

Status of the  
Georges Bank and Gulf of Maine Cod Stocks  
February 1979

by

F. M. Serchuk, P. W. Wood, R. Lewis, J. A. Penttila, and B. E. Brown

National Oceanic and Atmospheric Administration  
National Marine Fisheries Service  
Northeast Fisheries Center  
Woods Hole Laboratory  
Woods Hole, Massachusetts 02543

Laboratory Reference No. 79-10  
February 1979

## 1. Introduction

This report provides current assessment information on the Georges Bank and Gulf of Maine Atlantic cod stocks. It updates landings statistics and research survey data through 1978 and presents the results of the 1978 spring and autumn bottom trawl research vessel surveys. Background information for both stocks was previously summarized in Serchuk et al. 1977, 1978, and 1978b, and NEFC 1978.

## 2. Results and Discussion

### 2.1 Georges Bank Stock

#### 2.11 Landings Statistics

Provisional commercial landings in 1978 for Georges Bank were 35,000 metric tons (mt) (Table 1). USA landings totalled 26,286 mt, a 29% increase from the 1977 catch of 20,355 mt, and the highest domestic catch since 1937. Estimated 1978 Canadian commercial catches were 8,750 mt, an increase of 2,680 mt from 1977, and the highest since 1968.

USA reported commercial landings for 1977 and 1978 are believed to underestimate the catch due to wide-spread high discarding and the possibility of unreported landings. The Georges Bank fishery was closed twice in 1977 and four times in 1978 (Table 2), and has been regulated under a number of temporal (quarterly, weekly, daily, and per-trip) and vessel class catch limitations. The degree of inaccuracy in the landings statistics is, however, presently unknown.

Recreational landings of cod from the Georges Bank stock in 1977 and 1978 are not known. Estimated catches were not derived due to the uncertainty of the domestic catches in these years. These latter values are requisite for the recreational harvest estimation procedure detailed in Serchuk et al. 1977.

#### 2.12 Commercial Catch Composition

Distribution of the reported 1978 USA commercial Georges Bank landings, by market category, indicated that "market cod" (2.5-10.0 lbs; 1.1-4.5 kg) comprised 61% of the domestic catch by weight (Table 3). This is an increase of 20% in this category from 1977 and reflects the dominance of the 1975 year-class in the fishery and the growth in weight of this cohort into "market" category size. The 1978 market category landings distribution is similar to those of 1969 and 1974, when the strong 1966 and 1971 year-classes, respectively, were evident as "market-sized" fish. Previous yearly trends in market category catch composition and Georges Bank cod growth rate data suggest that the 1975 year-class will in 1979 again contribute substantially to "market" landings and afterward will appear in the "large" category.

The percentage of "scrod" landings in the Georges Bank cod catch declined sharply from 34% in 1977 to 11% in 1978. This decline is a result of the 1975 year-class growing into the larger "market" category from "scrod" during this period, and recruitment of the relatively weaker 1976 year-class into the fishery.

## 2.13 Research Vessel Bottom Trawl Survey Indices

### 2.131 Total Stratified Mean Catch Per Tow

Mean catch per tow indices (both numbers and weight) from the autumn 1978 bottom trawl survey on Georges Bank were among the highest in the autumn survey series. Mean number per tow (6.97) was 58% larger than the 4.42 in 1977. Mean weight (lbs) per tow in 1978 was 47.3, 86% larger than the 1977 index of 25.4 (Table 4). There were similar differences between the spring 1977 and 1978 survey number and weight indices. Sampling intensity in autumn 1978 was about 50% greater than in 1977 while the spring surveys had approximately equal sampling intensities (Table 5).

The trend in autumn weight per tow indices since 1974 reflects a steady increase in biomass, with the 1978 index being the highest observed. Spring survey weight per tow indices have not shown a consistent pattern as the autumn indices, although these values are more difficult to interpret as a series due to the change in sampling gear after 1972 (from 36 Yankee to 41 Yankee trawl), and the tendency for South Channel cod to migrate to Southern New England and south and west of Nantucket Shoals in late fall - early winter (Wise 1962). Nevertheless, the 1978 spring weight index is one of the highest observed.

### 2.132 Stratified Mean Number Per Tow By Age Group

Stratified mean catch per tow values in numbers at age for Georges Bank are given in Tables 6 and 7. These values were derived by applying the appropriate individual survey age-length key to each respective survey length-frequency distribution. Prior to 1970, autumn and spring cruise age-length data are not available. The 1978 spring survey age samples are currently being analyzed, and hence age composition data for this cruise could not be included in Table 7.

Autumn survey catch at age indices presented in Table 6 will differ from those listed previously (Serchuk et al. 1978, Table 5) since these latter values were derived by applying a pooled age-length key (the only data available at that time) obtained from the 1970-1974 surveys to the length frequencies from each survey.

The 1978 autumn catch per tow index of age 3 cod (1975 year-class) indicated that this group of fish comprised 49% of the Georges Bank population by number (3.396/6.970) (Table 6). Such dominance by a single year-class at age 3 has only been previously been noted (since 1960) by the 1966 and 1971 year-classes (1971 year-class in 1974 comprised 44% of the total survey number per tow index). The 1978 autumn age 3 index further implies that the 1975 year-class has not been reduced in size as quickly as were the strong 1966 and 1971 year-classes; the difference in the catch per tow indices

for the 1975 year class between ages 1 and 3 was only 14%. Although the higher numbers of the 1978 age group indices may reflect the variability of survey data since catches of several year classes increased over 1977, even if the 1978 autumn age 3 index were halved (1.698), this would only represent a 57% decrease from the 1976 age 1 index for this year class. This reduction would still be much less than the corresponding decrease of 80% noted for the 1971 year-class between ages 1 and 3.

The catch per tow of age 0 cod (1978 year-class) in the autumn 1978 survey (.308) was the highest for this age group since the 1975 survey, suggesting that the 1978 year-class may be better than average. This evaluation, however, must be considered tentative since there is a low correlation between age 0 autumn survey indices and virtual population analysis year-class sizes at age 2 ( $r^2=.33$ ,  $r=.57$ ).

The catch per tow of age 1 cod (1977 year-class) in the autumn 1978 survey (1.531) is slightly above the median age-1 survey index from 1970-1978. On this basis, the 1977 year-class might be considered at least average in strength. This estimate of relative year-class strength is consequently more optimistic than that deduced from the 1977 autumn age 0 index for the 1977 year-class. The correlation between survey abundance indices at age 1 and VPA year-class sizes at age 2 is  $r=.78$  (see Serchuk et al. 1978, Figure 3).

## 2.14 Yield Per Recruit

Yield per recruit analyses for different rates of fishing mortality and different ages of first capture ( $t_c$ ) for Georges Bank cod were calculated using the model of Paulik and Gales (1964) for  $W_\infty = 34.16$  kg,  $K = 0.120$ ,  $t_0 = -0.616$  years,  $t_r = 1.0$  years,  $t_\lambda = 17.0$  years and  $M = 0.2$  (Table 8). Yield per recruit curves were also calculated for  $t_c$  values of 1.9, 2.3, 2.5, 2.9, 3.0, and 3.2 years; these ages correspond with the mean selection lengths that would be obtained using cod-end stretched mesh sizes of 106, 120, 130, 140, 145, and 150 mm, respectively, assuming an average polyamide fiber cod selection factor of 3.6 (Holden 1971; Smolowitz 1979) (Figure 1).

Maximum yield per recruit ( $F_{\max}$ ) occurs at an age of first capture of 7.5 years and an instantaneous fishing mortality of  $F = 1.5$  (Table 8). The present Fishery Management Plan requires a stretched mesh size of at least 130 mm in the otter trawl cod-end. Under this regimen,  $F_{\max}$  occurs at a value of about 0.3 (Figure 1), with  $F_{0.1}$  (Gulland and Boerema 1973) being equal to 0.15.

Figure 1 indicates that for mesh sizes 106-150 mm, yield per recruit of Georges Bank cod increases as mesh size is increased for almost all values of fishing mortality, and that for any of these mesh sizes,  $F_{\max}$  occurs at relatively low fishing mortality values ( $F = 0.2-0.3$ ).

## 2.15 Fishing Effort Indices

Mean annual fishing effort indices were derived for 1964-1978 by dividing total reported catch (commercial and commercial and recreational) by the appropriate autumn survey catch per tow in weight (Table 9). In order to establish a smooth time-series of both catch and survey values to elucidate general trends, 3-year averages ( $\bar{x}$  year  $i = \Sigma \text{year}_{i-1} + \text{year}_i + \text{year}_{i+1}/3$ ) were calculated. Inclusion of the survey weight per tow index from year  $i+1$  in deriving the mean for survey year  $i$  enabled the reported catch and survey indices to more correctly correspond since commercial catches of recruiting fish ( $\leq$ age 2) in any given year are generally not proportionally represented in the survey weight per tow index until the year after.

Inspection of the derived fishing effort indices for Georges Bank, 1964-1978, (Table 9) indicates that fishing effort from 1971-1976 was less than half of that during 1964-1970. Assuming fishing effort is proportional to fishing mortality, this trend indicates that the reductions in fishing mortality in recent years have been significant. The autumn survey weight per tow values indicate that this decrease has been accompanied by an increase in stock biomass.

The fishing effort indices indicate a steady decline during 1975-1978. The 1977 and 1978 indices, however, probably underestimate relative fishing effort (fishing mortality) since the reported landings were used in deriving these values. As previously

mentioned (section 2.11), the actual catch in these years may have been much higher. Nevertheless, even if the reported commercial landings in 1977 and 1978 were doubled, the resultant fishing effort indices (1.50 and 1.71, respectively, using the averaging techniques noted in Table 9 ) would still be less than half of any of the annual values from 1965-1970.

#### 2.16 Implications of the Current Georges Bank Cod Assessment

Results of the present assessment indicate that the Georges Bank cod stock biomass is at a relatively high level. The 1978 autumn and spring survey weight per tow indices were among the highest seen in the bottom trawl series. The autumn 1978 catch (numbers) per-tow data indicated that the 1975 year-class comprised nearly half of the population in number, and has not been reduced in size as rapidly as either the strong 1966 or 1971 year-classes were. Recruitment of the 1977 year-class appears better than had previously been expected based on the 1977 age 0 catch per tow results. The 1978 year-class seems to be of average size based on the autumn 1978 age 0 index.

Fishing mortality in the past several years appear to be much lower than during the period 1965-1972. The actual fishing mortality rates for 1977 and 1978 cannot be determined in part, because of uncertainties in the landings statistics for these years.

In the absence of adequate current catch data, the present assessment has been largely based on survey data. The results of the 1978 surveys have been utilized throughout the assessment. Since the greatest utility of the survey series data is in evaluating population trends (both in relative abundance and composition), there is a risk associated with using the 1978 point estimates of stock status as sole indicators of present conditions. However, on a short term basis a harvest at the 1978 level appears to be sustainable at current population abundance.

## 2.2 Gulf of Maine Stock

### 2.21 Landings Statistics

Provisional 1978 reported commercial landings of Gulf of Maine cod were 12,542 MT (Table 10), the highest in the history of the fishery since the record-high year of 1945 (14,500 MT). USA landings accounted for 98% of the 1978 total; the remaining 2% (300 MT) was taken by Canada.

Both total commercial and USA reported commercial landings in 1978 approximated the corresponding 1977 landings values (Table 10) and resulted in successive annual commercial removals exceeding 12,000 MT for the first time since fishery records were kept (beginning in 1932).

USA reported commercial landings for 1977 and 1978 probably underestimate the actual catch. The Gulf of Maine cod fishery was closed twice in 1977 and six times during 1978 (Table 11), and has been regulated primarily by vessel class under a variety of quarterly, weekly, daily, and per-trip landing limitations. The extent of inaccuracy in the reported Gulf of Maine landings statistics is currently unknown.

Recreational Gulf of Maine cod landings in 1977 and 1978 could not be estimated as previously done (Serchuk et a. 1978 - Table 2) due to the absence of accurate commercial catch information. The 1978 Fishery Management Plan included a 2,500 MT recreational quota for Gulf of Maine cod .

#### 2.22 Commercial Catch Composition

Market category distribution of the reported 1978 commercial USA Gulf of Maine cod landings indicated that "scrod" cod comprised 16% of the catch (by weight), "market" cod, 44%, and "large" cod, 39% (Table 3). Since 1975, "market" cod have dominated the annual catch. This is a result of the entry of the strong 1971 year-class into "market" size beginning in 1975, and the subsequent body weight growth of the moderately strong 1973 and 1974 year-classes into "market-sized" fish in 1977 and 1978, respectively. This trend should continue again in 1979 as the 1974 year-class should remain in the "market" category for one more year.

Compared to the last three years (1975-1977), the 1978 percentage of "large" cod showed an increase, while the percent of "scrod" cod in the 1978 catch decreased. These data indicate that the 1971 year-class fully grew into "large" cod in 1978. The percentage of "scrod" cod landed in 1979 is expected to remain as low or lower than in 1978 since previous bottom trawl survey data (Serchuk et al. 1978-Figure 6) indicated that the 1976 year-class was not strong.

## 2.23 Research Vessel Bottom Trawl Survey Indices

### 2.231 Total Stratified Mean Catch Per Tow

Autumn 1978 bottom trawl survey mean catch per tow indices, both in numbers and weight, were among the highest observed in the Gulf of Maine cod survey catch series (Table 4). Mean number per tow in 1978 was 4.66, 87% larger than the 1977 index of 2.49; mean weight (lbs) per tow (26.2) was 27% larger than in 1977 (20.7). Both autumn indices have exhibited increasing trends since 1976 implying recent increases in population size and biomass.

The spring 1978 catch per tow indices (Table 4) were lower than in 1977. Mean number per tow was 9% lower (11.6 in 1977 to 10.5 in 1978), while mean weight per tow was 47% lower (2.48 in 1977 to 1.31 in 1978). Despite the 1978 index reduction, both the number and weight spring indices have remained relatively stable since 1974. This trend is at variance with the increases seen in the 1977 and 1978 autumn Gulf of Maine surveys.

## 2.232 Stratified Mean Number Per Tow By Age Group

Stratified mean catch per tow values in numbers at age for the Gulf of Maine, 1970-1977 are listed in Tables 6 and 7. These values were derived as detailed in section 2.132, using individual survey age-length keys applied to the respective survey length-frequency distributions. Both spring and autumn 1978 age samples are currently being analyzed (as well as the autumn 1976 samples) and thus age composition data from these cruises are omitted from Tables 6 and 7. Accordingly, preliminary evaluation of recent recruitment was assessed from the length-frequency distributions of the autumn and spring 1978 surveys.

Catch per tow of age 0 cod ( $\leq 14$  cm) from the autumn 1978 Gulf of Maine survey was 0.157, the highest age 0 value since 1974 (Table 6), and suggests that the 1978 year-class may be of average size (no age 0 cod were caught in either the 1976 or 1977 surveys).

The catch per tow of age 1 cod (15-32 cm) in the autumn 1978 survey was 1.10. Compared to previous age 1 autumn indices, the 1978 value is only exceeded by the 1972 age 1 index (3.58) which represented cod from the strong 1971 year-class and is considerably larger than the average of the 1973-1977 catches excluding the 1974 catch of the 1973 year-class.

The spring survey age 1 indices indicate 3 larger values (1969, 1971, and 1973 year-classes) with the remaining catches being at a lower level (the 1974 year-class, however, was intermediate). The 1978 index (15-23 cm cod) was 0.03 equal to the average of the years

1973-1978 (the years for which the 41 Yankee trawl was used) excluding the 1974 value for the 1973 year-class. Thus the 1978 spring survey indicates a lower stock size for the 1977 year-class than does the autumn 1978 survey.

#### 2.24 Yield Per Recruit

Yield per recruit analyses for Gulf of Maine cod were accomplished using the Paulik and Gales (1964) model with  $W_{\infty} = 33.04$  kg,  $K = 0.116$ ,  $t_c = 0.285$  years,  $t_r = 1.0$  years,  $t_{\lambda} = 17.0$  years, and  $M = 0.2$  (Table 12). Yield per recruit curves were additionally calculated for  $t_c$  values of 2.9, 3.3, 3.6, 3.9, 4.1, and 4.2 years (Figure 2); these ages correspond to fish possessing the mean selection lengths that would be obtained with cod end minimum stretched mesh size of 106, 120, 130, 140, 145, and 150 mm, respectively, assuming an average polyamide fiber cod selection factor of 3.6 (Holden 1971; Smolowitz 1979).

Maximum yield per recruit for Gulf of Maine cod occurs at an age of first capture of 8.5 years and an instantaneous fishing mortality of  $F = 1.5$  (Table 12). Under the present management plan which requires the use of minimum cod-end mesh size of 130 mm,  $F_{\max}$  occurs at about 0.3 (Figure 2), and  $F_{0.1}$  at 0.16.

For almost all values of fishing mortality, yield per recruit of Gulf of Maine cod increases as mesh size increases (Figure 2). Conditional  $F_{\max}$  occurs at a relatively low fishing mortality ( $F = 0.2-0.3$ ) for all of the mesh sizes analyzed (106-150 mm).

## 2.25 Fishing Effort Indices

Mean annual fishing effort indices were derived for 1964-1978 by dividing total reported landings (commercial and commercial and recreational) by the appropriate autumn survey catch per tow in weight (Table 9). Details and rationale for this methodology have previously been discussed (section 2.15).

The fishing effort indices for the Gulf of Maine cod stock can be grouped into three periods: (1) 1966-1971 when fishing effort values were relatively stable reflecting stabilization of both annual landings and population biomass (survey weight/tow); (2) 1972-1975 when fishing effort (and hence relative fishing mortality) increased annually (~100% increase between 1972 and 1975) as a consequence of increased yearly catches and sequential annual reductions in biomass; and (3) 1976-1978 during which fishing effort has trended downward while autumn survey weight per tow values have risen upward.

As presented, the 1978 data indicate that while landings have approached historically high levels, population biomass has also increased to near historically high levels. The 1978 fishing effort index is lower than any of the values since 1974, although still considerably higher than the annual indices during the stable 1966-1971 period. The production of the strong 1971 year-class, and the moderately strong 1973 and 1974 year-classes, have thus had a pronounced effect in increasing the Gulf of Maine stock biomass.

As noted earlier (section 2.21), the reported 1977 and 1978 commercial landings may underestimate actual catches and hence the derived 1977 and 1978 fishing effort indices may underestimate relative fishing mortality. If the actual commercial landings during each of these years were 40% higher than the reported catches (i.e., 17,500 MT), the resultant fishing effort indices (0.81 for 1977; 0.74 for 1978) would approximate the highest observed.

#### 2.26 Implications of the Current Gulf of Maine Cod Assessment

Results of the present assessment indicate that the Gulf of Maine cod stock biomass is at or near the highest level since the late 1960's - early 1970's. Both the autumn 1978 number and weight per tow indices were among the highest seen in the bottom trawl series, although corresponding spring 1978 indices exhibited decreases and indicated moderate stock biomass levels. Recruitment of the 1977 year-class as indicated by the autumn 1978 age 1 catch per tow index suggests this year-class may be reasonably strong. The spring 1978 age 1 catch index, however, indicated the 1977 year-class may be closer to the average size. This disparity is difficult to interpret since previous trends in relative year class strength between autumn and spring surveys have been consistent. The 1978 year-class appears to be average in strength as indicated by the autumn 1978 age 0 index.

Since 1975, fishing mortality appears to have decreased annually as evinced by fishing effort indices derived from reported landings. The 1978 relative fishing mortality level, however, is still above the

levels that corresponded with the stable stock biomass conditions during 1966-1971 when annual commercial landings were about 7,000 MT. Due to uncertainties in the 1977 and 1978 landings statistics, the relative fishing mortality rates for these years may be higher than calculated. If unreported catches of 5,000 MT occurred in both years, the respective fishing mortalities would have been near the highest levels ever previously observed.

The present Gulf of Maine recruited stock (age 3+) is dominated by fish from the 1971, 1973, and 1974 year-classes. While the 1977 year-class may be average or better, the 1976 year-class appears relatively poor.

The spring and autumn 1978 survey weight per tow indices, and the trends in the survey weight per tow indices since 1975, indicate that the recent landings levels have not resulted in any discernible stock biomass reductions. Hence, 1979 landings of the same magnitude should not adversely effect short-term population biomass.

If current recruitment patterns are similar to those in the past, sustained harvests at the recent levels will probably not maintain the present stock biomass. Commercial landings of greater than 11,000 MT in 1934 and 1945 were both followed by periods in which annual landings declined by greater than 50 percent. More recently, increases in relative fishing mortality, 1972-1975, were accompanied by stock

biomass levels lower than those in 1968-1971. The estimated relative fishing mortality for 1978 is greater than those during 1968-1971, although stock biomass is about the same as during 1968-1971.

### Literature Cited

- Gulland, J.A., and L.K. Boerema. 1973. Scientific advice on catch levels. Fish. Bull. 71(2):325-335.
- Holden, M.J. 1971. Report of the ICES/ICNAF Working Groups on Selectivity analysis. ICES Coop. Res. Rept. No. 25, 144 pp.
- NEFC (Northeast Fisheries Center). 1978. Biological aspects of optimum yield for Georges Bank and Gulf of Maine cod. NEFC, Woods Hole Lab. Ref. Doc. No. 78-19, 3 pp.
- Paulik, G.J., and L.E. Gales. 1964. Allometric growth and the Beverton-Holt yield equation. Trans. Amer. Fish. Soc. 93:369-381.
- Serchuk, F.M., P.W. Wood, S.H. Clark, and B.E. Brown. 1977. Analysis of the Georges Bank and Gulf of Maine cod stocks. NEFC, Woods Hole Lab. Ref. Doc. No. 77-24, 26 pp.
- Serchuk, F.M., P.W. Wood, and B.E. Brown. 1978. Atlantic cod (Gadus morhua): Assessment and status of the Georges Bank and Gulf of Maine stocks. January 1978. NEFC, Woods Hole Lab. Ref. Doc. No. 78-03, 25 pp.
- \_\_\_\_\_ 1978b. Summary and review of the 1978 assessment and status of the Georges Bank and Gulf of Maine cod stocks. NEFC, Woods Hole Lab. Ref. Doc. No. 78-11, 18 pp.
- Smolowitz, R.J. 1979. Mesh size and New England groundfish. NMFS, Woods Hole Lab. Ref. Doc. No. 79-02.
- Wise, J. 1962. Cod groups in the New England area. Fish. Bull. 63(1):189-203.

Table 1. Atlantic cod landings (metric tons, live) from Georges Bank and southward (ICNAF Div. 5Z - SA6), by country, 1960-1978.

	USA				Country					Total commercial	USA recreational	Grand Total
	5Z	5NK	6	Total	Canada	USSR	Spain	Poland	Other			
1960	10,391	443	-	10,834	19	-	-	-	-	10,853	11,395 <sup>1</sup>	22,248
1961	13,998	455	-	14,453	223	55	-	-	-	14,731	14,838	29,569
1962	15,232	405	-	15,637	2,404	5,302	-	143	-	23,486	16,146	39,632
1963	13,904	235	-	14,139	7,832	5,217	-	-	1	27,189	13,487	40,676
1964	12,325	-	-	12,325	7,108	5,428	18	48	238	25,165	11,955	37,120
1965	11,410	-	-	11,410	10,598	14,415	59	1,851	-	38,333	11,029 <sup>1</sup>	49,362
1966	11,794	-	196	11,990	15,601	16,830	8,375	269	69	53,134	11,440	64,574
1967	12,742	-	415	13,157	8,232	511	14,730	-	122	36,752	12,360	49,112
1968	14,967	-	312	15,279	9,127	1,459	14,622	2,611	38	43,136	13,620	56,756
1969	16,356	-	426	16,782	5,997	646	13,597	798	119	37,939	14,884 <sup>1</sup>	52,823
1970	14,535	-	364	14,899	2,583	364	6,874	784	148	25,652	13,246 <sup>1</sup>	38,898
1971	15,795	-	383	16,178	2,979	1,270	7,460	256	36	28,179	14,393	42,572
1972	13,140	-	266	13,406	2,545	1,878	6,704	271	255	25,059	11,957	37,016
1973	15,933	-	269	16,202	3,220	2,977	5,980	430	114	28,923	8,922 <sup>1</sup>	37,845
1974	17,870	-	507	18,377	1,374	476	6,370	566	168	27,331	10,055 <sup>1</sup>	37,386
1975	15,240	349	428	16,017	1,847	2,403	4,044	481	216	25,008	8,534	33,542
1976 <sup>2</sup>	14,220	272	414	14,906 <sup>3</sup>	2,328	933	1,633	90	36	19,926	8,115	28,041 <sup>4</sup>
1977 <sup>2</sup>	20,355	467	317	21,139 <sup>3</sup>	6,070 <sup>5</sup>	54	2	-	-	27,265	-	27,265 <sup>4</sup>
1978 <sup>2</sup>	26,286	-	-	26,286 <sup>3</sup>	8,750 <sup>5</sup>	-	-	-	-	35,036	-	35,036 <sup>4</sup>

<sup>1</sup>From angler surveys; remaining years estimated.

<sup>2</sup>Provisional.

<sup>3</sup>Reported USA landings are believed to underestimate actual commercial catch due to unreported catch and discards.

<sup>4</sup>Does not include recreational landings.

<sup>5</sup>Estimated.

Source: ICNAF Statistical Bulletins 1960-1976; ICNAF Summary Document 77/VI/8; ICNAF Summary Document 78/VI/28; NMFS Fisheries Management and Statistics Branch (1978 USA landings).

Table 2. Fishery Closure Management Actions in the Georges Bank Atlantic Cod Fisheries, 1977 and 1978.

Effective date	Action	Comments
August 22, 1977	Closure of the directed commercial cod fishery until January 1, 1978.	Commercial quota for 1977 taken. Incidental fishery permitted to continue.
December 24, 1977	Closure of all commercial groundfish fisheries, including incidental cod fishery, until January 1, 1978.	Emergency regulations implemented on 3 November expired. Original quotas already taken.
March 1, 1978	Closure of directed commercial cod fishery until April 1, 1978.	50 percent of first quarter quota taken. By-catch fishery permitted to continue.
March 20, 1978	Closure of commercial by-catch fishery until April 1, 1978.	Total first quarter quota reached.
September 17, 1978	Closure of commercial cod fishery for vessels 61-125 GRT until January 1, 1979.	Vessels in this class exceeded annual quota allocated to this class.
October 1, 1978	["New fishing year" enacted: October 1, 1978 - September 30, 1979].	
December 17, 1978	Closure of commercial cod fishery for vessels over 125 GRT until January 1, 1979.	Catches for first quarter of "new fishing year" by this vessel class near quota for class. By-catch fishery permitted to continue.

Table 3. Percentage of USA commercial Atlantic cod from Georges Bank and south, and the Gulf of Maine, by market category, 1964-1978.

Year	Georges Bank and South				Gulf of Maine			
	Large	Market	Scrod	Total	Large	Market	Scrod	Total
1964	45	47	8	100	29	59	12	100
1965	56	40	3	99	39	54	7	100
1966	53	37	10	100	42	48	10	100
1967	41	42	16	99	41	41	17	99
1968	34	46	19	99	47	43	9	99
1969	27	57	16	100	35	55	9	99
1970	30	62	8	100	43	52	6	101
1971	40	51	9	100	52	42	6	100
1972	37	53	10	100	58	35	7	100
1973	24	40	36	100	52	36	11	99
1974	24	59	17	100	39	33	28	100
1975	28	62	10	100	32	42	26	100
1976	34	48	18	100	29	45	20	94 (6%mixed)
1977	26	39	34	99	33	42	22	97 (3%mixed)
1978	28	61	11	100	39	44	16	99

Table 4. Stratified mean catch per tow in numbers and weight (lbs) for Atlantic cod from USA (NEFC) spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25) and in the Gulf of Maine (Strata 26-30 and 36-40), 1963-1978.

Year	Georges Bank				Gulf of Maine			
	Spring <sup>1</sup>		Autumn		Spring <sup>1</sup>		Autumn	
	Nos	Wt (lbs)	Nos	Wt(lbs)	Nos	Wt(lbs)	Nos	Wt(lbs)
1963	-	-	2.80	24.2	-	-	3.79	24.4
1964	-	-	1.91	15.7	-	-	2.57	31.0
1965	-	-	2.72	15.9	-	-	2.88	16.3
1966	-	-	3.09	11.1	-	-	2.43	17.6
1967	-	-	6.66	18.4	-	-	1.64	12.5
1968	3.03	17.1	2.12	11.7	3.48	24.4	2.80	26.5
1969	2.97	24.2	1.41	10.9	2.08	18.0	1.77	20.9
1970	2.78	21.3	3.25	17.1	1.41	15.1	3.14	22.4
1971	2.17	19.3	2.04	13.4	0.92	9.5	2.80	22.5
1972	5.74	25.9	8.39	31.3	1.32	10.9	5.96	17.7
1973	36.91	128.0	7.87	42.0	4.82	25.6	2.85	11.9
1974	9.45	49.5	2.24	11.2	1.86	10.1	2.77	12.2
1975	4.42	35.5	4.11	19.1	1.61	8.2	3.94	11.7
1976	4.52	25.4	6.68	24.0	1.78	10.3	1.38	9.2
1977	4.04	21.0	4.42	25.4	2.48	11.6	2.49	20.7
1978	7.89	42.5	6.97	47.3	1.31	10.5	4.66	26.2

<sup>1</sup>Spring surveys, 1968-1972, were accomplished with "36 Yankee" trawl; spring surveys from 1973 to 1978 were accomplished with "41 Yankee" trawl. No adjustments have been made to the catch per tow data for these gear differences.

Table 5. Number of tows, total number of Atlantic cod caught, and total weight (lbs) of Atlantic cod caught in USA spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25) and in the Gulf of Maine (Strata 26-30 and 36-40), 1963-1978.

Year	Georges Bank						Gulf of Maine					
	Spring			Autumn			Spring			Autumn		
	Number of tows	Total No. of cod caught	Total weight (lbs) of cod caught	Number of tows	Total No. of cod caught	Total weight (lbs) of cod caught	Number of tows	Total No. of cod caught	Total weight (lbs) of cod caught	Number of tows	Total No. of cod caught	Total weight (lbs) of cod caught
1963	-	-	-	57	178	1,262	-	-	-	57	296	1,815
1964	-	-	-	63	146	1,083	-	-	-	47	121	1,324
1965	-	-	-	66	201	954	-	-	-	48	241	1,341
1966	-	-	-	67	263	891	-	-	-	45	180	1,163
1967	-	-	-	66	430	1,379	-	-	-	48	97	711
1968	69	204	1,504	69	205	1,095	49	210	1,401	50	144	1,307
1969	74	203	1,684	73	105	754	53	137	1,193	51	124	1,315
1970	69	164	1,236	70	258	1,247	52	115	1,256	53	216	1,150
1971	73	169	1,288	73	161	926	57	66	681	55	228	1,668
1972	76	413	1,896	73	827	3,104	55	86	740	55	469	1,051
1973	71	2,650	9,141	73	664	3,174	48	369	1,947	54	229	789
1974	66	600	3,118	74	234	1,005	47	140	667	57	220	756
1975	71	305	2,380	73	345	1,408	52	206	808	65	687	1,523
1976	69	319	1,788	67	402	1,126	64	236	1,050	55	127	671
1977	71	306	1,674	101	694	3,337	67	342	1,396	71	264	1,869
1978	79	613	3,578	156	1,194	7,836	66	112	861	120	781	3,558

Table 6. Stratified mean catch per tow at age (numbers) of Atlantic cod from USA autumn bottom trawl surveys on Georges Bank (Strata 13-25) and in the Gulf of Maine (Strata 26-30 and 36-40), 1970-1978.

Year	Age													Totals					
	0	1	2	3	4	5	6	7	8	9	10	11	12+	0+	1+	2+	3+	4+	5+
<u>Georges Bank</u>																			
1970	.265	1.082	.867	.336	.445	.098	.000	.021	.035	.035	.063	.000	.000	3.247	2.982	1.900	1.033	.697	.252
1971	.256	.386	.405	.250	.193	.305	.117	.027	.057	.000	.000	.000	.048	2.044	1.788	1.402	.997	.747	.554
1972	.607	4.771	.830	1.135	.256	.156	.366	.070	.131	.014	.006	.000	.047	8.389	7.782	3.011	2.181	1.046	.790
1973	.130	1.121	3.891	.758	1.290	.135	.145	.112	.040	.089	.085	.023	.053	7.872	7.742	6.621	2.730	1.972	.682
1974	.296	.262	.419	.975	.105	.073	.066	.000	.044	.000	.000	.000	.000	2.240	1.944	1.682	1.263	.288	.183
1975	1.524	.637	.270	.400	1.080	.072	.100	.000	.000	.000	.024	.000	.000	4.107	2.583	1.946	1.676	1.276	.196
1976	.000	3.941	1.314	.500	.182	.474	.015	.193	.024	.034	.000	.013	.000	6.690	6.690	2.749	1.435	.935	.753
1977	.123	.192	2.778	.570	.204	.141	.321	.006	.022	.000	.007	.042	.014	4.420	4.297	4.105	1.327	.757	.553
1978	.308	1.531	.205	3.396	.775	.272	.134	.278	.038	.022	.000	.000	.011	6.970	6.662	5.131	4.926	1.530	.755
<u>Gulf of Maine</u>																			
1970	.476	.603	.170	.353	.211	.313	.271	.506	.084	.060	.023	.024	.047	3.141	2.665	2.062	1.892	1.539	1.328
1971	.863	.114	.153	.135	.383	.295	.278	.163	.204	.128	.040	.022	.020	2.798	1.935	1.821	1.668	1.533	1.150
1972	.020	3.576	.780	.978	.150	.060	.110	.025	.102	.155	.000	.000	.010	5.966	5.946	2.370	1.590	.612	.462
1973	.408	.210	1.393	.089	.325	.136	.050	.018	.033	.108	.077	.000	.010	2.857	2.449	2.239	.846	.757	.432
1974	.181	.720	.121	1.118	.187	.230	.050	.008	.008	.027	.021	.075	.031	2.777	2.596	1.876	1.755	.637	.450
1975	.030	.094	1.966	.086	1.510	.163	.070	.011	.002	.002	.000	.004	.004	3.942	3.912	3.818	1.852	1.766	.256
1976 <sup>1</sup>	(.000)	(.099)																	
1977	.000	.018	.291	.446	.937	.123	.481	.031	.079	.018	.027	.000	.051	2.502	2.502	2.484	2.193	1.747	.810
1978 <sup>1</sup>	(.157)	(1.100)																	

<sup>1</sup>Survey age samples currently being analyzed.

Table 7. Stratified mean catch per tow at age (numbers) of Atlantic cod from USA spring bottom trawl surveys on Georges Bank (Strata 13-25) and in the Gulf of Maine (Strata 26-30 and 36-40), 1970-1978.<sup>1</sup>

Year	Age													Totals					
	0	1	2	3	4	5	6	7	8	9	10	11	12+	0+	1+	2+	3+	4+	5+
	<u>Georges Bank</u>																		
1970	.000	.244	.522	.308	.830	.104	.420	.176	.039	.087	.008	.000	.045	2.783	2.783	2.539	2.017	1.709	.879
1971	.000	.133	.525	.322	.143	.375	.091	.225	.195	.051	.032	.032	.048	2.172	2.172	2.039	1.514	1.192	1.049
1972	.036	1.860	1.175	1.693	.327	.076	.208	.078	.141	.074	.032	.009	.039	5.748	5.712	3.852	2.677	.984	.657
1973	.036	.334	27.000	4.035	4.117	.418	.325	.244	.032	.126	.110	.025	.111	36.913	36.877	36.543	9.543	5.508	1.391
1974	.000	.286	2.921	3.828	.488	1.284	.282	.065	.165	.022	.059	.016	.037	9.453	9.453	9.167	6.246	2.418	1.930
1975	.000	.041	.242	1.309	1.982	.167	.440	.083	.060	.069	.000	.000	.025	4.418	4.418	4.377	4.135	2.826	.844
1976	.071	.834	1.232	.605	.443	1.008	.105	.168	.023	.000	.000	.000	.035	4.524	4.453	3.619	2.387	1.782	1.339
1977	.000	.018	2.261	.692	.335	.179	.466	.033	.042	.000	.000	.000	.013	4.039	4.039	4.021	1.760	1.068	.733
1978 <sup>2</sup>																			
	<u>Gulf of Maine</u>																		
1970	.000	.102	.079	.035	.060	.175	.299	.394	.048	.038	.063	.064	.057	1.414	1.414	1.312	1.233	1.198	1.138
1971	.000	.016	.091	.070	.187	.031	.053	.192	.132	.099	.038	.008	.000	.917	.917	.901	.810	.740	.553
1972	.000	.226	.098	.333	.126	.128	.023	.068	.065	.147	.036	.036	.033	1.319	1.319	1.093	.995	.662	.536
1973	.000	.022	2.724	.581	.397	.224	.125	.061	.143	.161	.134	.048	.210	4.830	4.830	4.808	2.084	1.503	1.106
1974	.000	.305	.036	.871	.211	.142	.073	.031	.031	.013	.037	.028	.084	1.862	1.862	1.557	1.521	.650	.439
1975	.004	.060	.448	.068	.683	.166	.071	.003	.003	.012	.036	.017	.039	1.610	1.606	1.546	1.098	1.030	.347
1976	.000	.027	.195	.672	.098	.575	.055	.069	.042	.000	.007	.003	.037	1.780	1.780	1.753	1.558	.886	.788
1977	.000	.016	.191	.334	1.278	.070	.507	.004	.065	.000	.000	.000	.024	2.489	2.489	2.473	2.282	1.948	.670
1978 <sup>2</sup>	(.000)	(.030)																	

<sup>1</sup>Spring surveys, 1968-1972, were accomplished with "36 Yankee" trawl; spring surveys from 1973-1978 were accomplished with "41 Yankee" trawl. No adjustments have been made to the catch per tow at age data for these gear differences.

<sup>2</sup>Survey age samples currently being analyzed.

Table 8. Yield per 1000 recruits (kg) for different rates of instantaneous fishing mortality (F) and different ages of fish capture ( $t_c$ ) for Georges Bank (Div. 5Z + SA 6) Atlantic cod. Natural mortality (M) = 0.2.

		Age at first capture (years) and corresponding length (cm) and weight (kg)																
		1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0
Instantaneous rate of fishing (F)		(26.11)	(33.21)	(39.90)	(46.20)	(52.14)	(57.72)	(62.99)	(67.94)	(72.61)	(77.01)	(81.15)	(85.05)	(88.72)	(92.18)	(95.43)	(98.50)	(101.39)
		(0.17)	(0.36)	(0.62)	(0.98)	(1.41)	(1.93)	(2.51)	(3.17)	(3.88)	(4.64)	(5.45)	(6.28)	(7.15)	(8.03)	(8.93)	(9.84)	(10.75)
0.1		1166	1214	1255	1287	1311	1324	1326	1319	1301	1275	1240	1199	1151	1099	1042	983	921
0.2		1253	1360	1459	1548	1623	1683	1726	1753	1763	1757	1737	1704	1660	1606	1543	1474	1399
0.3		1129	1273	1412	1542	1657	1754	1833	1890	1928	1946	1946	1929	1898	1853	1797	1732	1659
0.4		987	1153	1317	1473	1615	1740	1843	1925	1984	2022	2039	2036	2017	1982	1934	1875	1807
0.5		865	1043	1223	1397	1558	1701	1824	1923	1999	2051	2081	2090	2081	2054	2013	1960	1896
0.6		767	951	1141	1327	1502	1659	1795	1908	1996	2060	2101	2119	2117	2097	2062	2014	1954
0.7		688	876	1073	1267	1451	1619	1766	1889	1988	2060	2109	2135	2139	2125	2094	2050	1993
0.8		625	815	1015	1216	1407	1583	1739	1870	1976	2057	2112	2143	2153	2143	2117	2075	2021
0.9		573	764	967	1172	1369	1552	1714	1852	1964	2051	2111	2148	2162	2156	2133	2094	2042
1.0		531	722	927	1135	1337	1524	1691	1835	1953	2044	2110	2150	2168	2166	2145	2108	2058
1.1		496	686	892	1103	1308	1499	1671	1819	1942	2038	2107	2151	2172	2172	2154	2119	2071
1.2		466	656	863	1075	1283	1478	1653	1805	1932	2031	2104	2151	2175	2178	2161	2128	2081
1.3		441	630	837	1051	1261	1458	1637	1792	1922	2025	2101	2151	2177	2182	2167	2135	2090
1.4		420	607	815	1030	1241	1441	1623	1781	1913	2019	2097	2150	2178	2185	2172	2141	2097
1.5		401	588	795	1011	1224	1426	1610	1770	1905	2013	2094	2149	2179	2187	2176	2146	2103

Table 9. Relationship between total commercial landings of Atlantic cod (3-year averages),<sup>1</sup> total commercial and recreational landings of Atlantic cod (3-year averages)<sup>1</sup>, and USA autumn bottom trawl survey stratified mean catch (weight in pounds) per tow (3-year averages)<sup>1</sup> from Georges Bank (strata 13-25) and the Gulf of Maine (strata 26-30 and 36-40), 1963-1978. Landings data are in thousands of metric tons, live weight.

	Georges Bank					Gulf of Maine				
	Commercial landings (A)	Commercial & recreational landings (B)	Autumn survey wt/tow (C)	Fishing effort indices A/C B/C		Commercial landings (D)	Commercial & recreational landings (E)	Autumn survey wt/tow (F)	Fishing effort indices D/F E/F	
1964	26.9	41.7	18.6	1.45	2.88	3.3	5.4	23.9	0.14	0.23
1965	38.9	48.0	14.2	2.74	3.55	3.9	6.3	21.6	0.18	0.29
1966	42.7	50.1	15.1	2.83	3.60	6.1	7.7	15.5	0.39	0.50
1967	44.3	55.0	13.7	3.23	4.15	5.6	8.5	18.9	0.30	0.45
1968	39.3	55.8	13.7	2.87	3.86	7.0	10.0	20.0	0.35	0.50
1969	35.9	49.4	13.2	2.72	3.75	7.7	10.6	23.3	0.33	0.46
1970	30.9	47.8	13.8	2.24	3.25	8.2	11.1	21.9	0.37	0.51
1971	26.7	42.8	20.6	1.30	1.92	7.6	10.4	20.9	0.36	0.50
1972	27.4	39.1	28.9	0.95	1.35	6.9	9.3	17.4	0.40	0.53
1973	27.1	38.7	28.2	0.96	1.33	7.0	9.2	13.9	0.50	0.66
1974	27.1	36.4	24.1	1.12	1.50	7.7	9.9	11.9	0.65	0.83
1975	24.1	34.2	18.1	1.33	1.82	9.0	11.7	11.0	0.82	1.06
1976	24.1	34.4	22.8	1.06	1.46	10.6	12.5	13.9	0.76	0.90
1977	27.4		32.2	0.85		11.7		18.7	0.63	
1978 <sup>2</sup>	31.2		36.4	0.86		12.5		23.5	0.53	

<sup>1</sup> Average values calculated as  $\frac{\sum \text{year } i-1 + \text{year } i + \text{year } i+1}{3}$ .

<sup>2</sup> 1978 Average values calculated as  $\frac{\sum \text{year } 1977 + \text{year } 1978}{2}$ .

Table 10. Atlantic cod landings (metric tons, live) from the Gulf of Maine (ICNAF Div. 5Y), by country, 1960-1978.

	Country					Total commercial	USA recreational	Grand Total
	USA	Canada	USSR	Spain	Other			
1960	3,448	129	-	-	-	3,577	2,621	6,198 <sup>1</sup>
1961	3,216	18	-	-	-	3,234	2,444	5,678
1962	2,989	83	-	-	-	3,072	2,272	5,344
1963	2,595	3	133	-	-	2,731	1,713	4,444
1964	3,226	25	-	-	-	3,251	2,129	5,380
1965	3,780	148	-	-	-	3,928	2,537	6,465 <sup>1</sup>
1966	4,008	384	-	-	-	4,392	2,645	7,037
1967	5,676	297	-	-	-	5,973	3,746	9,719
1968	6,360	61	-	-	-	6,421	2,417	8,838
1969	8,157	59	-	152	116	8,484	3,100	11,584 <sup>1</sup>
1970	7,812	26	-	375	48	8,261	3,046	11,307 <sup>1</sup>
1971	7,380	119	-	159	4	7,662	2,804	10,466
1972	6,776	53	11	-	77	6,917	2,575	9,492
1973	6,069	68	-	-	9	6,146	1,821	7,967
1974	7,639	120	-	4	1	7,764	2,313	10,077 <sup>1</sup>
1975	8,903	86	-	26	-	9,015	2,671	11,686
1976 <sup>2</sup>	10,172 <sup>3</sup>	16	-	-	-	10,188	2,963	13,151 <sup>4</sup>
1977 <sup>2</sup>	12,427 <sup>3</sup>	74 <sup>5</sup>	-	-	-	12,501	-	12,501 <sup>4</sup>
1978 <sup>2</sup>	12,242 <sup>3</sup>	300 <sup>5</sup>	-	-	-	12,542	-	12,542 <sup>4</sup>

<sup>1</sup>From angler surveys; remaining years estimated.

<sup>2</sup>Provisional.

<sup>3</sup>Reported USA landings may underestimate actual commercial catch due to unreported catch.

<sup>4</sup>Does not include recreational landings.

<sup>5</sup>Estimated.

Source: ICNAF Statistical Bulletins 1960-1976; ICNAF Summary Document 77/VI/8; ICNAF Summary Document 78/VI/28; NMFS Fisheries Management and Statistics Branch (1978 USA landings).

Table 11. Fishery Closure Management Actions in the Gulf of Maine Atlantic Cod Fisheries, 1977 and 1978.

Effective date	Action	Comments
July 8, 1977	Closure of the directed cod fishery until January 1, 1978.	Commercial quota for 1977 taken. Incidental fishery permitted to continue.
December 24, 1977	Closure of all commercial groundfish fisheries, including incidental cod fishery until January 1, 1978.	Emergency regulations implemented on 3 November expired. Original quotas already taken.
March 1, 1978	Closure of directed commercial cod fishery until April 1, 1978.	50 percent of first quarter quota taken. By-catch fishery permitted to continue.
March 20, 1978	Closure of commercial by-catch fishery until April 1, 1978.	Total first quarter quota reached.
August 6, 1978	Closure of commercial cod fishery for vessels 61-125 GRT and fixed gear.	Vessels in these gear/size classes have taken their 1978 annual allocations.
August 16, 1978	Closure of all commercial cod fisheries until January 1, 1979.	Annual 1978 quota available to the commercial fishery exceeded.
October 1, 1978	["New fishing year" enacted: October 1, 1978 - September 30, 1979].	
November 19, 1978	Closure of commercial cod fishery for vessels over 125 GRT.	Catches for first quarter of "new fishing year" by this vessel class near quota for class. By-catch fishery permitted to continue.
December 17, 1978	Closure of commercial cod fishery for fixed gear.	Catches for first quarter of "new fishing year" by this gear class near quota for class. By-catch fishery permitted to continue.

Table 12. Yield per 1000 recruits (kg) for different rates of instantaneous fishing mortality (F) and different ages of first capture ( $t_c$ ) for Gulf of Maine (Div. 5Y) Atlantic cod. Natural mortality (M) = 0.2.

Instantaneous rate of fishing (F)	Age at first capture (years) and corresponding length (cm) and weight (kg)																
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0
	(11.66)	(19.26)	(26.43)	(33.19)	(39.58)	(45.60)	(51.29)	(56.66)	(61.72)	(66.50)	(71.00)	(75.26)	(79.27)	(83.06)	(86.64)	(90.01)	(93.19)
	( 0.01)	( 0.07)	( 0.18)	( 0.36)	( 0.61)	( 0.94)	( 1.34)	( 1.82)	( 2.36)	( 2.97)	( 3.62)	( 4.33)	( 5.07)	( 5.85)	( 6.65)	( 7.47)	( 8.31)
0.1	801	840	878	913	942	966	982	990	991	983	969	947	920	887	849	808	763
0.2	795	875	957	1036	1110	1176	1231	1274	1305	1323	1329	1323	1306	1279	1243	1200	1150
0.3	660	762	869	977	1082	1178	1264	1336	1394	1436	1463	1475	1474	1459	1434	1398	1353
0.4	533	643	764	889	1013	1129	1236	1328	1406	1466	1510	1537	1549	1546	1530	1503	1465
0.5	433	546	673	807	943	1073	1194	1301	1392	1466	1523	1561	1583	1590	1582	1562	1530
0.6	356	469	599	739	882	1021	1152	1270	1371	1456	1522	1569	1599	1613	1611	1596	1569
0.7	298	409	540	683	831	977	1115	1240	1350	1442	1515	1570	1606	1625	1629	1618	1595
0.8	253	362	492	637	788	938	1082	1213	1329	1427	1507	1567	1608	1632	1640	1632	1612
0.9	218	324	453	598	752	906	1053	1190	1311	1414	1498	1563	1608	1636	1647	1642	1625
1.0	191	293	421	567	722	878	1029	1169	1294	1401	1489	1558	1607	1637	1651	1649	1634
1.1	169	268	395	540	696	854	1007	1151	1279	1389	1481	1553	1605	1638	1654	1654	1641
1.2	150	247	372	517	673	833	989	1134	1265	1379	1473	1548	1602	1638	1656	1658	1646
1.3	135	230	353	497	654	815	972	1120	1253	1369	1466	1543	1600	1638	1658	1661	1651
1.4	123	215	337	480	637	799	958	1107	1243	1361	1460	1539	1597	1637	1658	1664	1654
1.5	112	202	323	465	622	785	945	1096	1233	1353	1454	1534	1595	1636	1659	1665	1657

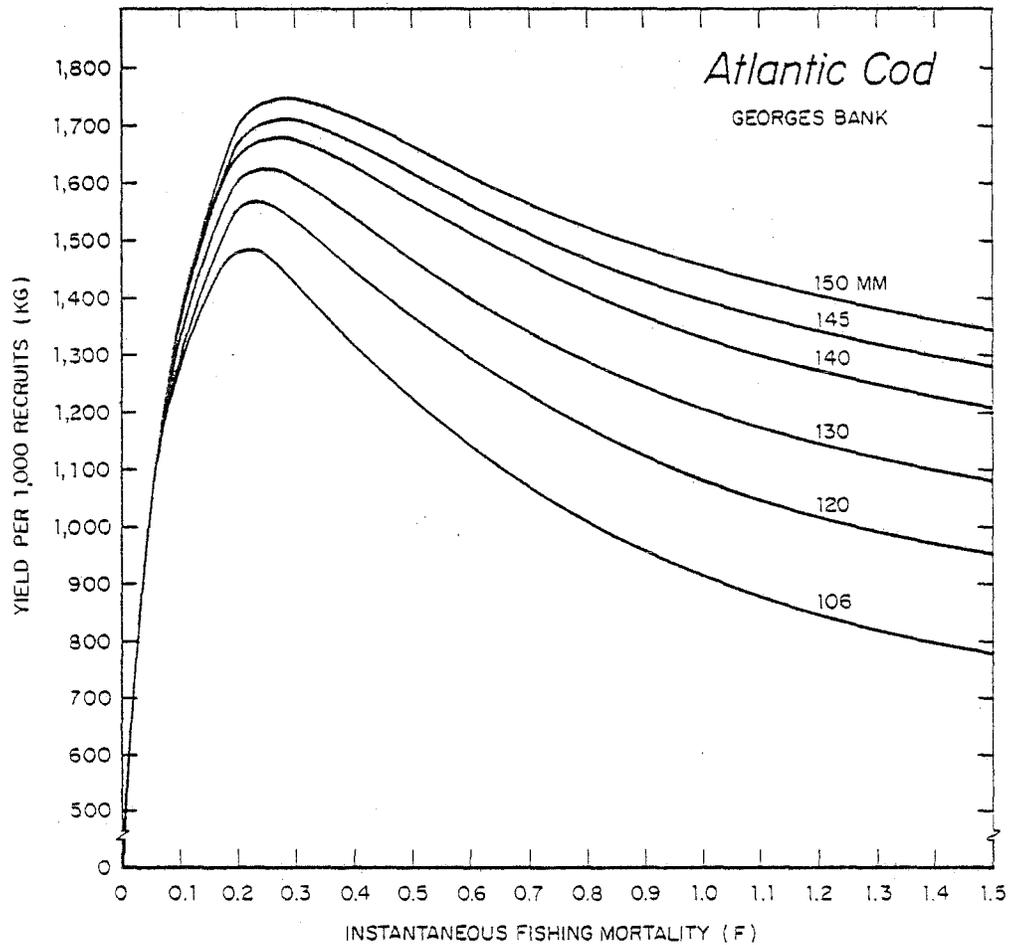


Figure 1. Yield per recruit curves for Georges Bank cod assuming otter-trawl cod-end minimum stretched mesh sizes of 106, 120, 130, 140, 145, and 150 mm. These values correspond to mean age at capture values of 1.9, 2.3, 2.5, 2.9, 3.0, and 3.2, respectively.  $W_{\infty} = 34.16$  kg,  $K = 0.120$ ,  $t_0 = -0.616$ ,  $t_r = 1.0$ ,  $t_{\lambda} = 17$ , and  $M = 0.2$ .

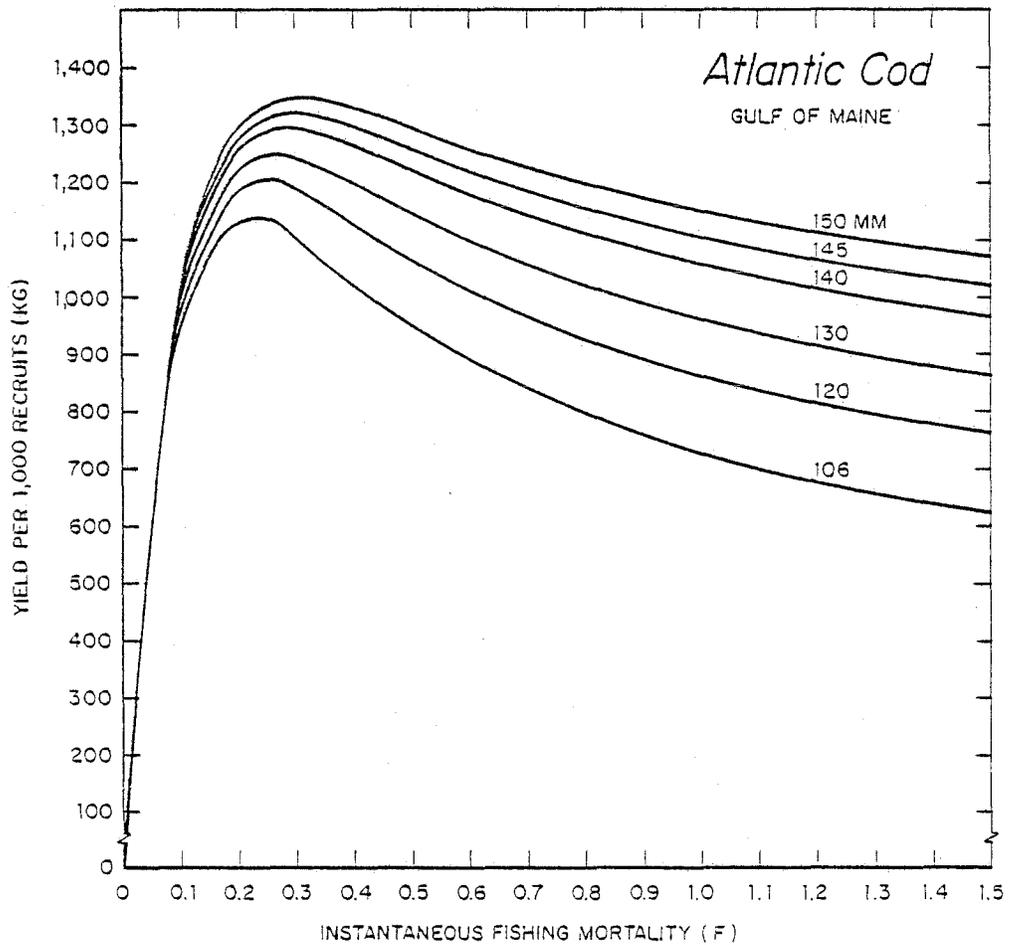


Figure 2. Yield per recruit curves for Gulf of Maine cod assuming otter-trawl cod-end minimum stretched mesh sizes of 106, 120, 130, 140, 145, and 150 mm. These values correspond to mean age at capture values of 2.9, 3.3, 3.6, 3.9, 4.1, and 4.2, respectively.  $W_{\infty} = 33.04$  kg,  $K = 0.116$ ,  $t_0 = 0.285$ ,  $t_r = 1.0$ ,  $t_{\lambda} = 17$ , and  $M = 0.2$ .