landings from Georges Bank were 5,200 mt (meats) in 1996, well below the 1987-1992 average of 13,000 mt. Of the 1996 total, U.S. landings accounted for 42 percent (2,200 mt) while Canadian landings accounted for 58% (3,000 mt). Landings for the U.S. more than doubled over 1995 levels while Canadian landings increased by 50%. Canadian landings have been significantly higher than U.S. totals since 1993.



"Stock rebuilding is occurring in the closed areas, but elsewhere on Georges Bank, fishing mortality remains high."

Since December 1994, half of the U.S. portion of Georges Bank has been closed to scallop harvesting due to implementation of area closures to protect groundfish stocks. This appears to have contributed to an increase in sea scallop stock biomass.

NEFSC sea scallop dredge survey indices for 1996 rebounded to long-term median levels, after declining to the lowest value in the time series in 1993. In the South Channel area of the Bank, the total abundance index in 1996 decreased slightly from 1995 levels. Abundance and biomass indices for recruited sea scallops in 1996 were more than 2 times higher than in 1995 and were the third highest observed in the time series; however, numbers of pre-recruit scallops per tow decreased 50% from 1995 levels. In the Southeast Part, abundance and biomass indices for 1996 were comparable to long-term averages; and while pre-recruit indices in 1996 increased 49% over 1995, recruits decreased slightly. In the U.S. portion of the Northern Edge and Peak, abundance and biomass indices for total scallops, pre-recruits, and recruits for 1996 increased to the second highest level observed since 1975.

Because of area closures, U.S. landings for 1994 and 1995 were the lowest observed since 1977. Fishing mortality in 1995 was estimated to be 0.41 (32% exploitation rate); the lowest since 1982, and lower than the overfishing definition ($F_{5\%}$=0.71; 49% exploitation rate) provided by New England Fishery Management Council, but is still higher than F_{max} (F=0.23; 20% exploitation rate). Stock rebuilding is occurring in the closed areas, but elsewhere on Georges Bank, fishing mortality remains high.

Middle Atlantic

The total nominal catch in 1996 was 4,700 mt, 23% below the 1995 total of 6,100 mt. Abundance indices increased between 1992 and 1995, but decreased substantially from 1995 to 1996. The index in 1996 was 67% lower than in 1995 and was the second lowest since 1985. The pre-recruit abundance index in 1996 decreased 86% from the 1995 level and is the third lowest in the history of the survey. The abundance index for recruits in 1996 was less than half of the 1995 value.

A significant redirection of fishing effort from Georges Bank to the Mid-Atlantic region occurred between 1993 and 1996. This resulted from a number of factors including low abundance on Georges Bank, strong 1990 and 1991 year-classes in the Mid-Atlantic region, and large-scale area closures on Georges Bank. Consequently, effort on Mid-Atlantic sea scallops increased greatly, with virtually all small scallops being harvested once available to the gear. The removal of maximum meat count regulations has resulted in even more effort on sea scallops in the 50-70 count range. Fishing mortality in this region appears to have increased to a record high in 1994 (F= 1.27, 69% exploitation rate). Although fishing mortality decreased to 0.85 (55% exploitation rate) in 1995, it was still higher than the above overfishing definition.

Amendment 4 to the Sea Scallop FMP specifies reductions in days at sea to reduce overall harvest rates and dependence on new recruits. Amendment 4 specifies an increase of ring size from 3.25 to 3.50 in., which is designed to shift size selectivity toward large-sized scallops; and restricts the shucking capacity of vessels by limiting crew size to a maximum of seven. However, in the absence of further reductions in fishing effort in the Mid-Atlantic region, all the measures specified in Amendment 4 appear insufficient to reduce fishing mortality below F_{max}.

The rapid growth potential of sea scallops and potential implications for management have been demonstrated in the closed areas on Georges Bank. After 20 months of closure, average densities within the closed areas were about three times higher than in open areas. These results indicate that area closures are a viable option for increasing spawning stock biomass. The importance of these area closures as a source of recruitment has yet to be evaluated.

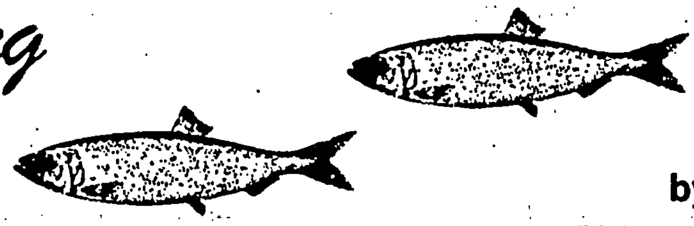
For further information

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]. 1997. [Report of the] 23rd Northeast Regional Stock Assessment Workshop (23rd SAW). Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-05.

Lai, H.L. and L. Hendrickson. 1997. Current resource conditions in Georges Bank and Mid-Atlantic sea scallop populations. Results of the 1996 NEFSC Sea Scallop Research Vessel Survey. Woods Hole, MA. NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 97-09.

River Herring



by J. Kocik

The term "river herring" is applied collectively to alewife, *Alosa pseudoharengus*, and blueback herring, *Alosa aestivalis*. The coastal range of the blueback herring is from Nova Scotia to Florida; the coastal range of the alewife extends from Labrador to South Carolina. In coastal rivers where ranges overlap, fisheries for these species are typically 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.).

River herring

NOAA Fisheries
NEFSC photo by Brenda Figuerido

Alewives spawn in spring when water temperatures are between 16°C and 19° C; blueback herring spawn later in 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; most individuals are sexually mature at age 4. River herring have supported one of the oldest documented fisheries in North America. It 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 is insignificant. The U.S. nominal catch averaged 24,800 mt annually between 1963 and 1969. Landings subsequently declined to an average of 4,000 to 5,000 mt until the mid-1980s; and more recently, to an average of about 500 mt from 1994-1996. The 1996 total (464 mt) nearly matched the record low of 423 mt in 1994. Maine, North Carolina and Virginia typically account for more than 90

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

percent of total landings from the Gulf of Maine through the Middle Atlantic. In response to the observed decline in nominal catch and apparent resource conditions, the Atlantic States Marine Fisheries Commission has prepared a comprehensive coastwide management plan for shad and river herring, to facilitate cooperative management and restoration efforts between the states. However, recovery has not been consistent. Several river herring populations along the east coast are still being exploited at higher than optimal levels and a great deal of historic spawning habitat remains 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. Atlantic States Marine Fisheries Commission, Washington, D.C. *ASMFC Spec. Rpt.* No. 19.

Harris. P.J. and R.A. Rulifson. 1989. Investigations of ocean landings for American shad and river herring from United States East Coast waters. Atlantic States Marine Fisheries Commission, Washington, D.C. *ASMFC Spec. Rept.* No. 18.

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. Martin Marietta Environmental Center, Columbia, MD.

Gulf of Maine - Middle Atlantic

River Herring

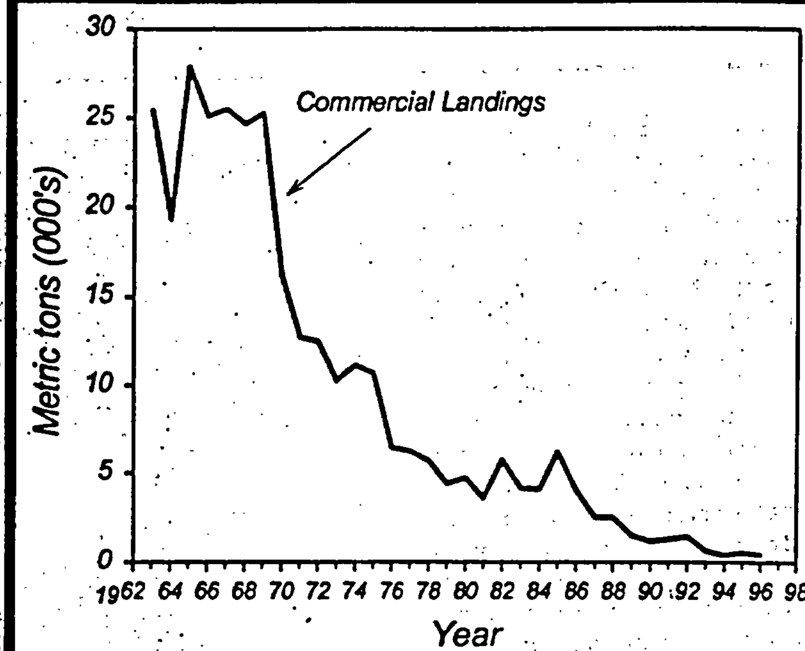


Table 34.1 Recreational catches and commercial landings (thousand metric tons)

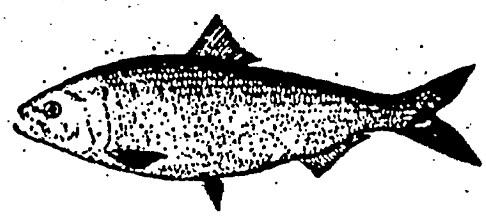
Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	4.9	2.5	2.5	1.5	1.2	1.3	1.5	0.7	0.4	0.6	0.4
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total nominal catch	5.9	2.5	2.5	1.5	1.2	1.3	1.5	0.7	0.4	0.6	0.4

Summary Status

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Minor
Management	=	Interstate FMP for Shad and River Herring
Status of exploitation	=	Varies by stock
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	=	None
Fishing mortality rate corresponding to overfishing definition	=	N/A

M = Variable $F_{0.1}$ = Variable F_{max} = Variable F_{1996} = Variable

American Shad

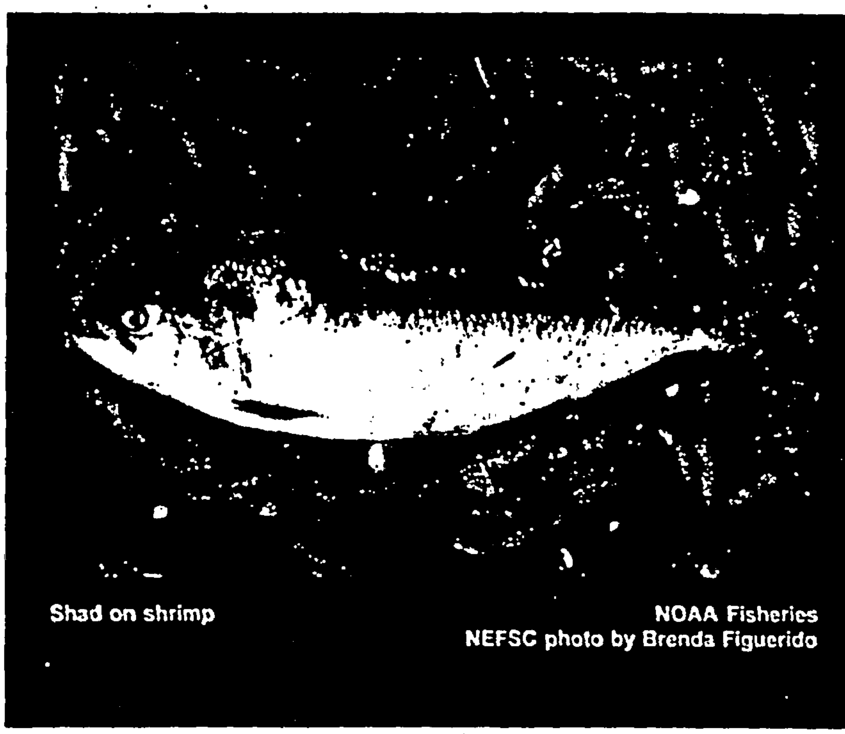


by J. Kocik

The American shad, *Alosa sapidissima*, is an anadromous species which occurs along the Atlantic coast from southern Labrador to northern Florida. It also has been introduced along the Pacific Coast. American shad undergo extensive seasonal migrations, moving into rivers for spawning beginning in January in southern rivers, and continuing until July in the northernmost portion of their range. After spawning, shad migrate north along the coast to Canada where they feed during the summer. A southward migration occurs later along the continental shelf where the fish overwinter 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 at age 4 and die after spawning. Fecundity ranges from 300,000 to 400,000 eggs. Progressing northward, increasing numbers of spawners survive, the mean age at first spawning increases to 5, and fecundity decreases to 125,000 to 250,000 eggs.

Almost every major river along the Atlantic seaboard historically supported a spawning population of American shad. They have been exploited for their flesh and roe since prior to Euro-American settlement. Atlantic coast landings exceeded 22,000 mt in 1896. In contrast, commercial landings north of Cape Hatteras, N.C. have averaged less than 1,100 mt annually since 1980. Since 1993, annual landings have exceeded 600 mt only once, in 1995. The principal gear used is the gillnet. Recreational angling is popular and catches may be significant, but no comprehensive estimates are available.



Shad on shrimp

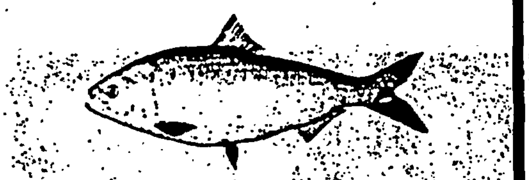
NOAA Fisheries
NEFSC photo by Brenda Figuerido

Excessive fishing has been blamed for historic declines in abundance in the Hudson and Connecticut Rivers, as well as in rivers in Maryland, North Carolina, and Florida. Throughout North America, dam construction along many larger rivers led to an almost complete disappearance of shad in many watersheds and the loss of associated fisheries. Pollution in the lower Delaware has been cited as the primary cause for the decline of the fishery in that system.

The Atlantic States Marine Fisheries Commission has implemented a coastwide management plan for American shad and river herring to facilitate cooperative management and restoration plans between states. Restoration efforts have involved habitat improvement, fish passage, stocking, and transfer programs. Despite improved returns in some major river systems such as the Susquehanna, Delaware and Connecticut Rivers, the range-wide abundance of American shad is well below historic levels.

A recent assessment characterized fishing mortality for 9 river stocks and resource trends for 13 river stocks of American shad. Total fishing mortality rates (river and coastal) were below the overfishing definition ($F_{30\%}$) for the 9 stocks that were evaluated. These results suggest that recent levels of exploitation in coastal intercept fisheries have not adversely impacted these stocks. In addition, juvenile shad production indices for 7 of these stocks suggested recruitment failure only in Maine. However, the total range of extant American shad populations includes additional populations in small river systems and small populations in

"For these stocks, individual states have developed fishing mortality targets to protect small stocks and rebuild others."



larger river systems that are actively being restored. Also, much historical shad habitat is vacant and may be targeted for restoration in the future. For these stocks, individual states have developed fishing mortality targets to protect small stocks and rebuild others. Asssessment studies have not quantitatively addressed these systems because of limited biological data. Like all mixed stock fisheries, small stocks can be at risk under conditions of uncertainty. Overall, this resource is considered to be fully exploited and at low levels of abundance.

For further information

Crecco, V.A. 1997. Stock assessment of American shad from selected Atlantic coast rivers. Atlantic States Marine Fisheries Commission, Washington, D.C. *ASMFC Spec. Rept.*

Gibson, M.R., V.A. Crecco, and D.L. Stang. 1988. Stock assessment of American shad from selected Atlantic coast rivers. Atlantic States Marine Fisheries Commission, Washington, D.C. *ASMFC Spec. Rept.* No. 15.

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. Martin Marietta Environmental Center, Columbia, MD.

Gulf of Maine-Middle Atlantic

American Shad

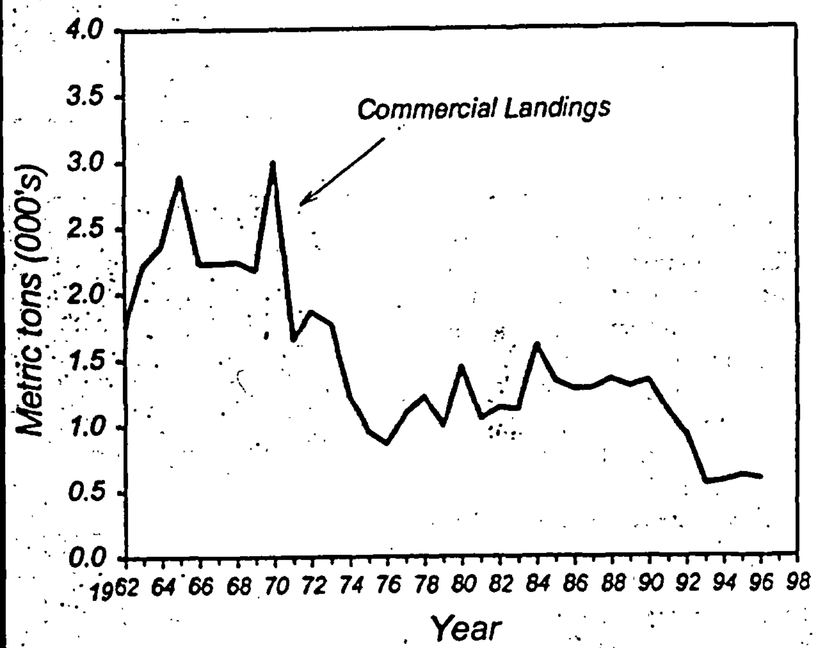


Table 35.1 Recreational catches and commercial landings (thousand metric tons)

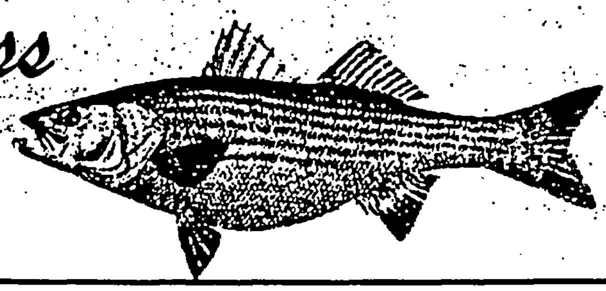
Category[1]	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	1.2	1.3	1.4	1.3	1.3	1.1	0.9	0.6	0.6	0.6	0.6
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	1.2	1.3	1.4	1.3	1.3	1.1	0.9	0.6	0.6	0.6	0.6

Summary Status

Long-term potential catch	=	Varies by stock
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Interstate FMP for Shad and River Herring
Status of exploitation	=	Varies by stock
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	=	$F_{30\%}$
Fishing mortality rate corresponding to overfishing definition	=	Varies by stock

M = varies by latitude $F_{0.1}$ = Variable F_{max} = Variable F_{1996} = Variable

Striped Bass



by G. Shepherd

The striped bass, *Morone saxatilis*, is an anadromous species distributed along the Atlantic coast from northern Florida to the St. Lawrence estuary. It has been successfully introduced in numerous inland lakes and reservoirs and to the Pacific coast, where it now occurs from Ensenada, Mexico to British Columbia. Striped bass spawn from mid-February in Florida to late June or July in Canada. 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.

Captive striped bass — NOAA Fisheries NEFSC photo by Brenda Figuerido

Most striped bass along the Atlantic coast are involved in two types of migrations: an upriver spawning migration from late winter to early spring, and coastal migrations that are apparently not associated with spawning activity. Coastal migrations may be quite extensive; striped bass tagged in Chesapeake Bay in winter and spring have been recaptured during the summer in the Bay of Fundy and fish tagged in the Hudson in spring have been recaptured off the coast of North Carolina during the winter. Coastal migratory behavior appears to be limited to stocks north of Cape Hatteras and is related to sex and age.

Atlantic coastal fisheries for striped bass rely primarily on production from populations spawning in the Hudson River and in tributaries of Chesapeake Bay. Chesapeake Bay has historically produced most of the striped bass found along the coast. However, during most of the 1970s and 1980s, juvenile production in the Chesapeake Bay was extremely poor, causing a severe decline in commercial and recreational landings during the mid-1970s. Poor recruitment for Chesapeake Bay was probably due primarily to overfishing; but poor water quality in spawning and nursery habitats likely also contributed. During the mid-1980s, stringent management measures were adopted by states from North Carolina to Maine in an attempt to rebuild the Chesapeake stocks. These measures, aimed at protecting 1982 and subsequent year classes until females could spawn at least once, were effective in increasing spawning stock size and recruitment. Signs of improved recruitment in Chesapeake Bay have appeared as well. Since 1987, indices of juvenile production in Virginia's Chesapeake Bay tributaries have been at or near record high levels in all but one year. High juvenile production in Maryland has begun to occur at regular frequencies as seen during the 1960s and early 1970s. Maryland's 1989 index was the fourth highest on record, and exceeded management criteria for relaxing fishery regulations in 1990. The 1993 and 1996 indices were the two highest on record with good production throughout the Chesapeake Bay estuary. As recruitment has improved, stock biomass has increased substantially and is expected to increase further over the short term under current levels of exploitation.

In recent years, recreational landings of striped bass have substantially exceeded commercial landings. In 1996, the estimated recreational harvest (6,700 mt) was over 3 times the commercial landings level. During

"As recruitment has improved, stock biomass has increased substantially and is expected to increase further over the short term..."

1996, an estimated 14.0 million striped bass were caught by recreational anglers; over 90 percent of these were released alive.

In 1995, Atlantic striped bass were formally declared to be a restored stock, and commercial and recreational management restrictions were relaxed somewhat. The stock has been managed at a target fishing mortality of 0.31 (25% exploitation rate), with overfishing defined as F_{msy} = 0.38 (29% exploitation rate). Fishing mortality in 1996, as determined from aged based analyses and tagging data, was estimated as 0.30 (24% exploitation rate).

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. 1996. Striped bass research study. Report for 1994. U.S. Department of the Interior, U.S. Department of Commerce, Washington, D.C.

NEFSC [Northeast Fisheries Science Center]. 1998. [Report of the] 26th Northeast Regional Stock Assessment Workshop (26th SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 98-03.

Gulf of Maine - Middle Atlantic

Striped Bass

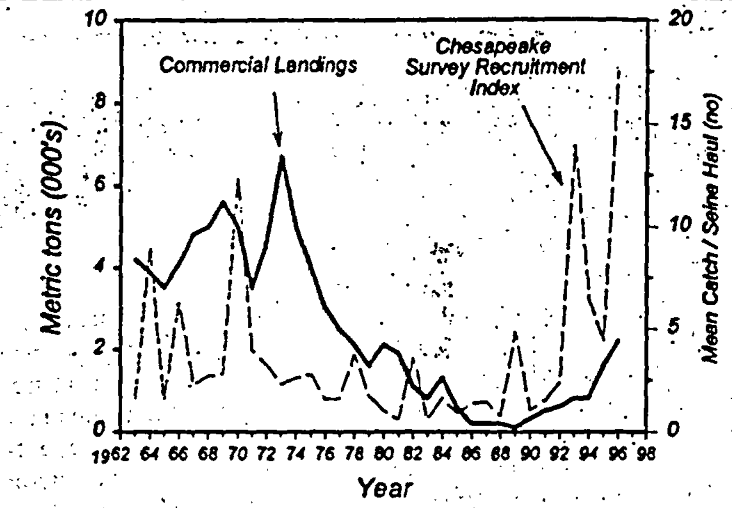


Table 36.1 Recreational harvest and commercial landings (thousand metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	1.2[1]	0.4	0.6	0.3	1.2	1.6	2.2	2.7	3.3	5.5	6.7
Commercial											
United States	1.2	0.1	0.1	0.1	0.3	0.5	0.6	0.8	0.8	1.6	2.2
Canada	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	2.4	0.5	0.7	0.4	1.5	2.1	2.8	3.5	4.1	7.1	8.9

[1] 1979-1986

Summary Status

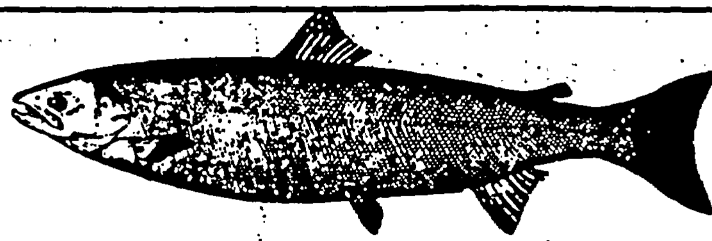
Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Interstate FMP for Striped Bass
Status of exploitation	=	Fully exploited[1]
Age at 50% maturity	=	2 years, males 6 years, females
Size at 50% maturity	=	29.7 cm (11.7 in.) males 71.1 cm (28.0 in.) females
Assessment level	=	Age structured
Overfishing definition	=	F_{msy}
Fishing mortality rate corresponding to overfishing definition	=	F_{msy} = 0.38

M = 0.15 $F_{0.1}$ = unknown F_{max} = unknown F_{1996} = 0.30

[1] Fishing prohibited in EEZ

Atlantic Salmon

by K. Friedland
J. Kocik



The Atlantic salmon, *Salmo salar*, is a highly prized food and game fish 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 now persist only in eastern Maine. Restoration and rehabilitation efforts, in the form of stocking and fish passage construction, are underway in the Connecticut, Pawcatuck, Merrimack, Penobscot, and eastern Maine 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 freshwater during fall. Eggs remain in gravel substrates and hatch during winter, and fry emerge in spring. Juvenile salmon, commonly called parr, remain in freshwater two to three years in New England rivers depending on growth. When parr grow to sufficient size (>16 cm or 6.4 in.) they develop into smolts and migrate to the ocean. Tagging data for New England stocks indicate that 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 to spawn. Those remaining at sea feed in the coastal waters of Canada, mostly Newfoundland and Labrador, and West Greenland. Historically, it has been in these foraging areas that commercial gillnet fisheries for salmon occurred. After their second winter at sea, most U.S. salmon return home to spawn. Three sea-winter and repeat-spawning salmon life history patterns also occur in New England populations.

The last two decades mark a period of decline in stock status for all Atlantic salmon populations of the North Atlantic. Both indices and complete measures of population abundance indicate that marine survival plummeted as much as fivefold for some stocks during these years. This has intensified concern over the additive effects of overfishing in both home-water and mixed stock fisheries on the high seas and habitat issues that persist in U.S. rivers.

Homewater fisheries are limited to an angling fishery in Maine on sea-run fish and a fishery on surplus broodstock in the upper Merrimack River. Angler catches in Maine have averaged approximately 486 salmon in recent years. Declines in runs has led to a no retention policy statewide, thus landings have been zero. The Merrimack River broodstock fishery began in 1993 and has resulted in an annual catch of approximately 1,000 salmon. The popularity of the fishery is reflected in increased license sales each successive year of the fishery. Management authority for Atlantic salmon in U.S. waters resides with the states and the New England Fishery Management Council.

The commercial fisheries in Canada and Greenland are managed under the auspices of the North Atlantic Salmon Conservation Organization (NASCO), of which the United States is a member. These fisheries have been evaluated by extensive tagging experiments with U.S. stocks. Harvest estimates based on Carlin tag returns have indicated exploitation rates of approximately 60% and 80%, for the U.S. 1-seawinter and 2-seawinter stock components, respectively. These results indicated that the stocks were overexploited.

The Greenland fishery is managed by a quota system that has been in place since 1976. Responding to concerns over stock status, a multi-year quota system was agreed to during 1993 negotiations within NASCO that provided a framework for quota setting based on a forecast model of salmon abundance. Subsequent to the NASCO quota agreement, a private initiative was successful in purchasing the 1993 and 1994 quotas with the exception of a small fishery for local use. In 1997, the agreement was modified to allow for a local use fishery and to provide for data collection even when stock abundance is below recommended conservation levels. Concerns persist that local harvests may take a significant fraction of the stock when at low abundance.

The Canadian fishery has been managed by time-area closures and quotas. Responding to concerns over

"Homewater fisheries are limited to an angling fishery in Maine on sea-run fish and a fishery on surplus broodstock in the upper Merrimack River."

the status of salmon stocks in North America, the fishery around Newfoundland, which was the largest component of the commercial fishery, was closed under moratorium by the Canadian government in 1992. Along with the moratorium, a fishing license buy-back program was also initiated. The remaining commercial fishery in Labrador has been reduced by an amount consistent with the reduction in licensed effort in that part of the province.

Responding to a petition request to list Atlantic salmon as endangered under the Endangered Species Act, the National Marine Fisheries Service and U.S. Fish and Wildlife Service conducted a status review of salmon populations in New England and developed a proposed rule to list several stocks in eastern Maine as threatened under the Act. Subsequently, the State of Maine developed a conservation plan to meet the goals of the proposed rule. The services have withdrawn the proposed rule and are working with the state to implement the conservation plan in lieu of a listing action.

For further information

Mills, D. 1989. Ecology and Management of Atlantic Salmon. New York: Chapman and Hall.

ICES NASWG. 1997. Report of the ICES North Atlantic Salmon Working Group. *ICES C.M.* 1996/Assess:10.

Atlantic Salmon

Penobscot River Stock

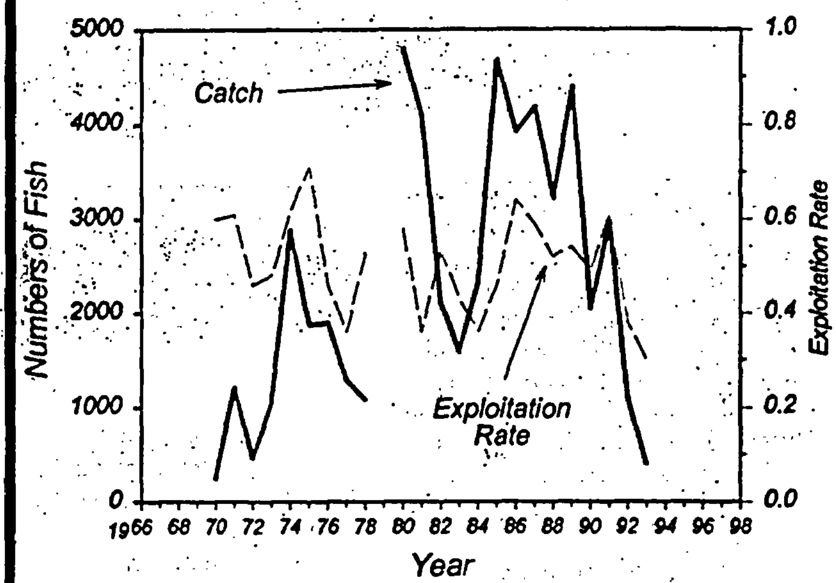


Table 37.1 Recreational catches and commercial landings (numbers, sea-run populations only)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	845	424	400	1007	1414	477	600	659	262	370	542
Commercial[1]											
United States	0	0	0	0	0	0	0	0	0	0	0
Canada	3339	1212	590	1722	780	1425	275	129	-	-	-
Greenland	2755	4175	3757	3797	1525	1871	1067	327	-	-	
Total nominal catch	4184	4391	5165	6486	5991	3427	2746	1855	589	370	542

[1]Carlin tag harvest estimates for Maine stocks

Summary Status

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Major
Management	=	Atlantic Salmon FMP NASCO Treaty
Status of exploitation	=	Protected
Age at 50% maturity	=	2 sea years
Size at 50% maturity	=	71.0 cm (28.0 in.)
Assessment level	=	Age structured
Overfishing definition	=	None defined, optimum yield is set at zero under FMP
Fishing mortality rate corresponding to overfishing definition	=	N/A

M = 0.12 $F_{0.1}$ = Unknown F_{max} = Unknown F_{1996} = 0.3

Atlantic and Shortnose Sturgeons

by K. Friedland

The Atlantic, *Acipenser oxyrhynchus*, and shortnose, *Acipenser brevirostrum*, sturgeons have been utilized as a high-quality food fish and as a source of caviar since colonial days. Both species are distributed as far south as Florida, but the Atlantic sturgeon is found as far north as Labrador, Canada whereas the shortnose sturgeon ranges only to New Brunswick, Canada.

Sturgeon once supported a substantial commercial fishery, but like other anadromous species, their populations were adversely affected by industrial use of rivers beginning in the 1800s and by overfishing. Their decline has left only remnant populations of both species and has resulted in the enactment of state management measures to protect the Atlantic sturgeon and an endangered species listing of the shortnose sturgeon under the federal Endangered Species Act (ESA). Today, the lack of fish passage facilities at dams and poor habitat conditions continue to stand as impediments to the re-establishment of many sturgeon populations.

The basic life history patterns for the two species are very similar, but there are important differences in distribution and migration that serve to minimize habitat overlap. Juveniles and adults of both species are benthic (or bottom) feeders, consuming a variety of crustaceans, bivalves, and worms. Sturgeons are relatively slow growing fish. As adults, shortnose sturgeon reach body lengths of approximately 100 cm (40 in.) whereas Atlantic sturgeon can attain more than twice that length. Both species begin spawning migrations to freshwater during late winter to early summer. The migrations occur later in the year at higher latitudes, and where the species co-occur, the shortnose sturgeon tends to begin its spawning migrations earlier than the Atlantic sturgeon. Both species are long lived (>15-20 years), mature late in life and are highly fecund, with their total egg

Shortnose Sturgeon

Summary Status

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

$M = 0.12$ $F_{0.1}$ = Unknown F_{max} = Unknown F_{1996} = Unknown

Atlantic Sturgeon

Summary Status

Long-term potential catch	=	Unknown
SSB for long-term potential catch	=	Unknown
Importance of recreational fishery	=	Insignificant
Management	=	Interstate FMP for Atlantic Sturgeon
Status of exploitation	=	Overexploited
Age at 50% maturity	=	20 to 25 years
Size at 50% maturity	=	200.0 cm (79.0 in.)
Assessment level	=	Index
Overfishing definition	=	None
Fishing mortality rate corresponding to overfishing definition	=	N/A

$M = 0.12$ $F_{0.1}$ = Unknown F_{max} = Unknown F_{1996} = Unknown production increasing proportionally to body size. Juvenile sturgeon remain in freshwater for their first summer of life and then migrate to deeper, more brackish water in winter. The juveniles migrate to and from freshwater for a number of years before entering the marine environment and joining the adult migration pattern. Migrations out of freshwater are well known for the Atlantic sturgeon, but have only been recently documented for the rarer shortnose sturgeon. Tagging studies have demonstrated that Atlantic sturgeon can migrate extensively along the coast both north and south of their natal river systems.

A large commercial fishery for sturgeon once existed, but in recent years the fishery has been limited and directed specifically at Atlantic sturgeon. Around the turn of the century, landings of sturgeon, believed to be a mix of the two species, were in excess of 3,000 mt (7 million lb) a year. As these populations became overexploited, catches declined dramatically, and only incidental landings were reported during the period 1900 to 1950. Some fishing activity began during the 1960s in the Carolinas, which sustained annual landings of perhaps 100 tons through the 1980s. These fisheries are now closed. Increases in landings in the early 1990s were due to increased catches in ocean fisheries off New York and New Jersey. Landings have since declined precipitously to only 3 mt in 1996. There is no significant sport fishery for sturgeon.

The Atlantic sturgeon is managed under an Atlantic States Marine Fisheries Commission (ASMFC) plan in coordination with state regulations. The ASMFC plan seeks to restore the commercial fishery to levels of 10 percent of 1890 landings (700,000 lb), while at the same time protecting stressed populations of Atlantic sturgeon. The plan proposes a minimum size limit (7 ft.) or other equally effective conservation measures as deemed appropriate. The plan also provides for a research program to evaluate stock status of Atlantic sturgeon. Atlantic sturgeon populations have declined to precariously low levels

Atlantic Coast Sturgeons

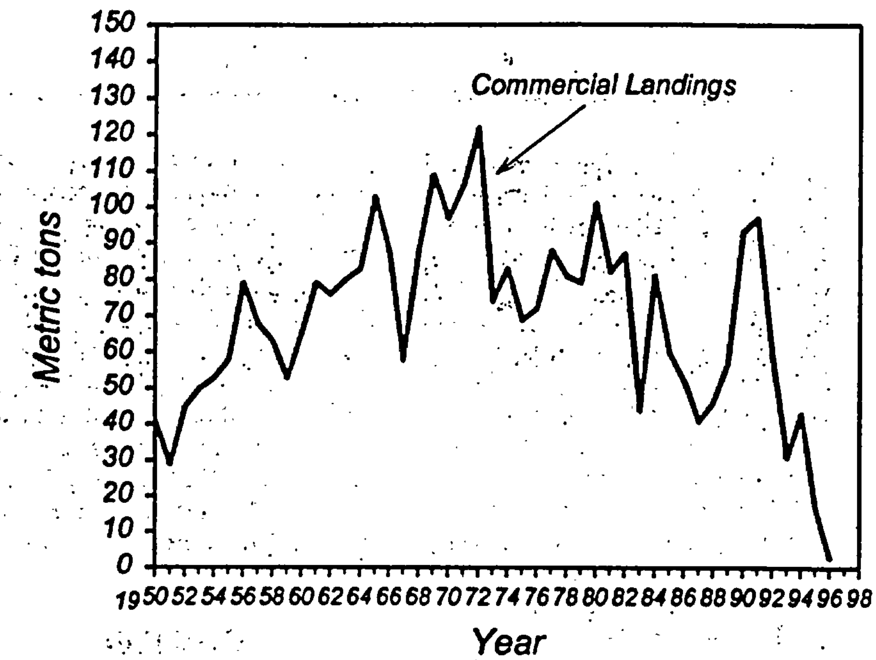


Table 38.1 Recreational catches and commercial landings (metric tons)

Category	1977-86 Average	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
U.S. recreational	-	-	-	-	-	-	-	-	-	-	-
Commercial											
United States	75	41	46	57	93	97	59	31	43	17	3
Canada	-	-	-	-	-	-	-	-	-	-	-
Total nominal catch	75	41	46	57	93	97	59	31	43	17	3

prompting a call for a voluntary fishing moratorium and consideration of a plan amendment. The National Marine Fisheries Service and U.S. Fish and Wildlife Service have received a petition to list Atlantic sturgeon as endangered; a decision is pending.

Shortnose sturgeon management is guided by a recovery plan under the Endangered Species Act. The recovery plan is being revised to reflect the increased knowledge accumulated on shortnose sturgeon populations and ecology in recent years. The endangered status of some shortnose sturgeon populations has been reviewed; a number of populations may be large enough to allow reclassification of their 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. Wildl. Serv., Biol. Rept.* 82(11.122); *U.S. Army Corps of Engineers TR EL*-82-4.

Harbor Porpoise

Debra L. Palka

The harbor porpoise (*Phocoena phocoena*) is one of the smallest cetaceans, reaching lengths of about 150 cm (5 feet) and weights of about 64 kg (140 pounds). Mean age at sexual maturity in females is 3.4 years, and they most often bear a calf every year. Harbor porpoise births generally occur in May after 11 months of pregnancy, while ovulation and conception follow in late June and early July. This is one of the shortest-lived of all cetaceans, with a maximum longevity of 17 years, but over 90% of animals examined are younger than 10.

Harbor porpoises are found in the northwestern Atlantic from North Carolina to Labrador. It has been suggested that there are four populations in the western North Atlantic Ocean; these being the western Greenland, Newfoundland-Labrador, Gulf of St. Lawrence, and Gulf of Maine/Bay of Fundy populations. These populations are currently thought to be reasonably discrete, as shown by studies of mitochondrial DNA, reproductive schedules, contaminants and radio tagging.

To determine abundance and seasonal distribution of harbor porpoise, the NEFSC has conducted aerial surveys in all seasons and shipboard line transect surveys during spring and summer. Large numbers of harbor porpoises are found in the Gulf of Maine - lower Bay of Fundy region in the summer months, but nearly none are found there during winter. The overall winter distribution is unknown, although during January to May, harbor porpoises strand on beaches from New Jersey to North Carolina and are caught as by-catch in the Mid-Atlantic coastal gillnet fisheries. There is little information concerning the distribution of harbor porpoises in non-summer months in Canadian waters.

Estimates of harbor porpoise abundance are available for the Gulf of Maine and Bay of Fundy region. Based on NEFSC line transect surveys during the months of July and August in 1991, 1992 and 1995, the inverse-weighted pooled estimate from these three surveys is 54,300 (CV=0.14, 95% CI 41,300 to 71,400) animals. The next abundance survey is scheduled for the summer of 1999.

By-Catch

Estimation of total mortality caused by commercial fisheries on the Gulf of Maine/Bay of Fundy harbor porpoise population has been a difficult task. The largest measured incidental catches have been taken by groundfish sink gillnet fisheries where harbor porpoises become entangled, presumably as they forage near the net. The NEFSC Sea Sampling Program has collected data on fishing activity and marine mammal interactions in the Gulf of Maine region since June 1989 and in the Mid-Atlantic (New Jersey to North Carolina) region since summer of 1994. The current level of observer coverage is approximately 4-7% of the total estimated U.S. fishing effort. In the Gulf of Maine, harbor porpoise takes have been observed throughout the year, but in the Mid-Atlantic takes have been observed only during January to May. Observed incidental catch rates have been applied to various measures of total fishing effort to estimate total incidental mortality. Estimation has been complicated by a number of factors including the seasonal migration of harbor porpoises, seasonal changes in patterns of fishing effort, and potential sources of bias in data collection. During an international workshop held in Woods Hole, MA during February 1994, estimates made before 1993 were found to be biased downward, in some cases due to under-reporting during unobserved hauls. A new method of estimating by-catch was subsequently developed and accepted by peer review. Estimates of by-catch for 1990 to 1996 for the U.S. Gulf of Maine and Mid-Atlantic sink gillnet fisheries based on application of this method are shown in Table 1.

A Canadian observer program in the lower Bay of Fundy has provided by-catch estimates for the Canadian sink gillnet fishery of 424 for 1993, 101 for 1994, and 87 for 1995. This fishery operates from June to September.

Biological Significance of the By-Catch

In 1994 the U.S. adopted a procedure to be used to assess the significance of human-related mortalities on marine mammal populations. This procedure involves calculating Potential Biological Removal (PBR) which is compared to the estimated mortality. The PBR is the product of a minimum abundance estimate, half of the maximum net productivity rate, and a recovery factor. The PBR for the Gulf of Maine/Bay of Fundy harbor porpoise population is 483. The average annual human-related mortality estimate is 1,667 (CV=0.09). Because mortalities exceed PBR, the population is classified as a strategic stock. Consequentially, two Take Reduction Teams were convened and each developed plans to reduce the fishery-related mortalities to PBR. One team met to develop a plan for the sink gillnet fishery in the Gulf of Maine and the other for the gillnet fishery in the Mid-Atlantic. The plans were based on area closures during critical time periods, use of acoustic alarms on the gillnets, and gear modifications.

For further information

Anonymous. 1992. Harbor porpoise in eastern North America: status and research needs. NOAA/NMFS/ NEFSC. *NEFSC Ref. Doc. 92-06.*

Bisack, K. 1997. Harbor porpoise bycatch estimates in the New England multispecies sink gillnet fishery: 1994 and 1995. *Rept. int. Whal. Commn.* 47:705-714.

Bravington, M.V. and K.D. Bisack. 1996. Estimates of harbor porpoise by-catch in the Gulf of Maine sink gillnet fishery. 1990-1993. *Rept. int. Whal. Commn.* 46:567-574.

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

Haley, N.J. and A.J. Read. 1993. Summary of the workshop on harbor porpoise mortalities and human interaction. *NOAA Tech. Memo.* NMFS-F/NER-5.

Palka, D.L., Read, A.J., Westgate, A.J. and Johnston, D.W. 1996. Summary of current knowledge of harbour porpoises in US and Canadian Atlantic waters. *Rept. int. Whal. Commn.* 46:559-565.

Palka, D. 1995. Abundance estimate of Gulf of Maine harbor porpoise, p. 27-50. *In*: A. Bjorge and G.P. Donovan (eds.) *Biology of the Phocoenids. Rept. int. Whal. Commn. Spec. Issue* 16.

Palka, D. (Ed.). 1994. Results of a scientific workshop to evaluate the status of harbor porpoises (*Phocoena phocoena*) in the western North Atlantic. Woods Hole, MA: NOAA/NMFS/NEFSC. *NEFSC Ref. Doc.* 94-09.

Polacheck, T., F.W. Wenzel, and G. Early. 1995. What do stranding data say about harbor porpoise (*Phocoena phocoena*)? p. 169-180. *In*: A. Bjorge and G.P. Donovan (eds.) *Biology of the Phocoenids. Rept. int. Whal. Commn. Special Issue* 16.

Read, A.J. 1994. Interactions between cetaceans and gillnet and trap fisheries in the northwest Atlantic. *Rept. int. Whal. Commn. Special Issue* 15: 133-147.

Read, A.J., and A.A. Hohn. 1995. Life in the fast lane: The life history of harbour porpoises from the Gulf of Maine. *Mar. Mamm. Sci.* 11(4):423-440.

Trippel, E.A., Wang, J.Y., Strong, M.B., Carter, L.S., and Conway, J.D. 1996. Incidental mortality of harbour porpoise (*Phocoena phocoena*) by the gillnet fishery in the lower Bay of Fundy. *Can. J. Fish. Aquat. Sci.* 53: 1294-1300.

Waring, G.T., D.L. Palka, K.D. Mullin, J.H.W. Hain, L.J. Hansen, and K.D. Bisack. 1997. U.S. Atlantic and Gulf of Mexico stock assessments - 1996. *NOAA Tech. Memo.* NMFS-NE-114.

Harbor Porpoise

Harbor porpoise dorsal fin — NOAA Fisheries NEFSC Photo Archive

Table 1. Revised U.S. harbor porpoise by-catch estimates, with measures of uncertainty; numbers have been rounded to the nearest hundred

Year	Gulf of Maine		Mid-Atlantic	
	Estimate	%CV	Estimate	%CV
1990	2900	32	-	-
1991	2000	35	-	-
1992	1200	21	-	-
1993	1400	18	-	-
1994	2100	18	-	-
1995	1400	27	103	57
1996	1200	25	311	31

Common Name Index

Scientific Name Index

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