Status of the Atlantic Cod Stock on Georges Bank
in Unit Areas 5Zj and 5Zm, 1978-89

by

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Abstract

Reported landings, catch at age and research indices for Canada and the USA are presented for the 5Zj,m management unit. Reported landings in 1989 decreased from 20000 t in 1988 to about 14000 t, primarily due to a reduction in Canadian OTB landings. Canada accounts for about 65% of total landings. Landings were dominated by the 1985 (40%) and the 1987 (27%) yearclasses in 1989. Revised estimated of USA survey indices (spring and autumn) in the 5Zj,m were calculated. Catch at age and all three survey indices were used in an ADAPT formulation to estimate population status. The resultant estimate of 3+F in 1989 was 0.29, the lowest in the series and may reflect premature closure of the Canadian OTB fishery. Population biomass in 1990 is estimated to be 69000 t, well above the 49000 t average. Catch projection for 1991, assuming a 1990 catch of 22000 t, indicates catches in the order of 11000 t (F0.1), 16000 t (F 50%) and 22000 t (status quo). Fishing mortality (3+) in 1990 is expected to be 0.39 and between 0.2 - 0.4 in 1991, depending on catch options. An analysis of the ratio of biomass in the Canadian zone of 5Zj,m indicates considerable seasonal and annual variation but an overall average of about 70%.

Résumé

On présente ici les débarquements déclarés, les prises selon l'âge et les indices de recherche canadiens et américains pour l'unité de gestion 5Zj,m. Les débarquements déclarés sont passés de 20 000 t en 1988 à environ 14 000 t en 1989, cela à cause surtout d'une baisse des prises au chalut à panneaux du côté canadien. La part du Canada représente environ 65 % des débarquements totaux. En 1989, ceux-ci ont été dominés par les classes d'âge de 1985 (40 %) et de 1987 (27 %). On a révisé les estimations d'indices de relevé américains (printemps et automne) dans l'unité 5Zj,m. Les prises selon l'âge et les trois indices de relevé ont servi à établir une formule ADAPT permettant d'estimer l'état de la population. Il en est résulté une estimation de 0,29 pour 3+F en 1989, la plus basse de la série, qui pourrait être due à la fermeture prématurée de la pêche au chalut à panneaux du côté canadien. On estime que la biomasse de population était de 69 000 t en 1989, ce qui est très supérieur à la moyenne de 49 000 t. Les projections de prises pour 1991, fondées sur des prises chiffrées à 22 000 t pour 1990, sont de l'ordre de 11 000 t ($F_{0.1}$), 16 000 t (F 50%) ou 22 000 t (statu quo). On s'attend à ce que la mortalité due à la pêche (3+) soit de 0,39 en 1990 et se situé entre 0,2 et 0,4 en 1991, selon l'option retenue pour les prises. Une analyse de la proportion de la biomasse située du côté canadien de l'unité 5Zj,m révèle une variation saisonnière et annuelle considérable, la moyenne générale étant d'environ 70 %.

## Introduction

The present report incorporates commercial catch data and research survey results to estimate stock status of cod for the 1978-89 time period in the two unit areas 5Zj and 5Zm. Definition of this management unit is based on analysis of tagging results as well as commercial and survey catch distribution and more recent tagging studies.

Cod are taken by both Canada and the USA in unit areas 5Zj and 5Zm and all data relating to USA catches, C/E and research vessel surveys were provided by the National Marine Fisheries Service (NMFS) at the Woods Hole, Mass., Laboratory.

## Trends in Reported Landings

Catches from unitareas 5Zj and 5Zm are thought to be under- or mis-reported prior to 1978 and estimates of population status prior to this time are suspect. Catch statistics since 1977, when foreign fleets were excluded from the 200 mile economic zones of Canada and the USA, are thought to be more reliable. Spatial distribution of foreign fleet catches in Subdiv. 5Ze are unknown. There have been no reported landings by foreign fleets since 1978.

### Fishery by Country and Gear

Canadian catches of cod are taken on the "Northeast Peak" of Georges Bank primarily between April and November. Landings have been dominated by otter trawlers, except in 1984 and 1989 (Table 1,Fig. 1). In 1988, otter trawlers, longliners and gillnetters accounted for 60%, 35% and 5%, respectively, of the 12700 t catch, the second highest in the twelve year series. In 1989 fixed gear (longline and gillnet) catches were 5400 t while those by otter trawl declined to 1900 t. The below average catch by otter trawlers reflects early closure of the fishery when the combined quota for 4X+5 was exceeded.

Catches by Canada and the USA in unitarea 5Zj and 5Zm for 1978-89 are summarized in Table 2 and in Figure 2. Catches peaked at 26000 t in 1982, averaged to about 16000 t between 1983-87 and increased to 20000 t in 1988. Since 1985, Canada has taken about 65% of the total catch. The reduction in 1989 to 14000 t was a result of decreased mobile gear catch by both Canada and the USA.

Temporal distribution of combined USA and Canada catches in 5Zj and 5Zm is shown in Table 3 by month. About 20% of the catch is taken in the first quarter, 10% in the last quarter and the remaining 70% in the April-September period.

## Age Composition of the Commercial Catch

### Sampling Intensity

Sampling coverage of the Canadian fishery prior to 1985 averaged about one sample per 1000 t landed. In 1985, 18 samples were collected, 19 in 1986 with a substantial increase to 33 samples in 1987, 40 in 1988 and 32 in 1989. Prior to 1978, sampling levels for Canadian catches were very low and it is unlikely that reliable estimates of removals at age could be obtained.

## Age Composition

Canadian samples were used to obtain statistics by age. The bias introduced
by applying otter trawl length frequencies to partition longline catches may
be significant in years lacking samples for this gear. Percent age composition
of Canadian catches are shown in Table 4(a). The 1985 year-class accounted
for 40% of the catch in numbers and the 1987 year-class at age 2 for 27% in
1989.

For the length weight relationship, values for a and b were derived from
Canadian commercial sampling data. With round weight in kilograms and length in
centimeters these values were a=0.0000163 and b=2.9048 and they were used
for both Canadian and USA sampling data.

Catch at age in the USA fishery for 1978-89 was estimated from USA samples of
5Zj and 5Zm catches for each year. Annual samples by market category and month
(or less frequent intervals if samples were not available) were combined to
provide estimates of catch at age by market category (Table 4(b)). Total USA
catch at age in 5Ze was available and used to estimate USA catch excluding
that in 5Zj,m (Table 4(c)). Comparison of percent catch at age for the two
USA areas indicates similarity in yearclass dominance but a higher proportional
catch at age two in the area outside of 5Zj,m. This could indicate either
a degree of emigration by young fish to outside the 5Zj,m area or relate
seasonal differences in the USA fishery.

The ratio of proportional catch at age for the USA and Canada in 5Zj,m is
given in Table 5. The ratio is close to 1 for most dominant age groups but
there is an indication of higher proportions in older agegroups for USA
catches. USA catch at age was added to the Canadian data to give an estimate
of total catch at age in 5Zj,m. The resultant proportional catch at age and
catch in numbers are given in Tables 6 and 7. In 1989, the 1985 yearclass
continued to dominate catches (43%) and the 1987 yearclass was also well
represented (Fig. 3). However, the 1986 yearclass at age 3 made a more
substantial contribution than expected from previous estimates of its
abundance. Survey indices and catch at age 2 suggest this yearclass is below
average, but sampling data for 1989 indicate the contribution of this
year-class was well estimated.

Mean length and weight at age for Canadian samples are given in Table 8 with
the plus age group set to 115 cm and 15 kg, the approximate mean for ages
10-15. There appears to be no trend in size or weight at age over the 12 year
time series.

### Stock Abundance Trends

### Research Surveys

Random, depth-stratified bottom trawl surveys have been conducted by NMFS in
the autumn since 1963 and a spring survey was added in 1968. A summer survey
was conducted from 1977 to 1981. Surveys in Subdivision 5Ze were completed by
Canada in March 1986-89. Mean catch per tow in numbers by age group for each
of the USA surveys is given in Table 9. No adjustment for different gears or
vessels used during the time series has been made. The spring survey used the
larger "Yankee 41" trawl from 1973-81 and considerable differences in catch

per tow might be anticipated. Total net  opening of the "41" trawl is about 1.7
times the opening of the "Yankee 36". New trawl doors have been used for both
spring and autumn surveys since 1985. Preliminary analysis of a study to
develop conversion factors indicates the new trawl doors are more effective.
The value of the conversion factor has not been resolved. However,
catches since 1985 do not appear to indicate a substantial change in
catchability, relative to the pre-1985 catches, and consultation with USA
researchers suggests a conversion factor for cod may not be necessary.

Data for USA surveys were provided by the NMFS and it was necessary to
reformat these data prior to their incorporation in the survey database
for analysis using STRAP software. An initial test to ensure correct
conversion and loading of data was carried out and comparison of total
abundance estimates in the 5Ze area showed no significant difference
between STRAP estimates and the reported USA estimates. However, some
differences in age-specific estimates was observed but this was
attributed to adjustment of age length keys (see below) and it was
concluded that STRAP estimates could replicate USA estimates.

To provide a survey index specific to 5Zj and 5Zm, USA and Canadian surveys for
1978-90 were re-analyzed. Only sets within the boundary of 5Zj and 5Zm were
included and the total stratum area inside the boundary was calculated for
each stratum. Three stratification schemes have been used to survey the area
and they include the Canadian 1986, 1987-90 and USA 1978-89 designs. Results
of re-partitioning strata are given below:

|  | Stratum | Total Area | 5Zj and 5Zm Area | |
|---|---|---|---|---|
| Canadian: | | | | |
| 1986 | 552 | 1179 | 1073 | sq. mi. |
|  | 553 | 2712 | 2696 | |
|  | 554 | 2672 | 79 | |
|  | 555 | 2082 | 1253 | |
| 1987-90 | 521 | 795 | 795 | |
|  | 522 | 1252 | 1252 | |
|  | 523 | 2295 | 1504 | |
|  | 524 | 3079 | 1350 | |
| USA | | | | |
| 1978-89 | 16 | 2980 | 2980 | |
|  | 17 | 360 | 360 | |
|  | 18 | 172 | 172 | |
|  | 19 | 2454 | 1059 | |
|  | 20 | 1221 | 335 | |
|  | 21 | 424 | 285 | |
|  | 22 | 454 | 229 | |

Initial results of STRAP for USA surveys indicated substantial numbers
of 'unknown' age fish. It was concluded that the sampling design for
USA surveys (duplicate measurement of fish in length frequencies and age
samples as well as no ageing below a specified length) was the primary
cause of unaged fish. Therefore, modified age length keys were used
to partition length frequencies. Modified keys were constructed by
augmenting existing keys with probable proportions at age for lengths with

no age observation. Since development of modified keys was based on
a subjective judgment of expected proportions of agegroups by length it
is unlikely that USA and Canadian results would be identical. However,
each of the modified keys are included in the STRAP output and it is
therefore possible to compare the impact of adjusted keys if required
in the future.

Results of STRAP analysis for each of the surveys are given in Table 9.
The 1982 USA spring survey is influenced by one tow of 1000 fish and the
resultant high catch rate has a high standard error. This tow has been
excluded by USA researchers in their analysis. Examination of tows in the
1982 survey indicates above average catches in several sets and strata
and therefore all tows were included in the present study. The 1990
spring USA survey was partitioned to age groups using the Canadian spring
1990 age length key since USA ageing was not available.

Total catch per tow has been variable for each of the surveys and a general
increase in the last 2-3 years of each survey is evident. Catch per tow is
strongly influenced by progression of year-classes over time and in particular
the 1983 and 1985 yearclasses.

The fall survey is assumed to be a post-fishery index and spring surveys are
assumed to be a pre-fishery index. Therefore the fall survey is lagged by one
year for comparison of indices (ie. fall 1977 age one vs spring 1978 age two).
In general, all three surveys appear to track yearclass strength and provide
a consistent index. The 1987 yearclass, which will be a substantial factor in
the 1990-93 fishery, appears to be above average in the Canadian and USA
spring surveys in 1989 and 1990.

Canada has conducted a summer survey in the Canadian zone (5Zc) in 1989 and
1990. The 1990 total mean catch per tow (16.2) was less than half that in
1989 (38.1) but the significance of this decline cannot yet be determined.
The decline occurred across all agegroups and may indicate a year effect
rather than an actual decrease in abundance.

Commercial Catch Rates

Canadian C/E for the mobile gear fleet in 1989 was not considered to be a
reliable index because of the premature closure of the fishery and an
updated C/E series was not possible. USA C/E was not available for 1988
or 1989. Therefore commercial C/E was not included in the analysis.


Estimation of Stock Size

Commercial C/E for Canada was not considered an appropriate index of
stock abundance. USA C/E for 1988 and 1989 were not available. Therefore
only research survey indices were used in the ADAPT formulation.


Initially, seven ADAPT formulations were considered. All three surveys,
combinations of surveys and each survey individually were examined to
determine consistency in population estimates. Results for weighted, by
population numbers, 3+ fishing mortality (as an index of population status)
and plusgroup population statistics are summarized in Table 10. Survey

combinations show similar estimates of population status. However, when
considered separately, the USA spring indicates the most pessimistic stock
status, the Canadian survey the most optimistic while the USA autumn survey
is intermediate. It was concluded that the three survey indices, when combined,
reflected a median estimate of stock status and therefore the ADAPT
formulation using all three indices was considered the best representation
of stock status.

Impact of the high 1982 USA spring survey index was examined by recalculating
the index without the anomolously high tow (see above). No improvement in
the statistical significance of parameter estimates was obtained when this
adjustment was included in the ADAPT formulation and it was concluded that
1982 USA survey index should be used without adjustment.

The Canadian survey, given its short time series, was considered a potential
source of increased variance in population estimates. However, comparison of
results obtained without the Canadian survey with those obtained using all
three indices indicated little change in estimated parameters or their
statistical significance. Therefore the ADAPT formulation using all three
indices was accepted. Initial ADAPT runs estimated survey coefficients for
ages 1-4 (0-3 autumn) with coefficients at older ages assumed to be equal
that for age 4. Extending calibration to age 5 (age 4 autumn) did not
influence population estimates or improve confidence in estimated parameters.

The resultant ADAPT formulation used to estimate stock status was therefore
based on estimates of the following parameters:

Year-class estimates $N_{i,1990}$ $i=1,4$

Calibration coefficients for each of the three surveys, where

$K_i$ $i=1,4$ USA spring survey
$K_i$ $i=0,3$ USA autumn survey
$K_i$ $i=1,4$ Canadian spring survey

Assumed catchability for ages greater than age 4 (age 3 autumn) equal
the oldest estimated for each survey. The following structure was imposed in
ADAPT model:

- error in catch assumed negligible
- F on oldest age group set to weighted F for ages 3-8
- F for ages 5-8 in 1989 set to F at age 4
- no intercept term fitted
- natural mortality set to 0.2
- logarithmic transform for indices

Input for the model consisted of:

- $C_{i,t}$ $i=1,9$; $t=1978-89$
- $RV1_{i,t}$ $i=1,9$; $t=1978-90$ USA spring survey
- $RV2_{i,t}$ $i=0,8$; $t=1977-89$ USA fall survey
- $RV3_{i,t}$ $i=1,9$; $t=1986-90$ Canadian spring survey

and the objective function required minimization of:

$$\sum_i \sum_t \{obs(\ln RV1_{i,t}) - pred(\ln RV1_{i,t})\}^2$$
$$+ \sum_i \sum_t \{obs(\ln RV2_{i,t}) - pred(\ln RV2_{i,t})\}^2$$
$$+ \sum_i \sum_t \{obs(\ln RV3_{i,t}) - pred(\ln RV3_{i,t})\}^2$$

and a total of 21 parameters were estimated from 116 observations.

Residuals for survey indices with zero catch at age (predominantly the USA fall survey) were excluded from the overall sum of residuals.

Calibration coefficients and population estimates were statistically significant from the above run except at age 1 (75% CV). Coefficients of variance were about 14-30% for USA survey catchability and the Canadian survey had higher CV's (22-49%), probably due to the short time series. Residuals for both USA survey indices were balance in most cases but some year effect was evident for the 1982 spring, and 1983, 1986 and 1987 fall surveys. The 1990 Canadian spring survey also had a strong pattern in residuals

The resultant residuals for the ADAPT formulation using all three indices are given in Table 11. Parameter estimates for stock numbers at age in 1990 and the slopes relating survey indices to population numbers, with their standard error and standard error/mean, are given in Table 12.

## Assessment Results

Population estimates from the above ADAPT formulation are given in Table 13 and indicate that the 1985 year-class is the largest observed with about 30 million fish at age 1. The 1980, 1983 and 1987 are also estimated to be well above the 1978-89 average abundance. The 1989 year-class, while not well estimated, appears to be above average in abundance at age 1. For ages 3+ abundance has increased from a low of 8 million in 1985 to a high of 22 million in 1988 and has remained at about that level in 1990. The 3+ biomass in 1990 is 69000 t and well above the 13 year average of 49000 t. Population biomass, abundance, fishing mortality for ages 3+ and recruitment at age 1 are given in Figures 4-7.

Fully recruited (3+) fishing mortality in 1989 is estimated to be 0.29, the lowest in the 12 year series. However, early closure of the Canadian OTB fishery in 1989 and a decline in USA 1989 catches contributed to the reduced exploitation rate. The 1986 year-class has an anomolously high F of 0.45 in 1989, a reflection of the unexpected high catch at age 3 in 1989.

To compare results of population status in 5Zj,m with those in 5Ze a similar ADAPT formulation using 5Ze indices and catch at age was examined. Results are given in Table 14 and summarized in Figure 8. While the overall trend in stock status is similar for 5Zj,m and 5Ze, some differences are apparent. Three plus biomass in 5Ze declined from 1978 to 1987 while it remained stable in 5Zj,m. An increase since 1987 occurred in both areas. Fishing mortality was higher in 5Ze compared to 5Zj,m and has diverged since 1987 with increased F's in 5Ze but a decreare in 5Zj,m. This indicates a higher exploitation rate outside the 5Zj,m area and possible differential recruitment between the two areas.

## Yield Per Recruit

A yield per recruit analysis using input data specific to the 5Zj,m area
was carried out. Mean weight at age derived from Canadian 1978-89
commercial catch samples and partial recruitment derived from the F matrix
for 1978-89 were used in the analysis. Full recruitment at age 3+ was assumed
and input parameters were as follows:

| Age | Mean Weight (kg) | Partial Recruitment |
|-----|------------------|---------------------|
| 1 | 0.696 | 0.004 |
| 2 | 1.391 | 0.378 |
| 3 | 2.249 | 1.000 |
| 4 | 3.579 | 1.000 |
| 5 | 5.012 | 1.000 |
| 6 | 6.448 | 1.000 |
| 7 | 8.333 | 1.000 |
| 8 | 10.340 | 1.000 |
| 9 | 10.948 | 1.000 |
| 10 | 13.723 | 1.000 |
| 11 | 16.499 | 1.000 |
| 12 | 17.869 | 1.000 |

and a value of 0.20 was assumed for natural mortality. The estimated
$F_{0.1}$ was 0.19 with a Y/R of 1.5866 and $F_{max}$ was 0.32 with a
Y/R of 1.6845. The calculated value of $F_{0.1}$ was close to the value
of 0.20 used for most cod stocks and therefore $F_{0.1}=0.20$ was
accepted for the 5Zj,m stock. Year-class abundance at age 2 appears to
influence partial recruitment which varies from about 20% for small
year-classes to as high as 60 for abundant year-classes. The mean value of
38% used in the Y/R should reflect average conditions.

## Prognosis and Catch Projection

The following input data were used for catch projections:

| Age | 1990 Beginning of Year Populations Numbers (000's) | Mean Weight (kg) | Partial Recruitment |
|-----|-----|-----|-----|
| 1 | 9959 | 0.696 | 0.004 |
| 2 | 6978 | 1.391 | 0.299 |
| 3 | 9659 | 2.249 | 1.000 |
| 4 | 1611 | 3.579 | 1.000 |
| 5 | 6465 | 5.012 | 1.000 |
| 6 | 556 | 6.448 | 1.000 |
| 7 | 647 | 8.333 | 1.000 |
| 8 | 78 | 10.340 | 1.000 |
| 9 | 133 | 10.948 | 1.000 |

As indicated earlier, the results of the assessment suggested that the
1989 year-class was above average in abundance. However, because the
estimate is imprecise, the 1989 year-class was assumed to be equal to the
geometric mean for the 1977-88 year-classes.

Results of the projection are given in Table 14. If the expected catch of

22000 t is taken in 1990, the fishing mortality will be about F=0.39, well above $F_{0.1}$ but similar to exploitation rates seen in recent years. Biomass (3+) is expected to decline from 69000 t to about 54000 t in 1991.

Catch projection for 1991 was completed using three options - fishing at $F_{0.1}$ in 1991, using the 50% rule in 1991 and a catch in 1991 equal the catch in 1990. Results of projections with these options, which are for total catch (USA and Canada), are given below:

| Option | F(3+) | | Biomass 3+ ('000 t) | | Catch ('000 t) | |
|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1990 | 1991 | 1990 | 1991 |
| 1. 22000 t in 1990 $F_{0.1}$ in 1991 | 0.39 | 0.20 | 54 | 53 | 22 | 11 |
| 2. 22000 t in 1990 50% rule in 1991 | 0.39 | 0.30 | 54 | 51 | 22 | 16 |
| 3. 22000 t in 1990 and in 1991 | 0.39 | 0.43 | 54 | 48 | 22 | 22 |

If fishing mortality is not allowed to exceed that in 1990, then a catch of about 20000 t in 1991 is implied. Cod in 5Zj,m are fully recruited at age 3 which means that forecasts are heavily dependent on estimates of incoming recruitment. The 1985 and 1987 year-classes will likely continue to contribute substantially to catches in 1991 but it is difficult to precisely forecast catches beyond 1991 because recruitment is variable and unpredictable. Recruitment in 1991 and later years will have a substantial impact on actual catches.

## Management Considerations

Cod in the 5Zj,m management unit will continue to be exploited by both the USA and Canada and it is necessary to develop a consistent management plan. The apparent reduction in fishing mortality in recent years indicates some improvement in stock status which could be the result of reduced catches by the USA after exclusion from 5Zc. Since 1985, the USA has accounted for an average of about 38% of the total 5Zj,m catch.

A study was undertaken to estimate the ratio of the 5Zj,m cod biomass relative to the 5Zc/5Zu (International) boundary as a means of determining the proportion of total biomass in 5Zj,m which would be available to the Canadian fleet. The approach used was similar to that used in estimating research survey abundance for the 5Zj,m area except that calculations were made relative to the 5Zu (USA) and the 5Zc (Canadian) part of the 5Zj,m management area. Within strata, only sets inside the respective boundary were selected for STRAP analysis and the subset area of each stratum used to calculate abundance. Initial trials resulted in missing observations for one or more strata in several years due to lack of sets in the area subset for USA surveys. The Canadian survey, which incorporates the 5Zu/5Zc boundary as a stratum boundary, did not have the same problem.

Examination of individual strata results for USA surveys identified US} strata 17,18,21 and 22 (see Figure 9) as having the most missing observations and of these only strata 21 and 22 appeared to require some adjustment for

Table 1. Nominal landings of cod by gear and month for Canada(M) in unit areas 5Zj,m. (Ot - otter trawl; LL - longline; GN - gillnet; Misc - miscellaneous)

| Year | Gear | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 78 | Ot | 167 | 763 | 241 | 26 | 305 | 1943 | 1139 | 22 | 220 | 1733 | 1625 | - | 8184 |
|  | LL | - | - | - | - | 11 | 193 | 295 | 128 | 74 | 19 | - | - | 720 |
|  | Misc | - | - | - | 1 | - | - | 1 | - | - | - | - | - | 2 |
|  | Total | 167 | 763 | 241 | 27 | 316 | 2136 | 1435 | 150 | 294 | 1752 | 1625 | - | 8906 |
| 79 | Ot | 72 | 301 | 179 | 78 | 74 | 1635 | 667 | 675 | 661 | 294 | 28 | 7 | 4671 |
|  | LL | - | - | - | 5 | 20 | 528 | 333 | 305 | 136 | 11 | - | - | 1338 |
|  | Misc | - | - | 1 | - | 1 | - | - | - | - | - | - | - | 2 |
|  | Total | 72 | 301 | 180 | 83 | 95 | 2163 | 1000 | 980 | 797 | 305 | 28 | 7 | 6011 |
| 80 | Ot | 23 | 86 | 4 | 53 | 110 | 1374 | 1594 | 786 | 637 | 617 | 69 | 100 | 5453 |
|  | LL | - | - | - | - | 208 | 950 | 596 | 496 | 337 | 47 | - | - | 2634 |
|  | Misc | - | - | 1 | 2 | 1 | 2 | 1 | - | - | - | - | - | 7 |
|  | Total | 23 | 86 | 5 | 55 | 319 | 2326 | 2191 | 1282 | 974 | 664 | 69 | 100 | 8094 |
| 81 | Ot | 2 | 204 | 55 | 8 | 38 | 540 | 1005 | 743 | 1024 | 36 | 230 | 98 | 3983 |
|  | LL | - | - | 1 | 2 | 537 | 1476 | 1043 | 837 | 286 | 281 | 56 | 5 | 4524 |
|  | Misc | - | - | - | 1 | - | - | - | - | - | - | - | - | 1 |
|  | Total | 2 | 204 | 56 | 11 | 575 | 2016 | 2048 | 1580 | 1310 | 317 | 286 | 103 | 8508 |
| 82 | Ot | 89 | 74 | - | - | 12 | 882 | 4283 | 2112 | 1509 | 2361 | 932 | 119 | 12372 |
|  | LL | - | 11 | 26 | 195 | 773 | 1036 | 1386 | 1083 | 634 | 307 | 34 | 4 | 5489 |
|  | Misc | - | - | - | - | - | - | - | - | - | - | - | - | - |
|  | Total | 89 | 85 | 26 | 195 | 785 | 1918 | 5669 | 3195 | 2143 | 2668 | 966 | 123 | 17862 |
| 83 | Ot | 179 | 80 | 9 | 6 | 35 | 2215 | 1094 | 2115 | 957 | 173 | 75 | 11 | 6949 |
|  | LL | - | - | 171 | 147 | 439 | 1441 | 699 | 576 | 1304 | 309 | 89 | - | 5175 |
|  | Misc | - | - | - | - | - | 6 | 34 | 3 | 5 | 1 | - | - | 49 |
|  | Total | 179 | 80 | 180 | 153 | 474 | 3662 | 1827 | 2694 | 2266 | 483 | 164 | 11 | 12173 |
| 84 | Ot | 5 | 3 | 13 | 1 | 39 | 272 | 93 | 239 | 61 | 19 | - | - | 745 |
|  | LL | - | - | 167 | 152 | 111 | 1192 | 1210 | 1183 | 605 | 286 | 49 | - | 4955 |
|  | Misc | - | - | - | - | - | 52 | 9 | - | - | - | - | - | 61 |
|  | Total | 5 | 3 | 180 | 153 | 150 | 1516 | 1312 | 1422 | 666 | 305 | 49 | - | 5761 |
| 85 | Ot | - | 2 | - | - | 165 | 1172 | 2561 | 2431 | 692 | 435 | 4 | 80 | 7546 |
|  | LL | - | 29 | 54 | 181 | 151 | 414 | 230 | 542 | 647 | 501 | 29 | 29 | 2807 |
|  | Misc | - | 1 | 2 | 14 | 15 | 24 | 9 | 19 | 4 | 2 | 1 | 1 | 92 |
|  | Total | - | 32 | 56 | 195 | 331 | 1606 | 2800 | 2992 | 1343 | 938 | 34 | 110 | 10441 |
| 86 | Ot | 15 | 9 | - | 15 | 6 | 2364 | 3137 | 477 | 49 | 11 | 4 | 22 | 6109 |
|  | LL | - | 58 | 81 | 12 | 24 | 146 | 120 | 538 | 606 | 409 | 12 | - | 2006 |
|  | Misc | 1 | 2 | 9 | 15 | 10 | 47 | 89 | 76 | 42 | 1 | - | - | 292 |
|  | Total | 16 | 69 | 90 | 42 | 40 | 2557 | 3346 | 1091 | 697 | 421 | 16 | 22 | 8407 |
| 87 | Ot | 18 | 1 | 3 | - | - | 2485 | 3811 | 889 | 145 | 2 | 78 | 44 | 7476 |
|  | LL | - | 6 | 112 | 68 | 8 | 292 | 591 | 1032 | 747 | 310 | 13 | 33 | 3212 |
|  | Misc | 5 | 11 | 15 | 17 | 9 | 142 | 466 | 391 | 89 | 2 | 6 | 2 | 1155 |
|  | Total | 23 | 18 | 130 | 85 | 17 | 2919 | 4868 | 2311 | 981 | 314 | 97 | 78 | 11843 |
| 88 | Ot | 23 | 520 | 57 | - | 13 | 3153 | 3138 | 416 | 18 | 99 | 29 | 9 | 7475 |
|  | LL | 54 | 86 | 68 | 205 | 27 | 1247 | 1686 | 392 | 386 | 114 | 10 | 1 | 4276 |
|  | Misc | 2 | 9 | 12 | 10 | 16 | 221 | 319 | 238 | 102 | 21 | 20 | 2 | 972 |
|  | Total | 79 | 615 | 137 | 215 | 56 | 4621 | 5143 | 1046 | 506 | 234 | 59 | 12 | 12723 |
| 89 | Ot | 4 | 140 | 7 | - | 2 | 1504 | 87 | 70 | 2 | 87 | 33 | 2 | 1938 |
|  | LL | 41 | 202 | 245 | 78 | 234 | 864 | 1050 | 1210 | 331 | 65 | - | - | 4320 |
|  | GN | - | - | - | - | - | 131 | 359 | 440 | 175 | 9 | - | - | 1114 |
|  | Misc | 7 | 7 | 9 | 22 | 47 | 176 | 85 | 151 | 15 | 3 | 3 | - | 525 |
|  | Total | 52 | 349 | 261 | 100 | 283 | 2675 | 1581 | 1871 | 523 | 164 | 36 | 2 | 7897 |

Table 2. Summary of total catches by Canada and the USA in unit areas
5Zj,m for 1978-89.

| Year | Canada | USA | Total |
|------|--------|------|-------|
| 1978 | 8906 | 5502 | 14408 |
| 1979 | 6011 | 6408 | 12419 |
| 1980 | 8094 | 6418 | 14512 |
| 1981 | 8508 | 8092 | 16600 |
| 1982 | 17862 | 8565 | 26427 |
| 1983 | 12173 | 8572 | 20745 |
| 1984 | 5761 | 10551 | 16312 |
| 1985 | 10441 | 6641 | 17082 |
| 1986 | 8407 | 5696 | 14103 |
| 1987 | 11843 | 4792 | 16635 |
| 1988 | 12723 | 7645 | 20368 |
| 1989 | 7897 | 6503 | 14400 |

Table 3. Proportional catch by month for USA and Canada in unit areas
5Zj,m 1978-89

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 78 | 0.04 | 0.12 | 0.07 | 0.05 | 0.07 | 0.19 | 0.12 | 0.03 | 0.03 | 0.16 | 0.13 | 0.01 |
| 79 | 0.03 | 0.07 | 0.09 | 0.06 | 0.06 | 0.23 | 0.12 | 0.14 | 0.08 | 0.06 | 0.04 | 0.02 |
| 80 | 0.04 | 0.12 | 0.07 | 0.06 | 0.05 | 0.19 | 0.19 | 0.11 | 0.08 | 0.05 | 0.01 | 0.02 |
| 81 | 0.03 | 0.14 | 0.05 | 0.02 | 0.06 | 0.18 | 0.19 | 0.13 | 0.10 | 0.04 | 0.03 | 0.02 |
| 82 | 0.02 | 0.05 | 0.06 | 0.03 | 0.06 | 0.11 | 0.27 | 0.14 | 0.10 | 0.11 | 0.04 | 0.01 |
| 83 | 0.03 | 0.09 | 0.05 | 0.03 | 0.05 | 0.23 | 0.14 | 0.16 | 0.13 | 0.04 | 0.03 | 0.02 |
| 84 | 0.08 | 0.18 | 0.05 | 0.04 | 0.07 | 0.17 | 0.14 | 0.12 | 0.07 | 0.05 | 0.01 | 0.01 |
| 85 | 0.03 | 0.08 | 0.10 | 0.05 | 0.05 | 0.11 | 0.19 | 0.20 | 0.09 | 0.07 | 0.01 | 0.02 |
| 86 | 0.04 | 0.12 | 0.11 | 0.07 | 0.04 | 0.20 | 0.24 | 0.08 | 0.05 | 0.03 | 0.00 | 0.01 |
| 87 | 0.04 | 0.02 | 0.04 | 0.06 | 0.06 | 0.20 | 0.30 | 0.15 | 0.06 | 0.02 | 0.02 | 0.03 |
| 88 | 0.05 | 0.08 | 0.08 | 0.05 | 0.05 | 0.28 | 0.27 | 0.06 | 0.03 | 0.01 | 0.02 | 0.02 |
| 89 | 0.06 | 0.08 | 0.06 | 0.06 | 0.09 | 0.28 | 0.13 | 0.14 | 0.04 | 0.03 | 0.02 | 0.03 |
| Mean | 0.04 | 0.10 | 0.07 | 0.05 | 0.06 | 0.20 | 0.19 | 0.12 | 0.07 | 0.06 | 0.03 | 0.02 |

Table 4. Percent catch at age of cod for Canadian and USA landings

| Age | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

(a) Canada

| Age | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.5 | 0.0 | 0.1 | 0.8 | 0.4 | 0.4 | 0.0 |
| 2 | 2.0 | 24.6 | 27.1 | 9.3 | 36.7 | 10.5 | 2.0 | 51.6 | 10.0 | 62.3 | 6.7 | 27.0 |
| 3 | 66.4 | 23.9 | 40.2 | 34.1 | 25.0 | 39.9 | 9.1 | 21.5 | 54.6 | 14.9 | 65.9 | 19.4 |
| 4 | 20.6 | 35.3 | 7.7 | 25.4 | 16.2 | 25.7 | 29.5 | 9.0 | 16.0 | 15.6 | 8.6 | 39.4 |
| 5 | 6.1 | 12.3 | 16.5 | 6.3 | 12.2 | 8.5 | 30.5 | 11.9 | 6.4 | 1.9 | 10.6 | 4.4 |
| 6 | 2.2 | 2.4 | 5.3 | 17.2 | 2.7 | 6.1 | 14.0 | 3.4 | 9.5 | 1.7 | 1.7 | 6.3 |
| 7 | 1.7 | 0.8 | 1.3 | 3.8 | 4.2 | 2.5 | 7.7 | 1.1 | 1.3 | 2.4 | 1.5 | 0.9 |
| 8 | 0.4 | 0.5 | 0.5 | 2.3 | 1.6 | 3.6 | 2.0 | 0.9 | 0.9 | 0.4 | 2.9 | 0.7 |
| 9 | 0.3 | 0.1 | 0.7 | 0.9 | 0.4 | 1.8 | 2.1 | 0.2 | 0.4 | 0.3 | 0.9 | 1.2 |

(b) USA in 5Zj,m

| Age | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.5 | 0.0 | 0.7 | 0.0 | 0.5 | 0.4 | 0.4 | 0.6 | 0.0 | 0.0 | 0.0 |
| 2 | 2.7 | 23.2 | 14.5 | 19.0 | 53.6 | 24.3 | 9.3 | 34.2 | 5.8 | 57.4 | 3.8 | 11.6 |
| 3 | 71.2 | 3.7 | 25.7 | 34.7 | 12.6 | 38.4 | 30.4 | 16.8 | 57.5 | 14.1 | 56.0 | 26.4 |
| 4 | 18.5 | 52.8 | 3.5 | 31.0 | 12.4 | 11.1 | 37.2 | 13.1 | 9.4 | 19.2 | 13.9 | 47.3 |
| 5 | 4.6 | 12.7 | 34.0 | 0.9 | 12.4 | 11.2 | 6.6 | 23.5 | 10.2 | 2.8 | 19.1 | 4.5 |
| 6 | 1.4 | 4.9 | 15.1 | 8.9 | 1.0 | 9.7 | 6.4 | 4.5 | 11.8 | 2.3 | 3.3 | 7.8 |
| 7 | 1.2 | 0.2 | 5.3 | 3.4 | 4.7 | 0.9 | 6.1 | 2.7 | 1.8 | 2.7 | 1.8 | 0.8 |
| 8 | 0.4 | 1.9 | 0.6 | 0.6 | 2.3 | 2.3 | 0.5 | 3.3 | 1.3 | 0.8 | 1.4 | 0.7 |
| 9 | 0.0 | 0.0 | 1.3 | 0.6 | 0.6 | 1.1 | 2.0 | 0.3 | 1.0 | 0.5 | 0.5 | 0.7 |

(c) USA in the remainder of 5Ze

| Age | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.4 | 0.9 | 0.1 | 2.8 | 0.7 | 1.1 | 1.7 | 3.0 | 0.2 | 0.0 | 0.0 |
| 2 | 4.2 | 19.5 | 27.6 | 33.0 | 55.1 | 29.6 | 16.0 | 51.3 | 23.6 | 65.8 | 18.5 | 24.5 |
| 3 | 63.8 | 8.3 | 42.9 | 35.2 | 18.2 | 46.3 | 38.6 | 17.3 | 55.6 | 9.3 | 63.9 | 33.5 |
| 4 | 18.8 | 51.3 | 2.3 | 15.4 | 11.6 | 9.8 | 30.6 | 10.4 | 6.6 | 17.6 | 5.2 | 36.3 |
| 5 | 8.0 | 11.1 | 13.8 | 1.0 | 8.0 | 5.9 | 5.1 | 13.3 | 4.0 | 2.3 | 9.2 | 1.8 |
| 6 | 0.3 | 5.1 | 7.2 | 10.3 | 0.8 | 4.9 | 3.5 | 2.7 | 5.2 | 2.3 | 1.4 | 3.2 |
| 7 | 4.0 | 0.9 | 3.3 | 3.1 | 2.8 | 0.6 | 3.5 | 1.7 | 0.7 | 1.8 | 0.9 | 0.5 |
| 8 | 0.4 | 3.4 | 0.7 | 0.7 | 0.5 | 1.6 | 0.2 | 1.5 | 0.8 | 0.5 | 0.8 | 0.1 |
| 9 | 0.4 | 0.0 | 1.3 | 1.2 | 0.3 | 0.6 | 1.5 | 0.1 | 0.5 | 0.2 | 0.1 | )0.0 |

Table 5. Ratio of USA to Canadian proportional catch at age of cod for
5Zj,m landings.

| Age | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 |
|-----|------|------|------|------|------|------|------|------|------|------|------|------|
| 1 | 0.1 | 1.0 | 0.2 | 6.7 | 0.1 | 1.1 | 41.0 | 3.9 | 0.7 | 0.0 | 0.0 | 1.0 |
| 2 | 1.4 | 0.9 | 0.5 | 2.0 | 1.5 | 2.3 | 4.7 | 0.7 | 0.6 | 0.9 | 0.6 | 0.4 |
| 3 | 1.1 | 0.2 | 0.6 | 1.0 | 0.5 | 1.0 | 3.3 | 0.8 | 1.1 | 0.9 | 0.9 | 1.4 |
| 4 | 0.9 | 1.5 | 0.5 | 1.2 | 0.8 | 0.4 | 1.3 | 1.5 | 0.6 | 1.2 | 1.6 | 1.2 |
| 5 | 0.7 | 1.0 | 2.1 | 0.1 | 1.0 | 1.3 | 0.2 | 2.0 | 1.6 | 1.5 | 1.8 | 1.0 |
| 6 | 0.6 | 2.0 | 2.8 | 0.5 | 0.4 | 1.6 | 0.5 | 1.3 | 1.2 | 1.4 | 1.9 | 1.2 |
| 7 | 0.7 | 0.2 | 4.0 | 0.9 | 1.1 | 0.4 | 0.8 | 2.5 | 1.4 | 1.1 | 1.2 | 0.9 |
| 8 | 1.1 | 3.8 | 1.1 | 0.3 | 1.4 | 0.6 | 0.2 | 3.5 | 1.5 | 1.8 | 0.5 | 1.0 |
| 9 | 0.0 | 0.1 | 1.8 | 0.7 | 1.4 | 0.6 | 0.9 | 1.2 | 2.5 | 1.7 | 0.6 | 0.6 |

Table 6. Percent age composition of cod for Canadian and USA landings
in 5Zj,m.

| Age | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 |
|-----|------|------|------|------|------|------|------|------|------|------|------|------|
| 1 | 0.0 | 0.3 | 0.0 | 0.4 | 0.1 | 0.5 | 0.3 | 0.2 | 0.7 | 0.3 | 0.3 | 0.0 |
| 2 | 2.3 | 23.9 | 22.7 | 14.6 | 42.4 | 16.4 | 7.3 | 46.4 | 8.3 | 60.9 | 5.6 | 20.0 |
| 3 | 68.4 | 14.1 | 35.1 | 34.6 | 21.2 | 39.6 | 24.6 | 20.1 | 56.0 | 14.7 | 62.3 | 22.7 |
| 4 | 19.8 | 43.8 | 6.2 | 28.5 | 15.1 | 19.7 | 35.6 | 10.3 | 13.3 | 16.7 | 10.8 | 43.2 |
| 5 | 5.5 | 12.5 | 22.9 | 3.4 | 12.3 | 9.7 | 13.8 | 15.6 | 8.0 | 2.2 | 14.0 | 4.5 |
| 6 | 1.9 | 3.6 | 8.9 | 12.8 | 2.2 | 7.6 | 8.8 | 3.8 | 10.5 | 1.9 | 2.3 | 7.0 |
| 7 | 1.5 | 0.5 | 2.7 | 3.6 | 4.4 | 1.8 | 6.7 | 1.6 | 1.5 | 2.5 | 1.6 | 0.9 |
| 8 | 0.4 | 1.2 | 0.6 | 1.4 | 1.9 | 3.1 | 0.9 | 1.7 | 1.0 | 0.5 | 2.3 | 0.7 |
| 9 | 0.2 | 0.1 | 0.9 | 0.8 | 0.5 | 1.6 | 2.1 | 0.2 | 0.7 | 0.3 | 0.7 | 1.0 |

Table 7. Catch at age of cod in numbers (000's) for Canada, USA and total in 5Zj and 5Zm, 1978-89.

|  |  | 1 | 2 | 3 | 4 | Agegroup 5 | 6 | 7 | 8 | 9 | 10+ | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 78 | Cdn | 2 | 65 | 2162 | 671 | 200 | 73 | 55 | 12 | 10 | 6 | 3256 |
|  | USA | 0 | 59 | 1571 | 409 | 102 | 32 | 26 | 9 | 0 | 0 | 2208 |
|  | Total | 2 | 124 | 3733 | 1080 | 302 | 105 | 81 | 21 | 10 | 6 | 5464 |
| 79 |  | 0 | 499 | 483 | 714 | 249 | 49 | 17 | 10 | 2 | 2 | 2025 |
|  |  | 10 | 443 | 71 | 1011 | 243 | 94 | 4 | 36 | 0 | 1 | 1913 |
|  |  | 10 | 942 | 554 | 1725 | 492 | 143 | 21 | 46 | 2 | 3 | 3938 |
| 80 |  | 1 | 704 | 1043 | 201 | 427 | 138 | 34 | 14 | 19 | 14 | 2595 |
|  |  | 0 | 212 | 374 | 51 | 496 | 220 | 77 | 9 | 19 | 0 | 1458 |
|  |  | 1 | 916 | 1417 | 252 | 923 | 358 | 111 | 23 | 38 | 14 | 4053 |
| 81 |  | 2 | 195 | 715 | 531 | 131 | 360 | 79 | 48 | 19 | 14 | 2094 |
|  |  | 17 | 458 | 835 | 745 | 21 | 215 | 82 | 14 | 15 | 3 | 2405 |
|  |  | 19 | 653 | 1550 | 1276 | 152 | 575 | 161 | 62 | 34 | 17 | 4499 |
| 82 |  | 7 | 2047 | 1394 | 906 | 678 | 150 | 234 | 91 | 24 | 45 | 5576 |
|  |  | 0 | 1399 | 328 | 324 | 324 | 25 | 124 | 60 | 16 | 12 | 2612 |
|  |  | 7 | 3446 | 1722 | 1230 | 1002 | 175 | 358 | 151 | 40 | 57 | 8188 |
| 83 |  | 15 | 345 | 1306 | 841 | 280 | 199 | 81 | 118 | 60 | 30 | 3275 |
|  |  | 13 | 575 | 910 | 262 | 265 | 229 | 21 | 54 | 27 | 13 | 2369 |
|  |  | 28 | 920 | 2216 | 1103 | 545 | 428 | 102 | 172 | 87 | 43 | 5644 |
| 84 |  | 0 | 21 | 98 | 317 | 328 | 151 | 83 | 22 | 23 | 33 | 1076 |
|  |  | 10 | 243 | 793 | 971 | 171 | 167 | 158 | 12 | 53 | 31 | 2609 |
|  |  | 10 | 264 | 891 | 1288 | 499 | 318 | 241 | 34 | 76 | 64 | 3685 |
| 85 |  | 4 | 2144 | 893 | 373 | 496 | 143 | 45 | 39 | 10 | 10 | 4157 |
|  |  | 8 | 646 | 317 | 248 | 444 | 85 | 51 | 62 | 5 | 25 | 1891 |
|  |  | 12 | 2790 | 1210 | 621 | 940 | 228 | 96 | 101 | 15 | 35 | 6048 |
| 86 |  | 19 | 229 | 1255 | 368 | 146 | 219 | 30 | 20 | 9 | 4 | 2299 |
|  |  | 9 | 95 | 939 | 153 | 167 | 192 | 30 | 21 | 17 | 10 | 1633 |
|  |  | 28 | 324 | 2194 | 521 | 313 | 411 | 60 | 41 | 26 | 14 | 3932 |
| 87 |  | 17 | 2784 | 667 | 697 | 84 | 76 | 109 | 20 | 13 | 5 | 4472 |
|  |  | 0 | 1116 | 274 | 373 | 55 | 44 | 52 | 15 | 9 | 5 | 1943 |
|  |  | 17 | 3900 | 941 | 1070 | 139 | 120 | 161 | 35 | 22 | 10 | 6415 |
| 88 |  | 16 | 247 | 2438 | 320 | 393 | 64 | 57 | 107 | 32 | 28 | 3702 |
|  |  | 0 | 92 | 1342 | 334 | 457 | 78 | 42 | 33 | 11 | 7 | 2396 |
|  |  | 16 | 339 | 3780 | 654 | 850 | 142 | 99 | 140 | 43 | 35 | 6098 |
| 89 |  | 0 | 645 | 464 | 941 | 106 | 151 | 22 | 17 | 28 | 15 | 2389 |
|  |  | 0 | 236 | 537 | 963 | 92 | 159 | 17 | 15 | 14 | 4 | 2037 |
|  |  | 0 | 881 | 1001 | 1904 | 198 | 310 | 39 | 32 | 12 | 19 | 4426 |

Table 8. Mean size at age of cod in 5Zj,m derived from Canadian samples, 1978-89.

(a) Length

| Year | 1 | 2 | 3 | Age group 4 | 5 | 6 | 7 | 8 | 9 | 10+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1978 | 44.3 | 53.9 | 57.9 | 63.6 | 74.6 | 76.0 | 89.9 | 86.0 | 93.6 | 115.0 |
| 1979 | - | 50.7 | 53.3 | 69.1 | 75.3 | 80.4 | 95.9 | 104.4 | 99.6 | 115.0 |
| 1980 | 36.7 | 49.3 | 60.1 | 66.7 | 78.0 | 85.7 | 87.6 | 105.6 | 105.2 | 115.0 |
| 1981 | 42.2 | 49.2 | 58.8 | 67.8 | 77.4 | 85.7 | 94.5 | 96.0 | 97.4 | 115.0 |
| 1982 | 36.8 | 49.8 | 57.1 | 69.8 | 78.6 | 84.9 | 95.0 | 95.8 | 107.2 | 115.0 |
| 1983 | 42.6 | 50.4 | 58.4 | 67.1 | 77.8 | 84.8 | 93.0 | 99.3 | 104.4 | 115.0 |
| 1984 | - | 50.2 | 60.4 | 70.2 | 76.9 | 83.5 | 92.2 | 99.7 | 101.4 | 115.0 |
| 1985 | 38.7 | 49.3 | 55.3 | 67.9 | 74.8 | 83.2 | 90.1 | 95.6 | 98.8 | 115.0 |
| 1986 | 39.6 | 51.7 | 63.5 | 71.0 | 79.7 | 86.9 | 92.8 | 96.2 | 94.5 | 115.0 |
| 1987 | 38.5 | 51.9 | 60.3 | 73.5 | 82.5 | 88.1 | 96.2 | 100.3 | 106.0 | 115.0 |
| 1988 | 40.9 | 48.0 | 60.3 | 70.1 | 79.9 | 84.5 | 95.3 | 100.1 | 102.3 | 115.0 |
| 1989 | 37.0 | 48.5 | 57.6 | 69.9 | 77.0 | 82.6 | 88.1 | 100.4 | 102.8 | 115.0 |

(b) Weight

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10+ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1978 | 0.656 | 1.206 | 2.121 | 2.644 | 3.540 | 5.682 | 6.141 | 9.268 | 8.399 | 15.0 |
| 1979 | - | 1.483 | 1.723 | 3.691 | 4.730 | 5.986 | 9.586 | 12.058 | 10.412 | 15.0 |
| 1980 | 0.572 | 1.348 | 2.427 | 3.241 | 5.116 | 6.707 | 7.148 | 12.324 | 12.169 | 15.0 |
| 1981 | 0.864 | 1.368 | 2.312 | 3.467 | 5.113 | 6.816 | 9.108 | 9.575 | 10.485 | 15.0 |
| 1982 | 0.592 | 1.410 | 2.128 | 3.814 | 5.335 | 6.656 | 9.158 | 9.574 | 12.941 | 15.0 |
| 1983 | 0.885 | 1.466 | 2.265 | 3.371 | 5.210 | 6.641 | 8.593 | 10.428 | 11.999 | 15.0 |
| 1984 | - | 1.438 | 2.477 | 3.841 | 4.977 | 6.310 | 8.541 | 10.486 | 11.034 | 15.0 |
| 1985 | 0.680 | 1.391 | 1.950 | 3.571 | 4.742 | 6.399 | 8.074 | 9.664 | 10.584 | 15.0 |
| 1986 | 0.723 | 1.573 | 2.897 | 3.944 | 5.623 | 7.208 | 8.618 | 9.512 | 9.996 | 15.0 |
| 1987 | 0.600 | 1.600 | 2.506 | 4.447 | 6.148 | 7.484 | 9.538 | 10.759 | 12.565 | 15.0 |
| 1988 | 0.790 | 1.270 | 2.489 | 3.862 | 5.662 | 6.641 | 9.309 | 10.765 | 11.636 | 15.0 |
| 1989 | 0.585 | 1.303 | 2.178 | 3.830 | 5.128 | 6.348 | 7.554 | 10.799 | 11.576 | 15.0 |

Table 9. Stratified mean catch per tow for survey indices. USA spring 1990 estimated with Canadian 1990 age length key.

|  | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(a) US spring 5Ze** | | | | | | | | | | | | | | |
| 1 |  | 0.22 | 0.29 | 0.03 | 1.96 | 0.39 | 0.22 | 0.27 | 0.12 | 0.88 | 0.03 | 0.73 | 0.39 | 0.23 |
| 2 |  | 0.13 | 0.88 | 1.46 | 1.40 | 4.51 | 1.27 | 0.28 | 2.70 | 0.43 | 1.62 | 0.66 | 1.79 | 0.90 |
| 3 |  | 3.57 | 0.19 | 1.74 | 2.28 | 7.64 | 1.97 | 0.48 | 0.66 | 1.85 | 0.40 | 3.25 | 0.83 | 2.14 |
| 4 |  | 0.66 | 1.22 | 0.14 | 1.43 | 6.55 | 0.49 | 0.84 | 1.11 | 0.37 | 0.79 | 0.42 | 2.02 | 0.86 |
| 5 |  | 0.43 | 0.37 | 1.13 | 0.10 | 5.38 | 0.47 | 0.28 | 1.40 | 0.56 | 0.07 | 0.66 | 0.33 | 1.36 |
| 6 |  | 0.11 | 0.16 | 0.25 | 0.68 | 0.08 | 0.30 | 0.31 | 0.28 | 0.63 | 0.17 | 0.07 | 0.46 | 0.12 |
| 7 |  | 0.51 | 0.06 | 0.11 | 0.25 | 1.53 | 0.05 | 0.15 | 0.23 | 0.05 | 0.15 | 0.05 | 0.05 | 0.25 |
| 8 |  | 0.05 | 0.11 | 0.03 | 0.11 | 0.36 | 0.13 | 0.01 | 0.19 | 0.14 | 0.04 | 0.07 | 0.09 | 0.03 |
| 9 |  | 0.08 | 0.02 | 0.03 | 0.01 | 0.07 | 0.01 | 0.09 | 0.04 | 0.12 | 0.05 | 0.01 | 0.06 | 0.03 |
| **(b) US spring 5Zj,m** | | | | | | | | | | | | | | |
| 1 |  | 0.17 | 0.44 | 0.02 | 1.38 | 0.64 | 0.44 | 0.13 | 0.08 | 1.13 | 0.01 | 0.58 | 0.27 | 0.06 |
| 2 |  | 0.01 | 1.70 | 1.90 | 1.27 | 9.40 | 2.33 | 0.14 | 3.67 | 0.62 | 2.17 | 0.45 | 1.96 | 0.51 |
| 3 |  | 3.27 | 0.14 | 1.86 | 1.97 | 20.28 | 4.06 | 0.52 | 1.15 | 2.05 | 0.46 | 5.05 | 0.59 | 2.76 |
| 4 |  | 0.72 | 1.65 | 0.18 | 1.40 | 18.09 | 0.87 | 0.78 | 1.92 | 0.55 | 0.98 | 0.50 | 3.02 | 0.90 |
| 5 |  | 1.03 | 0.64 | 1.93 | 0.06 | 13.78 | 0.68 | 0.31 | 2.75 | 0.78 | 0.01 | 0.84 | 0.58 | 1.13 |
| 6 |  | 0.22 | 0.22 | 0.38 | 0.49 | 0.01 | 0.42 | 0.25 | 0.60 | 0.98 | 0.34 | 0.08 | 0.68 | 0.12 |
| 7 |  | 0.88 | 0.11 | 0.08 | 0.25 | 4.50 | 0.18 | 0.22 | 0.35 | 0.05 | 0.28 | 0.03 | 0.09 | 0.31 |
| 8 |  | 0.12 | 0.14 | 0.05 | 0.10 | 1.01 | 0.07 | 0.01 | 0.45 | 0.21 | 0.06 | 0.14 | 0.07 | 0.04 |
| 9 |  | 0.05 | 0.01 | 0.04 | 0.01 | 0.57 | 0.01 | 0.14 | 0.13 | 0.27 | 0.11 | 0.01 | 0.11 | 0.05 |
| **(c) US autumn 5Ze** | | | | | | | | | | | | | | |
| 0 | 0.16 | 0.34 | 0.11 | 0.24 | 0.26 | 0.25 | 0.83 | 0.14 | 1.17 | 0.11 | 0.26 | 0.58 | 0.34 |  |
| 1 | 0.13 | 1.50 | 1.33 | 0.67 | 2.93 | 0.38 | 0.54 | 1.63 | 0.15 | 2.31 | 0.42 | 0.87 | 3.54 |  |
| 2 | 2.86 | 0.34 | 1.36 | 0.47 | 1.70 | 1.25 | 0.73 | 0.08 | 0.89 | 0.15 | 1.37 | 0.47 | 1.35 |  |
| 3 | 0.57 | 3.26 | 0.14 | 0.65 | 1.25 | 0.13 | 0.47 | 0.56 | 0.08 | 0.38 | 0.12 | 0.97 | 0.22 |  |
| 4 | 0.19 | 0.81 | 1.37 | 0.06 | 0.60 | 0.07 | 0.06 | 0.58 | 0.10 | 0.03 | 0.19 | 0.08 | 0.65 |  |
| 5 | 0.16 | 0.28 | 0.27 | 0.22 | 0.05 | 0.10 | 0.04 | 0.02 | 0.09 | 0.07 | 0.02 | 0.17 | 0.08 |  |
| 6 | 0.33 | 0.13 | 0.16 | 0.09 | 0.47 | 0.01 | 0.01 | 0.04 | 0.02 | 0.09 | 0.02 | 0.01 | 0.03 |  |
| 7 | 0.02 | 0.29 | 0.04 | 0.03 | 0.05 | 0.03 | 0.01 | 0.02 | 0.01 | 0.03 | 0.01 | 0.02 | 0.01 |  |
| 8 | 0.03 | 0.06 | 0.10 | 0.03 | 0.07 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.03 | 0.01 |  |
| **(d) US autumn 5Zj,m** | | | | | | | | | | | | | | |
| 0 | 0.08 | 0.17 | 0.26 | 0.49 | 0.49 | 0.01 | 0.94 | 0.04 | 2.24 | 0.22 | 0.29 | 0.18 | 0.52 |  |
| 1 | 0.01 | 2.14 | 2.40 | 1.16 | 3.44 | 0.67 | 0.08 | 1.82 | 0.39 | 5.20 | 0.24 | 1.02 | 0.91 |  |
| 2 | 5.12 | 0.21 | 2.38 | 0.62 | 1.78 | 0.83 | 0.27 | 0.09 | 1.80 | 0.11 | 1.53 | 0.33 | 2.13 |  |
| 3 | 1.02 | 4.14 | 0.17 | 0.98 | 1.37 | 0.05 | 0.57 | 0.66 | 0.30 | 0.35 | 0.23 | 2.13 | 0.36 |  |
| 4 | 0.28 | 0.59 | 2.20 | 0.04 | 0.39 | 0.08 | 0.03 | 1.08 | 0.03 | 0.01 | 0.19 | 0.25 | 0.97 |  |
| 5 | 0.22 | 0.09 | 0.36 | 0.28 | 0.02 | 0.01 | 0.02 | 0.03 | 0.01 | 0.01 | 0.01 | 0.44 | 0.13 |  |
| 6 | 0.27 | 0.09 | 0.13 | 0.03 | 0.04 | 0.01 | 0.02 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.05 |  |
| 7 | 0.03 | 0.13 | 0.04 | 0.04 | 0.01 | 0.04 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.07 | 0.01 |  |
| 8 | 0.01 | 0.01 | 0.03 | 0.04 | 0.01 | 0.01 | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 | 0.09 | 0.01 |  |
| **(e) Canadian spring 5Ze** | | | | | | | | | | | | | | |
| 1 |  |  |  |  |  |  |  |  |  | 0.60 | 0.25 | 0.28 | 1.64 | 0.43 |
| 2 |  |  |  |  |  |  |  |  |  | 2.27 | 2.13 | 0.99 | 2.78 | 2.43 |
| 3 |  |  |  |  |  |  |  |  |  | 2.81 | 0.93 | 4.67 | 1.38 | 3.78 |
| 4 |  |  |  |  |  |  |  |  |  | 0.37 | 1.09 | 0.59 | 2.84 | 2.09 |
| 5 |  |  |  |  |  |  |  |  |  | 0.65 | 0.34 | 1.02 | 0.36 | 3.87 |
| 6 |  |  |  |  |  |  |  |  |  | 0.44 | 0.12 | 0.13 | 0.42 | 0.42 |
| 7 |  |  |  |  |  |  |  |  |  | 0.26 | 0.22 | 0.08 | 0.05 | 0.93 |
| 8 |  |  |  |  |  |  |  |  |  | 0.04 | 0.08 | 0.17 | 0.10 | 0.12 |
| 9 |  |  |  |  |  |  |  |  |  | 0.07 | 0.03 | 0.04 | 0.12 | 0.12 |
| **(f) Canadian spring 5Zj,m** | | | | | | | | | | | | | | |
| 1 |  |  |  |  |  |  |  |  |  | 1.81 | 0.09 | 0.40 | 0.83 | 0.32 |
| 2 |  |  |  |  |  |  |  |  |  | 8.33 | 4.27 | 1.00 | 4.66 | 1.86 |
| 3 |  |  |  |  |  |  |  |  |  | 7.50 | 1.50 | 12.46 | 1.66 | 8.19 |
| 4 |  |  |  |  |  |  |  |  |  | 0.76 | 1.77 | 1.31 | 3.95 | 4.57 |
| 5 |  |  |  |  |  |  |  |  |  | 1.61 | 0.41 | 2.00 | 0.61 | 10.41 |
| 6 |  |  |  |  |  |  |  |  |  | 1.04 | 0.22 | 0.25 | 0.82 | 1.28 |
| 7 |  |  |  |  |  |  |  |  |  | 0.52 | 0.44 | 0.21 | 0.11 | 2.64 |
| 8 |  |  |  |  |  |  |  |  |  | 0.08 | 0.21 | 0.48 | 0.22 | 0.35 |
| 9 |  |  |  |  |  |  |  |  |  | 0.15 | 0.03 | 0.05 | 0.28 | 0.38 |

Table 10. Comparison of 3+ population and fishing mortality estimates from ADAPT
formulations using combinations of survey indices for cod in 5Zj,m.

| | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(a) Canadian and USA spring and USA autumn** | | | | | | | | | | | | |
| Numbers | 16752 | 10911 | 13203 | 13483 | 12839 | 14165 | 10642 | 8470 | 11345 | 9279 | 21685 | 15607 |
| Biomass | 34423 | 41762 | 51271 | 52175 | 52048 | 50186 | 43045 | 31768 | 44135 | 41380 | 69579 | 59918 |
| Weight F | 0.43 | 0.36 | 0.31 | 0.38 | 0.52 | 0.46 | 0.43 | 0.55 | 0.43 | 0.35 | 0.35 | 0.29 |
| **(b) USA spring and autumn** | | | | | | | | | | | | |
| | 16728 | 10887 | 13167 | 13427 | 12738 | 13968 | 10391 | 8187 | 10619 | 8476 | 21201 | 15035 |
| | 34373 | 41669 | 51123 | 51957 | 51687 | 49534 | 42068 | 30659 | 41364 | 37629 | 66217 | 56663 |
| | 0.44 | 0.36 | 0.31 | 0.38 | 0.52 | 0.46 | 0.45 | 0.57 | 0.47 | 0.39 | 0.36 | 0.31 |
| **(c) Canadian and USA spring** | | | | | | | | | | | | |
| | 16756 | 10916 | 13208 | 13490 | 12861 | 14210 | 10667 | 8502 | 11559 | 9450 | 20101 | 14261 |
| | 34432 | 41779 | 51295 | 52206 | 52116 | 50324 | 43185 | 31914 | 44840 | 42224 | 66247 | 55278 |
| | 0.43 | 0.36 | 0.31 | 0.38 | 0.52 | 0.45 | 0.43 | 0.54 | 0.42 | 0.34 | 0.38 | 0.32 |
| **(d) Canadian spring and USA autumn** | | | | | | | | | | | | |
| | 16776 | 10935 | 13241 | 13548 | 12935 | 14349 | 10926 | 8812 | 11941 | 10043 | 23949 | 17683 |
| | 34475 | 41857 | 51427 | 52417 | 52417 | 50821 | 44090 | 33022 | 46618 | 44914 | 77102 | 68660 |
| | 0.43 | 0.36 | 0.30 | 0.37 | 0.51 | 0.45 | 0.42 | 0.52 | 0.40 | 0.32 | 0.31 | 0.25 |
| **(e) Canadian spring** | | | | | | | | | | | | |
| | 17039 | 11206 | 13660 | 14188 | 14053 | 16704 | 13929 | 11943 | 20011 | 20076 | 43288 | 35870 |
| | 35034 | 42908 | 53132 | 54900 | 56481 | 58484 | 55673 | 45726 | 77794 | 89560 | 149778 | 149357 |
| | 0.43 | 0.35 | 0.29 | 0.35 | 0.46 | 0.37 | 0.31 | 0.36 | 0.22 | 0.15 | 0.16 | 0.12 |
| **(f) USA spring** | | | | | | | | | | | | |
| | 16720 | 10879 | 13151 | 13405 | 12705 | 13889 | 10263 | 8090 | 10406 | 8103 | 17564 | 11896 |
| | 34355 | 41635 | 51063 | 51872 | 51558 | 49279 | 41617 | 30216 | 40460 | 36126 | 56550 | 44657 |
| | 0.44 | 0.36 | 0.31 | 0.38 | 0.52 | 0.47 | 0.45 | 0.58 | 0.48 | 0.42 | 0.45 | 0.40 |
| **(g) USA autumn** | | | | | | | | | | | | |
| | 16734 | 10895 | 13180 | 13430 | 12772 | 14112 | 10488 | 8134 | 11051 | 9212 | 23383 | 17227 |
| | 34385 | 41695 | 51172 | 51992 | 51786 | 49905 | 42507 | 30819 | 42763 | 40203 | 72966 | 65070 |
| | 0.44 | 0.36 | 0.31 | 0.38 | 0.52 | 0.46 | 0.44 | 0.58 | 0.45 | 0.35 | 0.32 | 0.27 |

Table 11. Residuals for survey indices froa ADAPT foraualtion with Canadian, USA spring and USA fall surveys for cod in 5Zj,a.

(a) USA spring

| Age | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | -0.15 | 0.18 | -0.22 | 0.92 | 0.47 | 0.31 | -0.28 | -0.07 | 0.31 | -0.13 | 0.15 | 0.03 | -0.29 |
| 2 | | -0.32 | 0.52 | 0.93 | 0.38 | 7.73 | 1.70 | -0.33 | 2.18 | 0.08 | -0.84 | -0.06 | 0.38 | -0.35 |
| 3 | | -0.06 | -0.47 | -0.23 | 0.30 | 18.69 | 1.69 | -0.49 | 0.29 | -0.14 | -0.52 | 0.15 | -0.33 | -0.13 |
| 4 | | -1.08 | -1.10 | -0.38 | -0.73 | 16.57 | -0.47 | -1.38 | 0.99 | -0.05 | -0.95 | -0.37 | -1.78 | 0.13 |
| 5 | | 0.52 | -0.37 | 0.43 | -0.29 | 12.59 | -0.03 | -0.31 | 1.54 | 0.28 | -0.26 | -0.28 | 0.15 | -1.98 |
| 6 | | 0.03 | -0.06 | -0.23 | -0.34 | -0.21 | -0.12 | -0.09 | 0.31 | 0.40 | 0.07 | -0.08 | 0.14 | -0.15 |
| 7 | | 0.71 | -0.00 | -0.09 | -0.09 | 4.07 | 0.08 | -0.03 | 0.21 | -0.09 | -0.01 | -0.14 | 0.02 | -0.00 |
| 8 | | 0.10 | 0.04 | -0.03 | 0.01 | 0.80 | -0.13 | -0.03 | 0.35 | 0.14 | -0.03 | -0.03 | -0.02 | 0.00 |
| 9 | | 0.03 | 0.01 | -0.02 | -0.05 | 0.52 | -0.10 | 0.05 | 0.11 | 0.23 | 0.07 | -0.05 | 0.03 | -0.01 |

(b) USA fall

| Age | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | -0.24 | -0.10 | 0.02 | 0.03 | 0.32 | -0.12 | 0.53 | -0.11 | 1.41 | 0.08 | -0.14 | -0.06 | 0.17 | |
| 1 | -0.32 | 0.95 | 1.43 | 0.26 | 1.76 | 0.03 | -0.39 | 0.32 | -0.15 | 2.17 | -0.27 | -0.57 | 0.04 | |
| 2 | 3.68 | -0.05 | 1.48 | -0.10 | 1.09 | -0.20 | -0.17 | -0.28 | 0.85 | -0.31 | -0.59 | -0.07 | 0.88 | |
| 3 | 0.42 | 3.22 | -0.02 | 0.27 | 0.86 | -0.40 | -0.15 | 0.35 | 0.10 | -0.30 | -0.06 | 0.52 | 0.10 | |
| 4 | 0.11 | 0.25 | 1.70 | -0.08 | -0.01 | -0.16 | -0.18 | 0.68 | -0.14 | -0.08 | -0.18 | 0.11 | -0.07 | |
| 5 | 0.16 | -0.00 | 0.16 | 0.00 | -0.05 | -0.17 | -0.09 | -0.07 | -0.18 | -0.08 | -0.04 | 0.26 | 0.04 | |
| 6 | 0.21 | 0.05 | 0.07 | -0.09 | -0.10 | -0.03 | -0.06 | -0.01 | -0.02 | -0.08 | -0.05 | -0.01 | -0.05 | |
| 7 | 0.02 | 0.10 | 0.01 | 0.01 | -0.06 | -0.03 | -0.00 | -0.02 | -0.01 | -0.02 | -0.05 | 0.04 | -0.00 | |
| 8 | 0.00 | 0.01 | 0.01 | 0.02 | -0.01 | -0.03 | 0.00 | 0.00 | -0.00 | -0.00 | -0.01 | 0.06 | -0.01 | |

(c) Canadian spring

| Age | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | 0.71 | -0.10 | -0.17 | 0.52 | -0.15 |
| 2 | | | | | | | | | | 6.68 | -4.98 | -0.57 | -0.19 | -0.79 |
| 3 | | | | | | | | | | 2.39 | -0.77 | 1.05 | -0.48 | 1.46 |
| 4 | | | | | | | | | | -0.50 | -2.28 | -0.52 | -6.14 | 2.94 |
| 5 | | | | | | | | | | 0.57 | -0.15 | -0.34 | -0.30 | 3.89 |
| 6 | | | | | | | | | | -0.17 | -0.35 | -0.08 | -0.32 | 0.72 |
| 7 | | | | | | | | | | 0.23 | -0.18 | -0.14 | -0.03 | 1.99 |
| 8 | | | | | | | | | | -0.08 | 0.03 | 0.12 | 0.02 | 0.27 |
| 9 | | | | | | | | | | 0.07 | -0.06 | -0.07 | 0.11 | 0.25 |

Table 12. Parameter estimates for age 1-9 population at the beginning of
1990 and slopes for survey indices for cod in 5Zj,m.


APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION
ORTHOGONALITY OFFSET.........        0.006900
MEAN SQUARE RESIDUALS .......        0.930841

|     | PAR. EST. | STD. ERR. | SE/mean. |
| --- | --------- | --------- | -------- |
| Age | Population |          |          |
| 1   | 1.27584E4 | 9.57206E3 | 7.50255E-1 |
| 2   | 6.97809E3 | 3.01486E3 | 4.32046E-1 |
| 3   | 9.65876E3 | 3.59780E3 | 3.72491E-1 |
| 4   | 1.61150E3 | 6.85217E2 | 4.25205E-1 |
| 5   | 6.46502E3 | 2.68048E3 | 4.14613E-1 |
| 6   | 5.55920E2 | 2.31336E2 | 4.16132E-1 |
| 7   | 6.46785E2 | 3.08874E2 | 4.77554E-1 |
| 8   | 7.81403E1 | 4.45454E1 | 5.70069E-1 |
| 9   | 1.32586E2 | 6.11983E1 | 4.61576E-1 |
|     | US spring survey | | |
| 1   | 2.76735E-5 | 8.28579E-6 | 2.99413E-1 |
| 2   | 1.23815E-4 | 3.41610E-5 | 2.75904E-1 |
| 3   | 2.99148E-4 | 8.19488E-5 | 2.73941E-1 |
| 4+  | 4.80415E-4 | 6.21860E-5 | 1.29442E-1 |
|     | US Autumn survey | | |
| 0   | 2.77651E-5 | 8.23487E-6 | 2.96591E-1 |
| 1   | 1.24348E-4 | 3.57808E-5 | 2.87749E-1 |
| 2   | 1.29599E-4 | 3.55024E-5 | 2.73941E-1 |
| 3+  | 1.60594E-4 | 2.29285E-5 | 1.42773E-1 |
|     | Canadian spring survey | | |
| 1   | 3.68189E-5 | 1.80135E-5 | 4.89248E-1 |
| 2   | 3.80043E-4 | 1.74663E-4 | 4.59588E-1 |
| 3   | 6.96260E-4 | 3.14700E-4 | 4.51986E-1 |
| 4+  | 1.00857E-3 | 2.30165E-4 | 2.28209E-1 |

Table 13. Results of ADAPT formulation using Canadian and USA spring and USA autumn
survey indices for cod in 5Zj,m.

(a) Population numbers (000's)

| Age | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11678 | 9557 | 8812 | 16504 | 6263 | 4660 | 14719 | 5317 | 29750 | 5063 | 15616 | 8523 | 12758 |
| 2 | 2630 | 9559 | 7815 | 7214 | 13495 | 5121 | 3790 | 12041 | 4343 | 24332 | 4130 | 12771 | 6978 |
| 3 | 11127 | 2041 | 6974 | 5570 | 5315 | 7931 | 3361 | 2864 | 7334 | 3262 | 16392 | 3075 | 9659 |
| 4 | 3754 | 5732 | 1170 | 4428 | 3158 | 2793 | 4488 | 1945 | 1250 | 4020 | 1819 | 10001 | 1611 |
| 5 | 1054 | 2097 | 3132 | 730 | 2470 | 1472 | 1289 | 2509 | 1031 | 552 | 2323 | 898 | 6465 |
| 6 | 402 | 590 | 1271 | 1729 | 460 | 1116 | 712 | 604 | 1204 | 561 | 326 | 1133 | 556 |
| 7 | 344 | 234 | 353 | 717 | 895 | 218 | 526 | 295 | 288 | 614 | 350 | 139 | 647 |
| 8 | 34 | 208 | 173 | 189 | 441 | 409 | 86 | 213 | 155 | 182 | 357 | 197 | 78 |
| 9 | 37 | 9 | 129 | 121 | 99 | 225 | 179 | 40 | 83 | 90 | 117 | 165 | 133 |
| 3+ | 16752 | 10911 | 13203 | 13483 | 12839 | 14165 | 10642 | 8470 | 11345 | 9279 | 21685 | 15607 | 19149 |

(b) Biomass (t)

| Age | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6520 | 6471 | 5038 | 14157 | 3609 | 4108 | 9966 | 3547 | 21216 | 3327 | 12232 | 4990 | 7470 |
| 2 | 2598 | 13974 | 10532 | 9664 | 18727 | 7358 | 5383 | 16227 | 6719 | 38070 | 5150 | 16412 | 8967 |
| 3 | 19430 | 3451 | 16708 | 12523 | 10974 | 17481 | 8169 | 5388 | 20618 | 7892 | 39655 | 6511 | 20454 |
| 4 | 8072 | 20597 | 3794 | 15056 | 11684 | 9217 | 16884 | 6643 | 4860 | 17280 | 6816 | 37158 | 5988 |
| 5 | 2977 | 9670 | 16003 | 3647 | 12906 | 7466 | 6320 | 11350 | 5606 | 3319 | 12726 | 4418 | 31815 |
| 6 | 1805 | 3290 | 8539 | 11614 | 3007 | 7268 | 4435 | 3722 | 8417 | 4080 | 2103 | 6834 | 3355 |
| 7 | 1629 | 2181 | 2530 | 6396 | 8112 | 1859 | 4372 | 2295 | 2438 | 5765 | 3203 | 1008 | 4707 |
| 8 | 263 | 2480 | 2128 | 1764 | 4097 | 4216 | 901 | 1964 | 1456 | 1926 | 3761 | 2099 | 831 |
| 9 | 248 | 92 | 1569 | 1175 | 1268 | 2677 | 1964 | 406 | 740 | 1118 | 1314 | 1889 | 1515 |
| 3+ | 34423 | 41762 | 51271 | 52175 | 52048 | 50186 | 43045 | 31768 | 44135 | 41380 | 69579 | 59918 | 68664 |

(c) Fishing mortality

| Age | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.05 | 0.12 | 0.14 | 0.11 | 0.33 | 0.22 | 0.08 | 0.30 | 0.09 | 0.19 | 0.10 | 0.08 |
| 3 | 0.46 | 0.36 | 0.25 | 0.37 | 0.44 | 0.37 | 0.35 | 0.63 | 0.40 | 0.38 | 0.29 | 0.45 |
| 4 | 0.38 | 0.40 | 0.27 | 0.38 | 0.56 | 0.57 | 0.38 | 0.44 | 0.62 | 0.35 | 0.51 | 0.24 |
| 5 | 0.38 | 0.30 | 0.39 | 0.26 | 0.59 | 0.53 | 0.56 | 0.53 | 0.41 | 0.33 | 0.52 | 0.28 |
| 6 | 0.34 | 0.31 | 0.37 | 0.46 | 0.55 | 0.55 | 0.68 | 0.54 | 0.47 | 0.27 | 0.66 | 0.36 |
| 7 | 0.30 | 0.10 | 0.43 | 0.29 | 0.58 | 0.73 | 0.71 | 0.44 | 0.26 | 0.34 | 0.37 | 0.37 |
| 8 | 1.15 | 0.28 | 0.16 | 0.45 | 0.48 | 0.62 | 0.57 | 0.74 | 0.35 | 0.24 | 0.57 | 0.20 |
| 9 | 0.36 | 0.29 | 0.39 | 0.37 | 0.60 | 0.56 | 0.63 | 0.53 | 0.43 | 0.32 | 0.52 | 0.33 |
| 3+ | 0.43 | 0.36 | 0.31 | 0.38 | 0.52 | 0.46 | 0.43 | 0.55 | 0.43 | 0.35 | 0.35 | 0.29 |

Table 14. Results of ADAPT formulation using Canadian and USA spring and USA autumn survey indices for cod in 5Ze.

(a) Population numbers (000's)

| Age | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 28212 | 23524 | 19601 | 40403 | 17496 | 9620 | 28771 | 9315 | 47511 | 12773 | 29982 | 44107 | 24227 |
| 2 | 4653 | 23097 | 19229 | 15967 | 33055 | 14024 | 7789 | 23482 | 7505 | 38757 | 10431 | 24533 | 36111 |
| 3 | 25876 | 3451 | 16994 | 12390 | 10128 | 18103 | 7965 | 5199 | 13413 | 4950 | 24799 | 7100 | 17900 |
| 4 | 8194 | 14044 | 1871 | 8711 | 6228 | 4799 | 8612 | 3442 | 2056 | 6869 | 2722 | 12974 | 3006 |
| 5 | 2916 | 4621 | 7136 | 1091 | 4878 | 2757 | 2043 | 4085 | 1589 | 960 | 3745 | 1317 | 6842 |
| 6 | 1085 | 1641 | 2735 | 3748 | 683 | 2242 | 1231 | 923 | 1640 | 864 | 539 | 1737 | 795 |
| 7 | 1435 | 774 | 935 | 1254 | 1814 | 318 | 1002 | 516 | 379 | 771 | 482 | 225 | 958 |
| 8 | 62 | 864 | 565 | 361 | 656 | 865 | 110 | 396 | 225 | 231 | 395 | 253 | 119 |
| 9 | 159 | 8 | 478 | 381 | 187 | 350 | 404 | 48 | 140 | 118 | 134 | 148 | 173 |
| 3+ | 39727 | 25404 | 30714 | 27936 | 24575 | 29435 | 21367 | 14609 | 19442 | 14764 | 32816 | 23754 | 29793 |

(b) Biomass

| Age | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15751 | 15929 | 11207 | 34659 | 10083 | 8481 | 19481 | 6214 | 33882 | 8393 | 23484 | 25823 | 14184 |
| 2 | 4596 | 33763 | 25914 | 21392 | 45871 | 20151 | 11063 | 31645 | 11612 | 60640 | 13007 | 31526 | 46406 |
| 3 | 45186 | 5834 | 40716 | 27858 | 20911 | 39905 | 19361 | 9781 | 37706 | 11975 | 59991 | 15035 | 37908 |
| 4 | 17616 | 50464 | 6067 | 29622 | 23045 | 15835 | 32399 | 11755 | 7994 | 29531 | 10198 | 48207 | 11169 |
| 5 | 8236 | 21314 | 36457 | 5451 | 25483 | 13983 | 10014 | 18478 | 8645 | 5770 | 20516 | 6479 | 33671 |
| 6 | 4869 | 9157 | 18368 | 25168 | 4467 | 14603 | 7669 | 5689 | 11465 | 6289 | 3478 | 10479 | 4795 |
| 7 | 6798 | 7208 | 6691 | 11185 | 16434 | 2708 | 8324 | 4008 | 3211 | 7248 | 4409 | 1641 | 6968 |
| 8 | 479 | 10299 | 6960 | 3370 | 6093 | 8907 | 1148 | 3655 | 2116 | 2450 | 4160 | 2689 | 1261 |
| 9 | 1076 | 86 | 5821 | 3713 | 2404 | 4172 | 4421 | 484 | 1247 | 1474 | 1505 | 1695 | 1982 |
| 3+ | 84260 | 104361 | 121080 | 106367 | 98837 | 100112 | 83335 | 53850 | 72384 | 64737 | 104257 | 86225 | 97754 |

(c) Fishing mortality

| Age | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.01 | 0.00 | 0.02 | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.10 | 0.11 | 0.24 | 0.26 | 0.40 | 0.37 | 0.20 | 0.36 | 0.22 | 0.25 | 0.18 | 0.12 |
| 3 | 0.41 | 0.41 | 0.47 | 0.49 | 0.55 | 0.54 | 0.64 | 0.73 | 0.47 | 0.40 | 0.45 | 0.66 |
| 4 | 0.37 | 0.46 | 0.34 | 0.38 | 0.61 | 0.65 | 0.55 | 0.57 | 0.56 | 0.41 | 0.53 | 0.44 |
| 5 | 0.37 | 0.32 | 0.44 | 0.27 | 0.58 | 0.61 | 0.59 | 0.71 | 0.41 | 0.38 | 0.57 | 0.30 |
| 6 | 0.14 | 0.36 | 0.58 | 0.53 | 0.57 | 0.61 | 0.67 | 0.69 | 0.55 | 0.38 | 0.67 | 0.40 |
| 7 | 0.31 | 0.11 | 0.75 | 0.45 | 0.54 | 0.86 | 0.73 | 0.63 | 0.30 | 0.47 | 0.45 | 0.44 |
| 8 | 1.81 | 0.39 | 0.19 | 0.46 | 0.43 | 0.56 | 0.64 | 0.84 | 0.44 | 0.35 | 0.78 | 0.18 |
| 9 | 0.31 | 0.31 | 0.51 | 0.46 | 0.58 | 0.63 | 0.66 | 0.71 | 0.46 | 0.41 | 0.57 | 0.36 |
| 3+ | 0.39 | 0.42 | 0.47 | 0.45 | 0.57 | 0.58 | 0.60 | 0.68 | 0.48 | 0.40 | 0.48 | 0.49 |

Table 15. Results of catch projection for 1991 assuming a catch of
22000 t in 1990 for cod in 5Zj,a.

| Age | Beginning 1991 Population Number | Biomass | Option A 1991 Catch | Option B 1991 Catch | Option C 1991 Catch |
|---|---|---|---|---|---|
| 1 | 9959 | 6280 | 5 | 8 | 11 |
| 2 | 8141 | 9972 | 596 | 882 | 1245 |
| 3 | 5082 | 9420 | 1884 | 2698 | 3656 |
| 4 | 5347 | 15772 | 3154 | 4518 | 6121 |
| 5 | 892 | 3684 | 737 | 1055 | 1430 |
| 6 | 3579 | 19019 | 3804 | 5448 | 7381 |
| 7 | 308 | 2114 | 423 | 605 | 820 |
| 8 | 358 | 3052 | 610 | 874 | 1185 |
| 9 | 43 | 390 | 78 | 112 | 151 |
| 1+ | 33709 | 69703 | 11292 | 16200 | 22000 |
| 3+ | 19149 | 53451 | 10690 | 15310 | 20744 |

Catch of 22000 t assumed for 1990

Option A: Fishing at $F_{0.1}$=0.2 in 1991

Option B: Fishing at 50% rule F=0.3 in 1991

Option C: Catch in 1991 = catch in 1990 = 22000 t

Table 16. Stratified mean catch per tow of cod in 5Zj,m for USA and Canadian waters by stratum from USA surveys. Values estimated from a multiplicative model or assumed to be zero are indicated with an '*'.

**Autumn**

| Year | 16 USA | 16 Cdn | 17 USA | 17 Cdn | 18 USA | 18 Cdn | 19 USA | 20 USA | 21 USA | 21 Cdn | 22 USA | 22 Cdn |
|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 1970 | 0.000 | 2.000 | 0.000 | 0.000 | 0.000* | 2.000 | 5.000 | 19.500 | 4.000 | 18.500 | 3.203* | 8.000 |
| 1971 | 0.500 | 2.400 | 0.000 | 5.000 | 0.000 | 0.000 | 5.500 | 20.000 | 1.000 | 2.500 | 1.563* | 0.000 |
| 1972 | 0.000 | 11.180 | 0.000* | 5.000 | 0.000 | 0.000 | 0.000 | 0.000 | 13.000 | 13.000 | 0.000 | 5.822* |
| 1973 | 0.400 | 11.000 | 0.000 | 14.000 | 0.000 | 5.500 | 3.330 | 33.670 | 6.653* | 34.500 | 1.625* | 0.875* |
| 1974 | 0.000* | 0.900 | 0.000* | 0.000 | 0.000* | 1.500 | 0.000* | 3.325* | 1.672* | 33.000 | 1.119* | 0.000 |
| 1975 | 0.000 | 4.710 | 0.000* | 2.000 | 0.000 | 2.000 | 0.000 | 7.500 | 2.402* | 11.500 | 0.500* | 2.349 |
| 1976 | 0.000 | 20.670 | 0.000 | 0.330 | 0.000 | 1.500 | 0.200 | 0.000 | 1.777* | 64.000 | 0.440* | 0.230* |
| 1977 | 0.000 | 6.200 | 0.000 | 5.830 | 0.000 | 9.543* | 1.400 | 37.000 | 5.600 | 32.800 | 4.876 | 3.000 |
| 1978 | 0.000 | 13.420 | 0.000 | 5.170 | 0.000 | 5.750 | 37.390 | 1.670 | 0.000 | 27.000 | 2.000 | 21.500 |
| 1979 | 2.290 | 15.080 | 0.000 | 2.000 | 0.000* | 12.670 | 1.500 | 6.000 | 4.268* | 16.330 | 1.000 | 1.670 |
| 1980 | 0.000 | 3.600 | 0.000 | 14.710 | 0.000 | 0.500 | 1.200 | 6.500 | 3.000 | 25.000 | 7.000 | 11.000 |
| 1981 | 2.500 | 11.330 | 3.000 | 25.330 | 0.000 | 1.500 | 1.250 | 15.000 | 5.959* | 15.000 | 4.000 | 1.670 |
| 1982 | 0.000 | 0.670 | 0.000* | 3.000 | 0.000* | 3.568 | 0.000 | 5.500 | 2.721* | 15.000 | 5.000 | 0.000 |
| 1983 | 0.000 | 0.750 | 0.000* | 0.670 | 0.000 | 1.000 | 0.000 | 1.000 | 1.132* | 35.500 | 0.500 | 1.107* |
| 1984 | 0.000 | 7.570 | 0.000* | 8.750 | 0.000 | 8.500 | 0.000 | 1.000 | 3.567* | 11.000 | 0.000 | 3.485* |
| 1985 | 0.000 | 8.000 | 0.000* | 2.250 | 0.000 | 0.670 | 0.000 | 0.500 | 1.873* | 44.000 | 1.254* | 1.000 |
| 1986 | 0.500 | 9.250 | 0.000* | 4.000 | 0.000 | 2.500 | 0.000 | 0.000 | 1.000 | 13.500 | 0.000 | 0.000 |
| 1987 | 0.000 | 5.000 | 0.000* | 1.000 | 0.000* | 10.500 | 0.000 | 0.000 | 4.000 | 9.500 | 1.000 | 1.000 |
| 1988 | 0.000 | 5.250 | 0.000* | 5.330 | 0.000* | 11.000 | 0.200 | 0.500 | 4.645* | 9.670 | 2.000 | 38.000 |
| 1989 | 0.000 | 15.670 | 4.000 | 7.000 | 0.000 | 4.881* | 0.000 | 3.000 | 1.000 | 39.000 | 1.500 | 1.000 |

**Spring**

| Year | 16 USA | 16 Cdn | 17 USA | 17 Cdn | 18 USA | 18 Cdn | 19 USA | 20 USA | 21 USA | 21 Cdn | 22 USA | 22 Cdn |
|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 1970 | 2.000 | 6.570 | 0.000 | 3.500 | 0.000 | 0.500 | 1.670 | 9.260 | 1.59* | 1.000 | 17.86* | 0.000 |
| 1971 | 3.200 | 2.860 | 0.000 | 1.670 | 0.000 | 0.000 | 2.750 | 3.000 | 1.000 | 11.670 | 2.80* | 0.000 |
| 1972 | 7.250 | 8.110 | 0.000 | 1.000 | 0.000 | 0.000 | 12.000 | 10.000 | 2.000 | 11.000 | 6.30* | 4.000 |
| 1973 | 34.330 | 22.290 | 0.000* | 3.250 | 0.000 | 7.000 | 26.000 | 643.330 | 15.000 | 6.000 | 6.000 | 8.500 |
| 1974 | 9.000 | 26.130 | 0.000 | 4.000 | 8.250 | 1.000 | 3.000 | 3.000 | 5.87* | 12.250 | 0.000 | 4.321* |
| 1975 | 2.250 | 3.170 | 0.000* | 2.250 | 0.000* | 0.330 | 5.000 | 10.800 | 2.000 | 0.000 | 7.68* | 2.000 |
| 1976 | 2.000 | 3.430 | 0.000* | 7.330 | 0.000* | 0.500 | 17.250 | 27.400* | 2.000 | 8.000 | 0.000 | 9.154* |
| 1977 | 0.750 | 2.800 | 0.000 | 1.330 | 0.000 | 0.000 | 8.430 | 21.000 | 4.000 | 19.000 | 2.000 | 0.000 |
| 1978 | 4.500 | 6.000 | 1.000 | 6.670 | 0.000 | 0.500 | 7.000 | 1.000 | 10.61* | 15.000 | 3.94* | 31.330 |
| 1979 | 1.600 | 6.070 | 0.000 | 3.670 | 0.000* | 1.330 | 1.290 | 4.580* | 0.000 | 28.400 | 0.000 | 1.670 |
| 1980 | 11.000 | 14.140 | 3.000 | 3.750 | 0.000* | 1.000 | 2.250 | 1.000 | 7.562 | 5.500 | 6.81* | 3.500 |
| 1981 | 7.330 | 4.670 | 2.000 | 10.000 | 0.000* | 0.000* | 10.400 | 41.670 | 1.58* | 19.000 | 1.000 | 2.000 |
| 1982 | 2.750 | 24.000 | 2.000 | 3.000 | 5.000 | 4.000 | 1.330 | 24.330 | 1.60* | 8.000 | 30.040 | 6.000 |
| 1983 | 0.250 | 6.800 | 3.000 | 9.000 | 0.000 | 3.000 | 0.000 | 86.000 | 26.000 | 3.08* | 1.000 | 4.000 |
| 1984 | 1.500 | 1.860 | 0.000* | 3.500 | 0.000 | 0.000 | 0.670 | 13.000 | 1.000 | 5.000 | 2.000 | 3.000 |
| 1985 | 3.670 | 16.570 | 2.000 | 3.670 | 0.000 | 6.000 | 7.750 | 23.000 | 1.84* | 16.500 | 3.32* | 8.500 |
| 1986 | 4.000 | 6.000 | 2.000 | 0.330 | 0.000 | 0.500 | 10.670 | 9.000 | 1.500 | 36.500 | 2.44* | 6.000 |
| 1987 | 2.600 | 7.000 | 0.000 | 8.330 | 0.000 | 0.500 | 1.800 | 10.000 | 5.99* | 3.000 | 2.59* | 3.000 |
| 1988 | 3.670 | 17.000 | 0.000 | 11.000 | 0.000* | 1.000 | 5.250 | 4.000 | 24.500 | 17.000 | 0.000 | 10.000 |
| 1989 | 4.600 | 18.400 | 0.000 | 1.500 | 0.000* | 1.000 | 8.500 | 22.500 | 0.000 | 9.000 | 2.23* | 0.000 |
| 1990 | 3.710 | 3.000 | 0.000 | 6.000 | 2.500 | 3.962 | 5.780* | 6.000 | 7.000 | 5.330 | 3.382* | 15.000 |

Table 17. Ratio of cod abundance in Canadian zone to total abundance in 5Zj,m derived from research surveys.
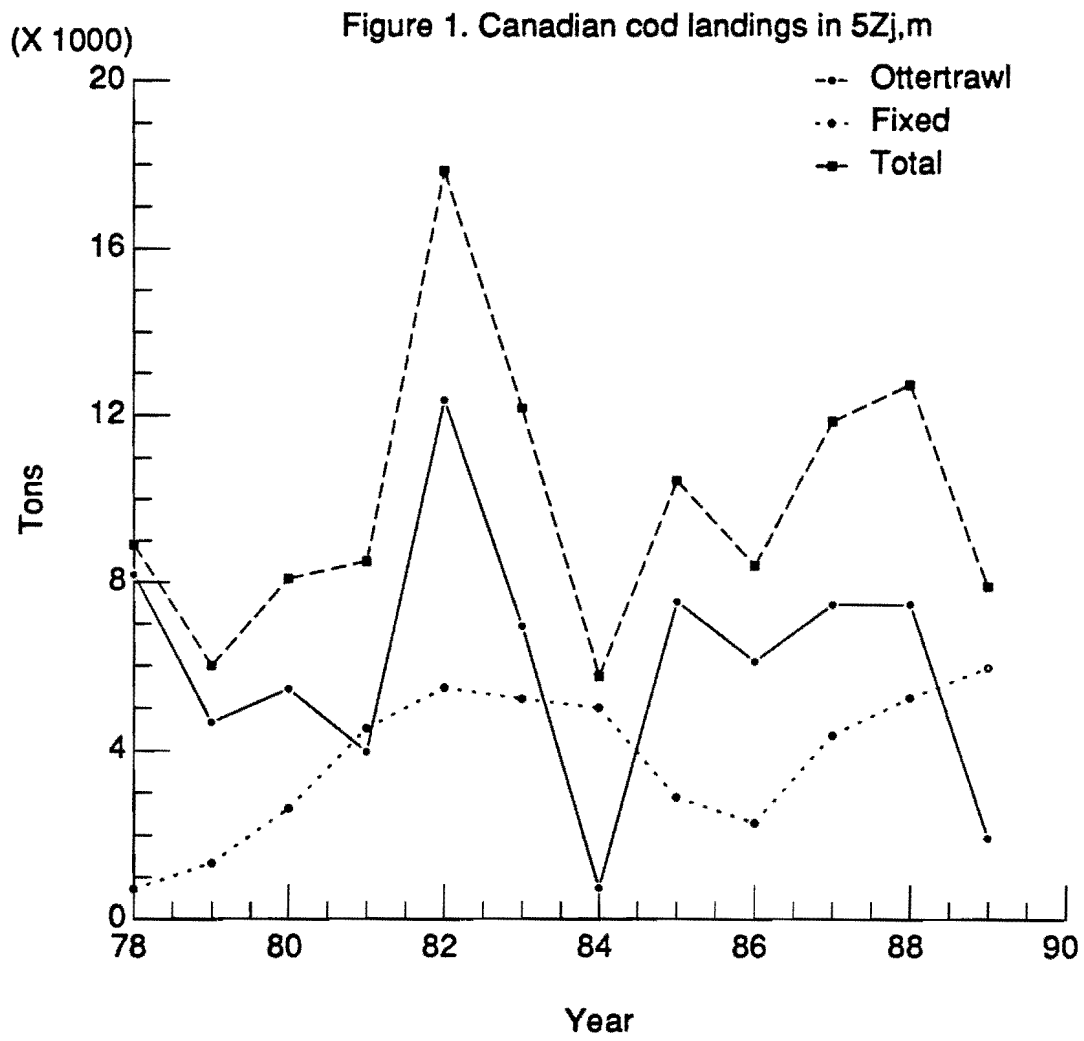(##### indicate zero catch)

(a) USA Fall (September/October)

| Age | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.46 | 0.40 | 1.00 | 0.93 | 1.00 | 0.44 | ##### | 1.00 | 1.00 | 0.99 | 0.94 | 0.64 | ##### | 0.99 | 1.00 | 0.99 | 1.00 | 1.00 | 0.70 | 0.77 | |
| 1 | 0.54 | 0.25 | 0.93 | 0.94 | 1.00 | 0.96 | 0.96 | ##### | 1.00 | 0.93 | 0.88 | 0.61 | 0.58 | 0.99 | 0.98 | 1.00 | 0.52 | 1.00 | 0.96 | 0.96 | |
| 2 | 0.77 | 0.20 | 0.96 | 0.65 | 1.00 | 0.81 | 0.93 | 0.54 | 0.87 | 0.83 | 0.78 | 0.84 | 0.71 | 0.97 | 0.95 | 1.00 | 1.00 | 0.97 | 0.97 | 0.98 | |
| 3 | 0.19 | 0.32 | 0.99 | 0.36 | 1.00 | 0.89 | 0.85 | 0.34 | 0.85 | 0.74 | 0.69 | 0.88 | 0.98 | 0.87 | 0.96 | 1.00 | 0.74 | 0.92 | 0.98 | 0.98 | |
| 4 | 0.25 | 0.42 | 1.00 | 0.30 | 1.00 | 0.82 | ##### | 0.30 | 0.70 | 0.67 | 0.32 | 0.90 | 0.99 | 1.00 | 0.96 | 1.00 | ##### | 0.93 | 0.99 | 0.98 | |
| 5 | 1.00 | 0.47 | 1.00 | 0.37 | 1.00 | ##### | 1.00 | 0.48 | 0.80 | 0.60 | 0.51 | 1.00 | ##### | 1.00 | 0.77 | ##### | ##### | ##### | 1.00 | 0.98 | |
| 6 | ##### | 0.70 | ##### | ##### | 1.00 | 0.56 | ##### | 0.31 | 0.80 | 0.77 | 1.00 | 0.45 | ##### | 1.00 | 0.85 | 1.00 | 1.00 | ##### | ##### | 1.00 | |
| 7 | ##### | 1.00 | ##### | 1.00 | ##### | ##### | 1.00 | 1.00 | 0.42 | 1.00 | 0.17 | ##### | 0.00 | ##### | ##### | ##### | ##### | ##### | 1.00 | ##### | |
| 8 | ##### | ##### | ##### | 0.11 | ##### | ##### | ##### | ##### | ##### | 0.00 | 1.00 | ##### | ##### | 1.00 | ##### | ##### | ##### | ##### | 1.00 | ##### | |
| 9 | ##### | ##### | ##### | ##### | ##### | ##### | ##### | ##### | ##### | 0.33 | ##### | ##### | ##### | ##### | 1.00 | ##### | ##### | ##### | ##### | ##### | |
| 10+ | ##### | ##### | ##### | ##### | ##### | ##### | ##### | ##### | ##### | ##### | ##### | 0.00 | ##### | ##### | ##### | 1.00 | ##### | 0.00 | ##### | ##### | |
| 1+ | 0.48 | 0.30 | 0.96 | 0.65 | 1.00 | 0.79 | 0.96 | 0.50 | 0.88 | 0.80 | 0.79 | 0.72 | 0.66 | 0.95 | 0.97 | 1.00 | 0.56 | 0.96 | 0.97 | 0.96 | |

(b) USA Spring (March/April)

| Age | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | ##### | ##### | 0.00 | ##### | ##### | ##### | 0.00 | ##### | 0.58 | ##### | ##### | 0.06 | 0.00 | ##### | ##### | 0.00 | 0.00 | ##### | 0.00 | 0.00 | 1.00 |
| 1 | 0.80 | 0.28 | 0.23 | 0.59 | 0.72 | ##### | 0.23 | ##### | 0.28 | 0.94 | 1.00 | 0.33 | 0.83 | 0.29 | 0.86 | 0.26 | 0.17 | ##### | 0.06 | 0.43 | 0.49 |
| 2 | 0.80 | 0.92 | 0.42 | 0.10 | 0.83 | 0.07 | 0.37 | 0.17 | ##### | 0.77 | 0.54 | 0.21 | 0.67 | 0.14 | 1.00 | 0.62 | 0.49 | 0.60 | 0.64 | 0.53 | 0.82 |
| 3 | 0.49 | 0.37 | 0.35 | 0.09 | 0.69 | 0.13 | 0.32 | 0.52 | 0.60 | 0.80 | 0.54 | 0.30 | 0.86 | 0.30 | 0.59 | 0.66 | 0.51 | 0.54 | 0.78 | 0.69 | 0.80 |
| 4 | 0.34 | 0.40 | 0.44 | 0.15 | 0.45 | 0.10 | 0.43 | 0.61 | 0.62 | 0.84 | 0.59 | 0.36 | 0.85 | 0.32 | 0.33 | 0.64 | 0.45 | 0.61 | 0.84 | 0.61 | 0.75 |
| 5 | 0.62 | 0.28 | 0.76 | 0.14 | 0.45 | 0.15 | 0.33 | 0.48 | 0.36 | 0.90 | 0.59 | 0.41 | 0.83 | 0.53 | 0.22 | 0.52 | 0.52 | ##### | 0.67 | 0.70 | 0.68 |
| 6 | 0.43 | 0.18 | 0.94 | 0.19 | 0.48 | 0.12 | ##### | 0.65 | 0.66 | 0.77 | 0.69 | 0.26 | ##### | 0.63 | 0.28 | 0.47 | 0.53 | 0.72 | 0.96 | 0.51 | 0.72 |
| 7 | 1.00 | 0.35 | 0.75 | 0.57 | 0.99 | 0.13 | 0.29 | 0.85 | 0.76 | 1.00 | 0.61 | 0.32 | 0.66 | 0.98 | 0.37 | 0.75 | 1.00 | 0.54 | 1.00 | 0.37 | 0.66 |
| 8 | ##### | 0.19 | 0.57 | ##### | 0.41 | ##### | 0.28 | 0.46 | 1.00 | 1.00 | 1.00 | 0.00 | 0.84 | 0.00 | ##### | 0.71 | 0.80 | 0.53 | 0.16 | 0.69 | 0.51 |
| 9 | 1.00 | 0.73 | 1.00 | 0.49 | 0.78 | 0.00 | ##### | ##### | 1.00 | ##### | 0.74 | ##### | 0.85 | ##### | 0.15 | 0.63 | 0.84 | 0.55 | ##### | 0.43 | 0.40 |
| 10+ | 1.00 | 0.29 | 0.50 | 0.64 | 0.13 | ##### | 0.00 | ##### | 1.00 | ##### | 0.85 | ##### | ##### | 1.00 | ##### | 0.84 | ##### | ##### | 1.00 | 0.69 | 0.04 |
| 1+ | 0.59 | 0.47 | 0.37 | 0.12 | 0.67 | 0.11 | 0.30 | 0.33 | 0.58 | 0.83 | 0.57 | 0.29 | 0.77 | 0.32 | 0.42 | 0.60 | 0.47 | 0.60 | 0.71 | 0.57 | 0.76 |

(c) Canadian Spring (February/March)

| Age | 87 | 88 | 89 | 90 |
|---|---|---|---|---|
| 0 | ##### | ##### | ##### | ##### |
| 1 | ##### | ##### | ##### | 1.00 |
| 2 | 0.47 | 0.26 | 0.16 | 0.25 |
| 3 | 0.89 | 0.59 | 0.70 | 0.79 |
| 4 | 0.91 | 0.88 | 0.84 | 0.90 |
| 5 | 0.87 | 0.81 | 0.86 | 0.87 |
| 6 | 1.00 | 0.91 | 0.93 | 0.91 |
| 7 | 0.81 | 0.60 | 0.87 | 0.94 |
| 8 | 1.00 | 1.00 | 1.00 | 0.94 |
| 9 | 0.56 | 0.73 | 1.00 | 1.00 |
| 10+ | 1.00 | 0.49 | 0.66 | 1.00 |
| 1+ | 0.88 | 0.84 | 0.76 | 0.89 |

Figure 1. Canadian cod landings in 5Zj,m

Figure 2. Cod landings by Canada and USA in 5Zj,m
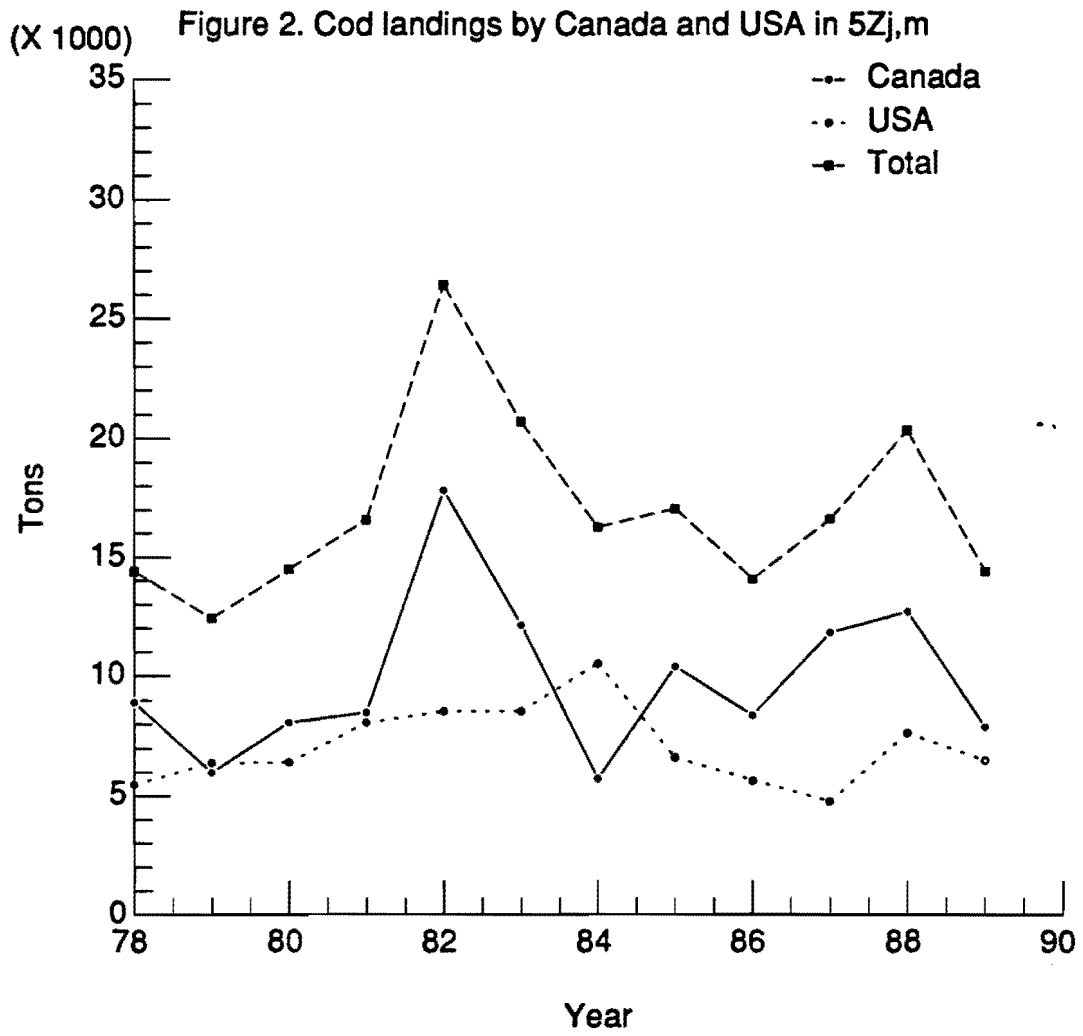
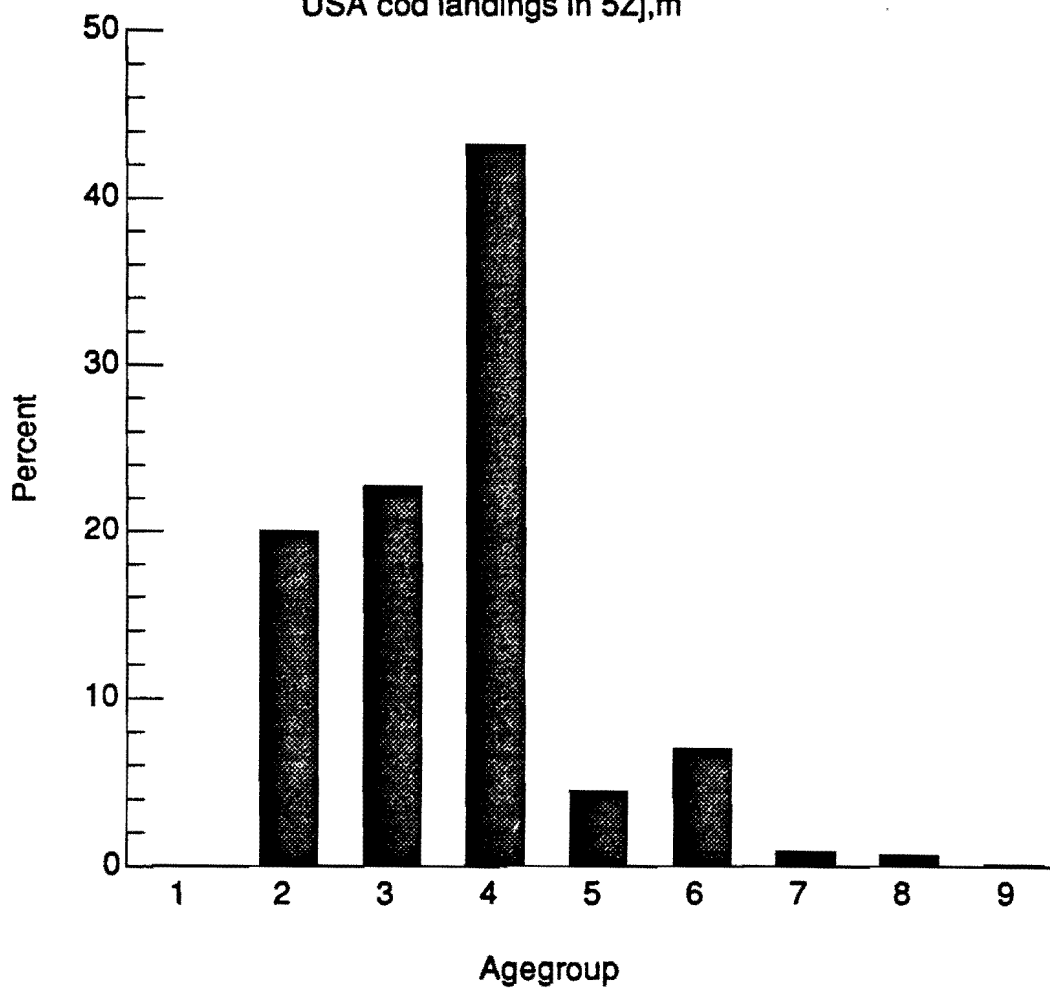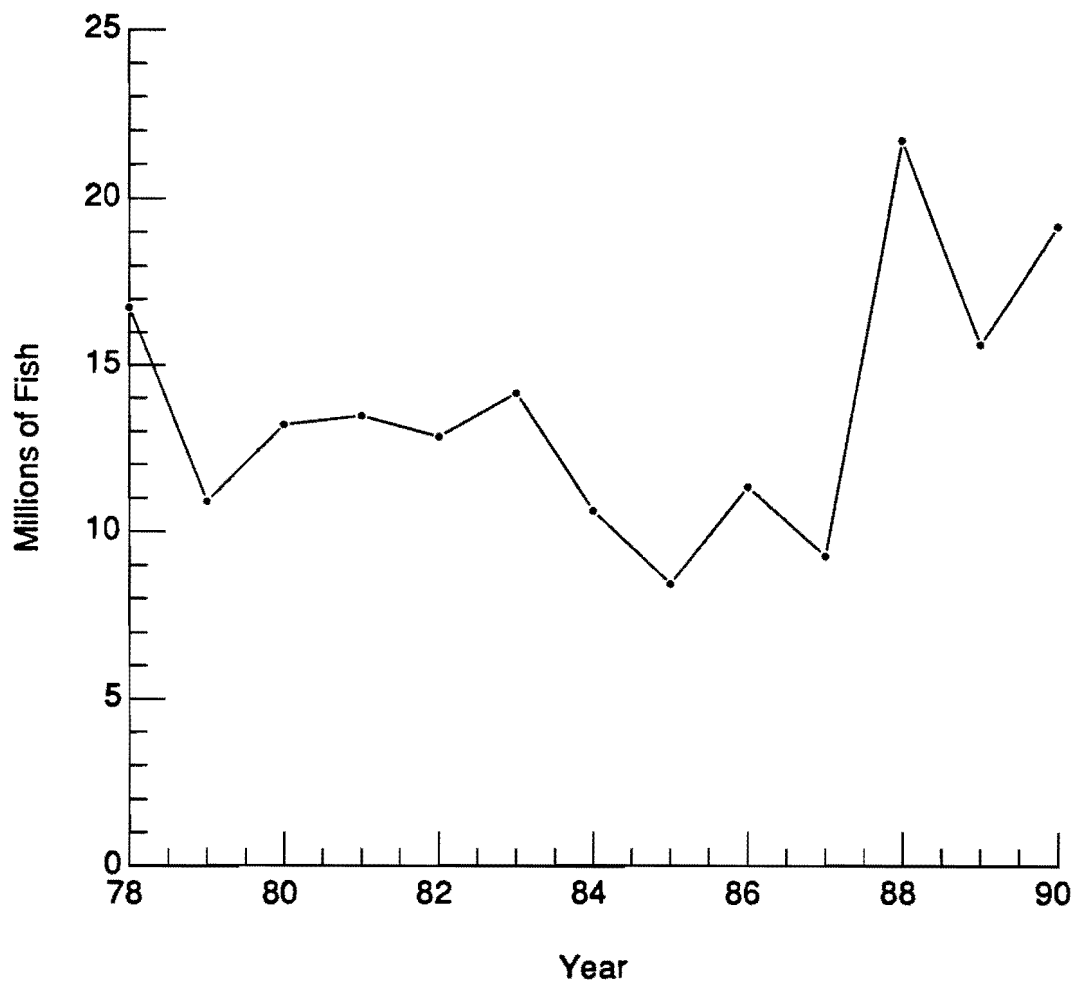Figure 3. Percent catch at age for Canadian and USA cod landings in 5Zj,m

Figure 4. 5Zj,m cod population numbers at age 3+
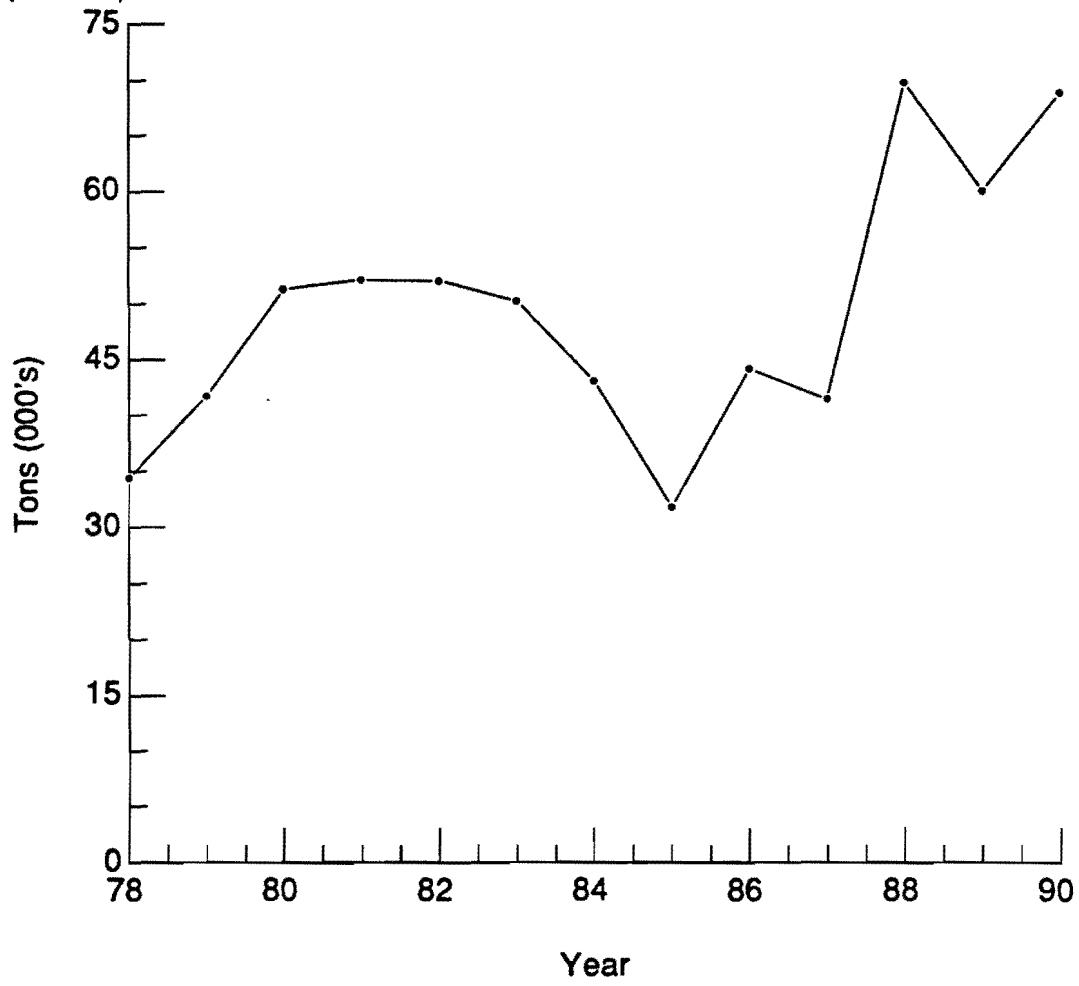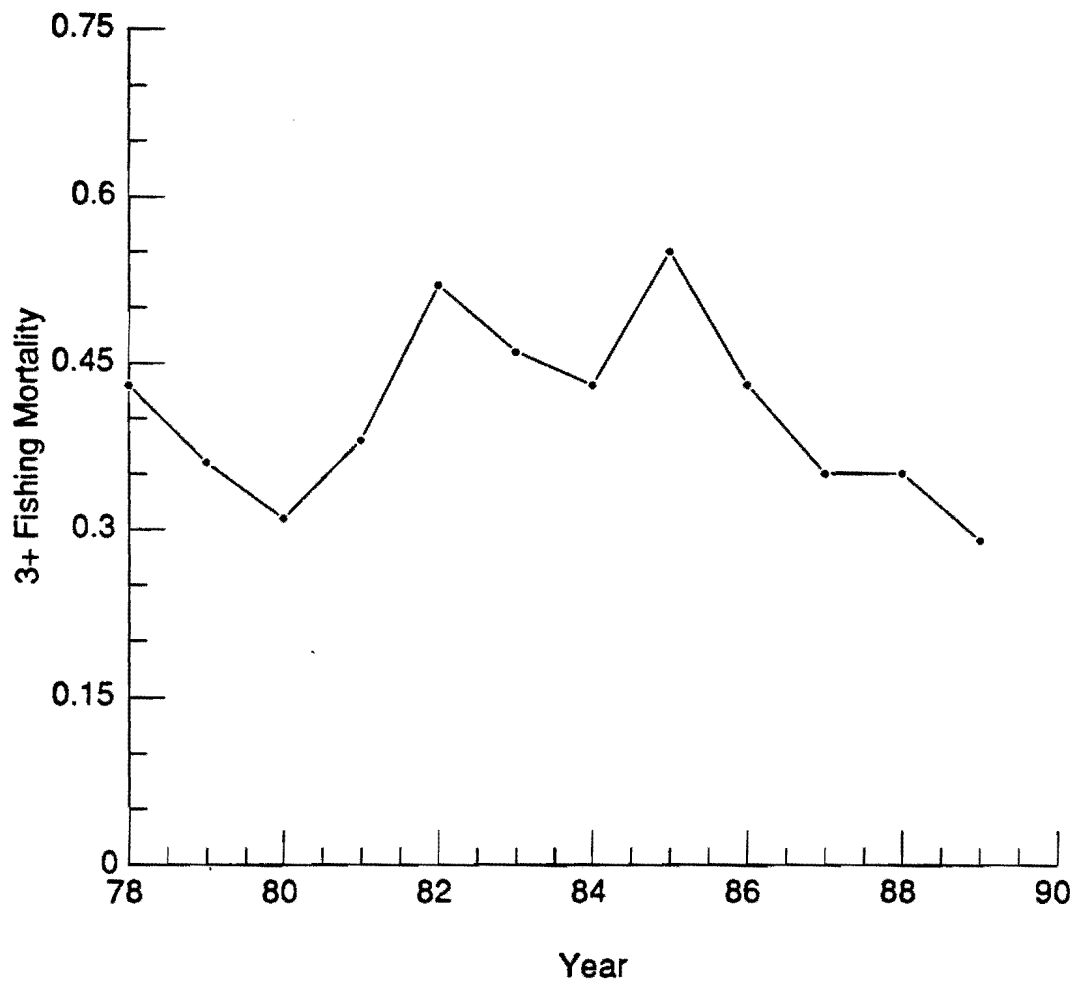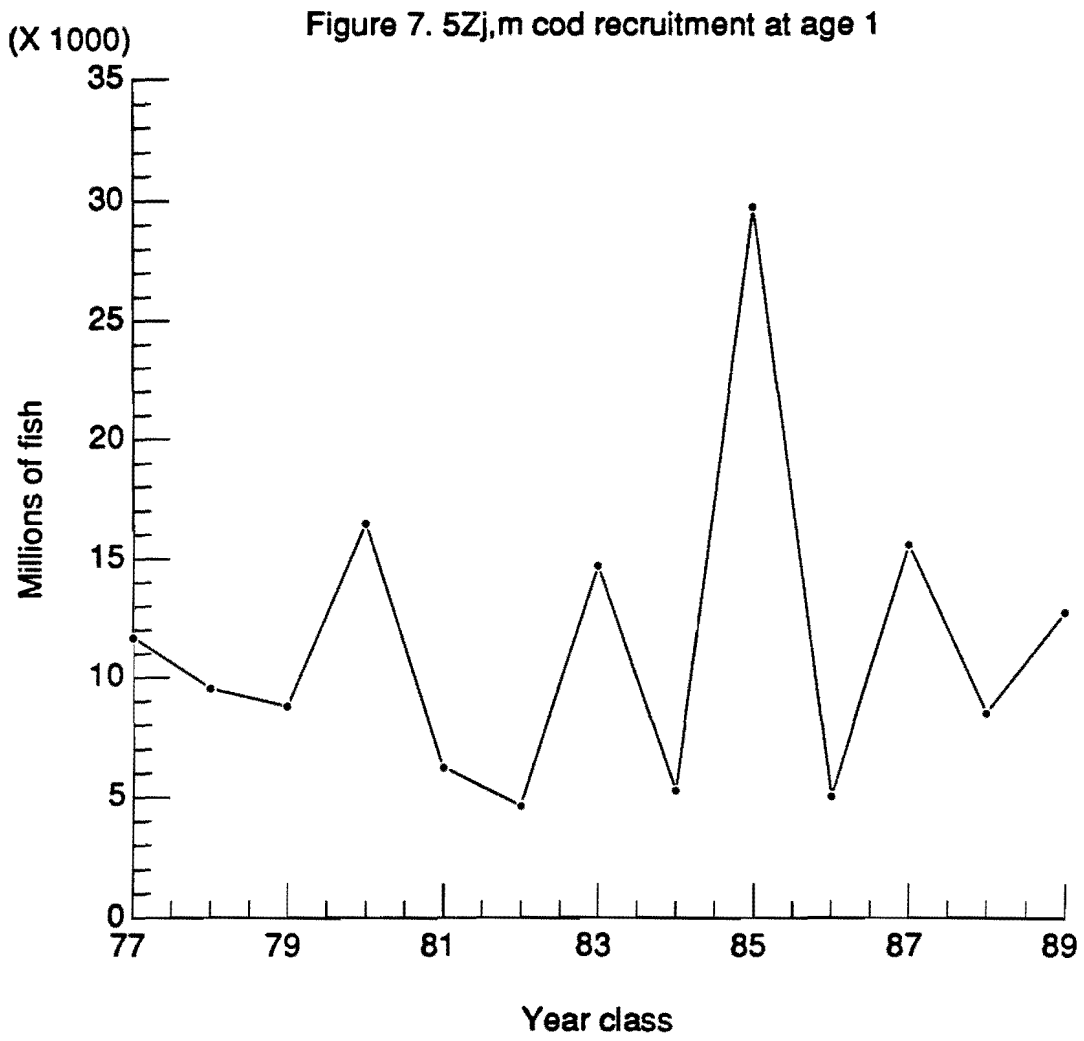
Figure 5. 5Zj,m cod population biomass for ages 3+

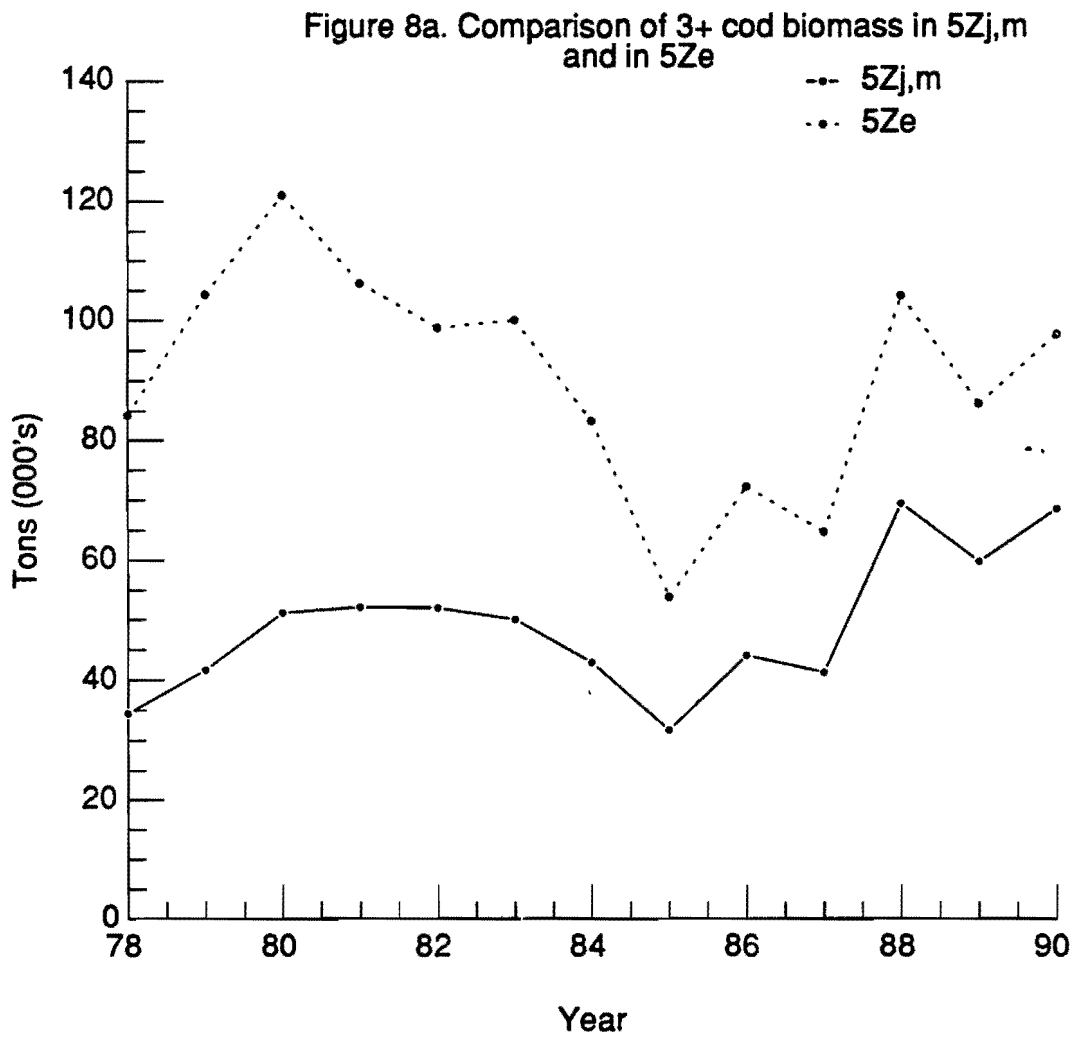Figure 6. 5Zj,m cod fully recruited (3+) fishing mortality

Figure 7. 5Zj,m cod recruitment at age 1

Figure 8a. Comparison of 3+ cod biomass in 5Zj,m and in 5Ze

Figure 8b. Comparison of 3+ cod fishing mortality in 5Zj,m and 5Ze
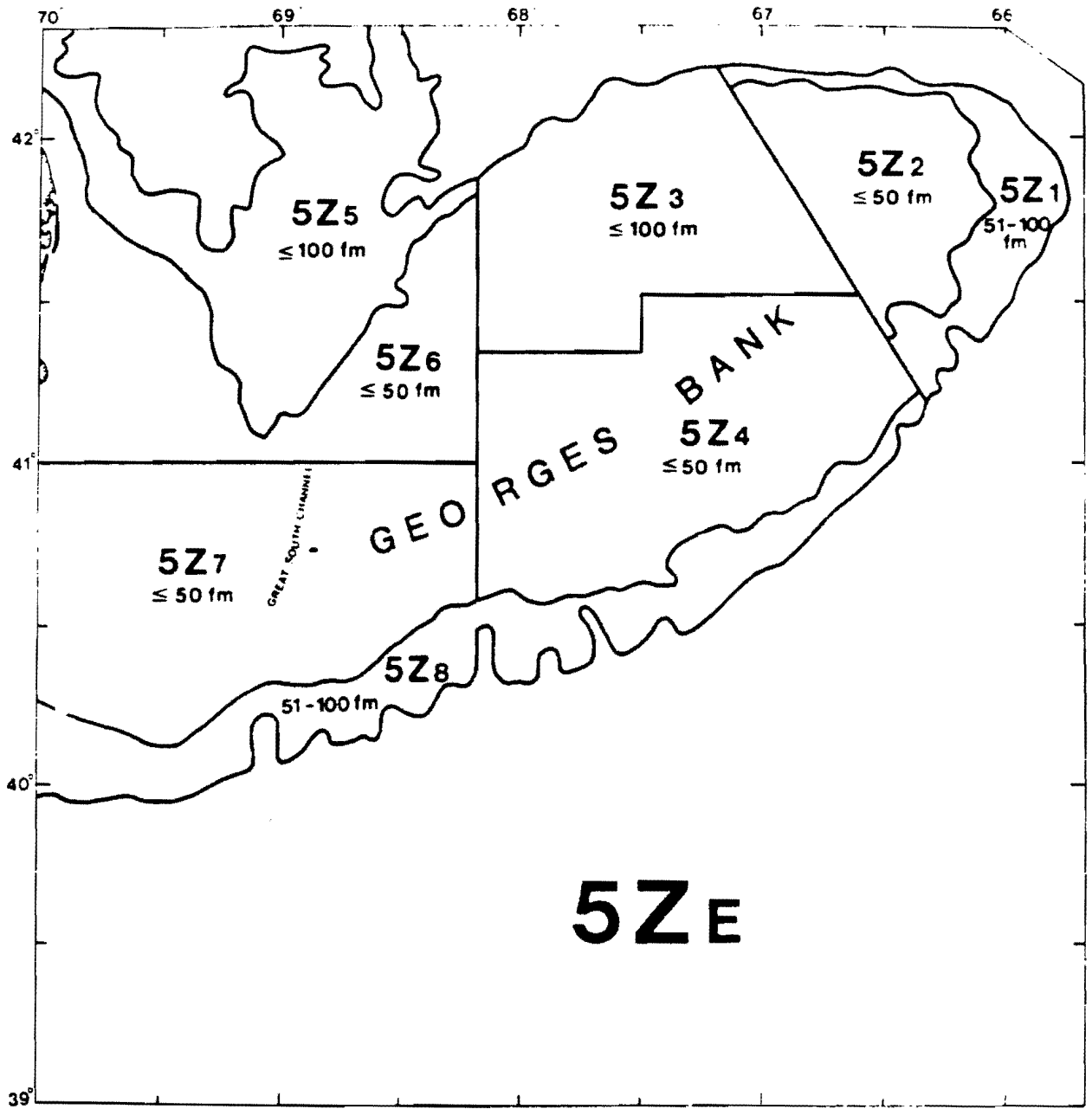
Figure 9a. Stratification scheme used for Canadian Georges Bank surveys, 1987-present.

Figure 9b. Stratification scheme used for USA Georges Bank surveys, 1963-present

Figure 10. Ratio of cod abundance in Canadian zone to total 5Zj,m abundance from surveys