Estimation of discards in the commercial trawl fishery for Northeast Arctic cod (*Gadus morhua* L.) and some effects on assessment

Cand. Scient. thesis in fisheries biology

by

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Contents

Abstract

Discarding of small fish has been and still is a large problem in many fisheries. It is a problem because most of the discarded fish die and are a direct loss to the biomass of the stock. When discards occur and it is not accounted for in the assessment, the total mortality from the stock is underestimated. Thus, it will cause bias in the VPA estimates and in analysis based on these estimates. In the present work, discards in the commercial trawl fishery for Northeast Arctic cod, during the years 1946 – 1998, were estimated from two points of view. The first was to assume that the USSR did not have any discards and adjust the other countries' catch at age distributions according to the USSR landings. The second was to use selectivity properties and abundance estimates to estimate age distributions in the catches and adjust the catches according to these. The differences between the estimated and reported catch numbers were then regarded as discards. New VPA numbers at age were estimated and the biological reference point F_{med} was calculated. The results from the first approach were considered not to be any reliable. The results from the second approach were as expected, high in the 1950s and 1960s with a decreasing trend towards the 1980s. The results indicate also that the USSR had discards or that they had errors in the reported catches. Discards were shown to have a large influence on the VPA estimates, especially stock numbers at age three, which resulted in a small increase in the value of F_{med}. Due to the large errors in the VPA stock numbers of Northeast Arctic cod, as indicated by the estimates of discards, it is suggested that the Arctic Fisheries Working Group should revise the catch numbers at age that are used in the VPA.

1. Introduction

Northeast Arctic cod (*Gadus morhua*) is the most important commercially exploited fish resource in the Barents Sea. The habitat of Northeast Arctic cod extends from the spawning grounds along the coast of Norway through the southern and central Barents Sea (Michalsen, 1999). The most important spawning areas are located in the vicinity of Lofoten, Sørøya, and the banks off Møre. The cod reach maturity at an age of 6-9 years and the mature fish arrive at the spawning grounds from late January and onwards, the most intense spawning occurs from mid-March to mid-April (Bergstad et al., 1987). The eggs and larvae are transported northwards by the currents during April-August and in August-September is the 0-group distributed over large areas in the Barents Sea and off Svalbard (Nakken, 1994). The immature cod is geographically separated into two components, one in the Svalbard – Bear Island area and one in the Barents Sea (Brander, 1994), these two components make seasonal north-south and east-west migrations, respectively, and the range of these migrations increases with age. When capelin becomes a major food item, at an age of 3-4, the immature follow the spawning migration of capelin to the coast of northern Norway and Murman (Nakken, 1994). After spawning the mature cod migrate to the feeding areas in the Barents Sea (Bergstad et al., 1987). The area where the Northeast Arctic cod is distributed is divided into fishing areas 1, 2a and 2b (figure 1) by the International Council for the Exploration of the Sea (ICES).

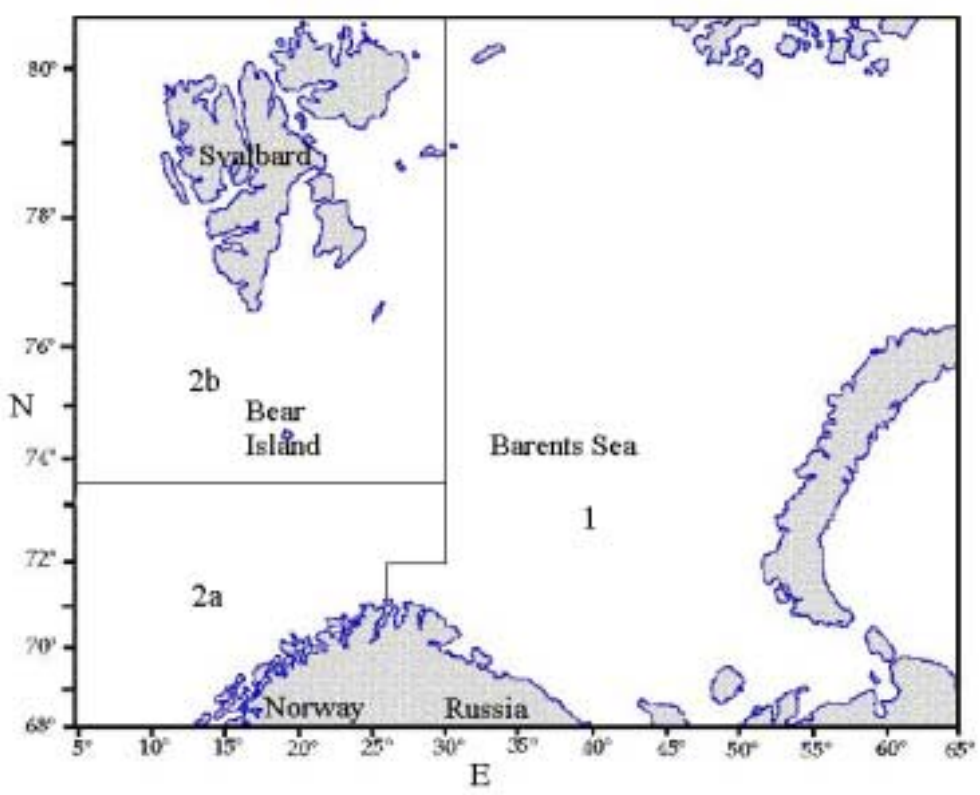

Figure 1 ICES fishing areas in the Barents Sea.

In the 1930s the fisheries for Northeast Arctic cod started to evolve from coastal to offshore fisheries and the efficiency increased in both these fisheries (Jakobsen, 1993). There are three main fisheries for Northeast Arctic cod, the "skrei fishery" on migrating spawning cod, the "Finnmark fishery" on the migratory prespawning cod following the capelin to the northern Norwegian coast, and the offshore fishery, taking place at the feeding grounds (Brander, 1994). The development of bigger and more efficient fishing vessels and fishing gears has put a great pressure on the cod stock (Nakken, 1998). This has made assessment a necessity and an important tool as basis for the advice to the management of the cod stock, which is necessary to protect it from depletion and to make sure that it gives a sustainable yield.

Stock assessments of- and research on- the Northeast Arctic cod stock, e.g. the determination of spawning stock – recruitment relationships, are based on stock number at age matrices from the Virtual Population Analysis (VPA) (Hilborn & Walters, 1992). Stock size as estimated by VPA is available from 1946 (ICES, 2000). VPA calculates the number of fish alive in each year-class for each past year based on the reported, past catches and the relationship between stock numbers at age, N_i, and reported catch numbers at age, C_i, is given by the following equation (Hilborn & Walters, 1992):

$$N_i = \frac{C_i}{s_i} + \frac{C_{i+1}}{s_i \cdot s_{i+1}} + \ldots + \frac{C_{i+n}}{s_i \cdot s_{i+1} \cdot \ldots \cdot s_{i+n}} \qquad (1)$$

where C is the yearly catch number of a year-class and s is the yearly natural survival rate of the same year-class. Thus, for the assessment to be effective it needs reliable catch data from the fishing fleets. This is not always the case, catches may not be reported (illegal catches), escaped fish may die due to injuries caused by the gear and caught fish may be discarded. All of these factors will cause the stock numbers at age to be underestimated.

The problem of unreported (illegal) catches has been discussed in the Arctic Fisheries Working Group (AFWG) (Schöne, 1999), but is currently not taken into account in the assessment. In 1992 rumors and allegations of unreported catches flourished (Jakobsen, 1993) and in the period 1990-1994 unreported catches are added to the catch statistics (ICES, 2000). In other years there are no knowledge of the magnitude of unreported catches. Allegations of unreported cod-catches flourished also in the national Norwegian news in the fall of 2000.

Mortality due to injuries caused by the gear may be divided into two categories. Fish dying because of damage to scales or other injuries caused when escaping through the meshes of a cod-end or through a metal grid sorting-device, and predation of fish that are exhausted or injured by the gear. According to Soldal et al. (1993) Scottish and Russian investigations in the 1980s indicated that escaped cod had high mortality rates, but newer research indicate low mortality for cod after contact with the gear (Soldal et al., 1991; DeAlteris & Reifsteck, 1993; Soldal et al., 1993; Soldal, 1996; Soldal & Engås, 1997). Small fish that escape from a trawl may also be more vulnerable to predation due to exhaustion or to injuries. However, Løkkeborg & Soldal (1995) showed that small cod that escaped from a trawl had no increased risk of predation. This experiment was conducted in a controlled environment and the results might be different if tested under conditions more representative to actual fishing operations.

Discards are defined as caught fish that are returned to sea due to various reasons. Survival studies show that discarded fish have high mortality rates (Jean, 1963) and are assumed to be a direct loss to the abundance and biomass of the stock. The main reasons for discarding of Northeast Arctic cod are: (a) low market value of small cod (high grading), (b) fish below legal minimum landing size, (c) damaged or poor quality of fish. Discards due to low market value of small fish were assumed to be quite high in the 1950s and 1960s (ICES, 1965a; Nakken, 1994). According to Crean & Symes (1994) fisheries managed under systems of output control, such as quotas and minimum landing size, have become notorious for high level of discards. It is therefore plausible to assume that the minimum landing size, which were introduced

in the 1960s, has caused discards of small fish. Discarding of young fish due to poor condition is known to have taken place in the 1980s (Mehl, 1991; Nakken, 1994).

The amount of discards depends probably on marked demand of small fish, size and age composition of the stock, condition of the fish, fishing-area, selection of the gear and the discarding policy among skippers and crews. The discarding policy among skippers and crews may vary between the countries. It was believed that the Soviet Union had no discards (Hylen & Rørvik, 1983) due to the fact that they used most of the fish for their internal market and had fixed prices (Jakobsen, 1999). Garrod (1967) estimated the discards of Northeast Arctic cod in the English trawler fleet during the 1950s and found discard rates up to 42% by number (1953). Several investigations were done onboard vessels in the Norwegian trawler fleet in the 1960s – 1980s (Hylen, 1965b; Hylen, 1967a; Hylen, 1967b; Hylen & Smedstad, 1974; Hylen, 1987) and the discards by number were high (up to 42% in 1987). In the 1990s the AFWG considered discards in the Barents Sea not to be a major problem (ICES, 1999b), but investigations onboard German trawlers in 1998 showed a portion of 36% undersized and juvenile cod in catches of a certain area (Schöne, 1999). In the latest AFWG report (ICES, 2000) the Working Group states that unknown quantities of cod probably have been discarded.

Quite a few actions have been carried out in attempt to minimize the discarding problem. Between the 1950s and the early 1980s the minimum mesh sizes were increased several times to reduce catches of small juvenile cod and thereby the discards. At the same time they increased the minimum legal landing size, which might have had an opposite effect on the discards. In the early 1990s was a discard

ban introduced in the Norwegian economical zone and the Svalbard zone as well as an area closure system, i.e. an area where the amount of undersized fish in the catches exceeds 15% by number is closed for fishing. Regulations prohibiting discards and catches of undersized cod are now in effect both in Norwegian and Russian zones (ICES, 2000). The use of a sorting grid system to improve the selection was made compulsory in the bottom trawl fishery for gadoid species in the Barents Sea in 1997 (Isaksen, 1997).

The purpose of the present thesis was to estimate the magnitude of discards of small cod in the trawl fishery for Northeast Arctic cod during the years 1946 – 1998 and to examine some effects of this bias in the catch data on the estimation of stock numbers at age three, four and five. The estimation of discards was done using two main approaches. The first approach was to assume that USSR had no discards and then adjust the catches from other countries according to the USSR catches. The second approach was to use cod-end selection curves and stock abundance estimates to estimate age proportions in the catches and to adjust the catches from the various countries, including the USSR catches, according to these proportions. New VPA numbers at ages three, four and five were estimated and the effect of an increase in the numbers of three-year olds on the calculation of F_{med} was investigated.

2. Materials and methods

Members of the Arctic Fisheries Working Group (AFWG) have collected commercial catch data on Northeast Arctic cod since 1946. These data provide information on catch numbers by age, area and country, and makes the foundation of my work.

Two different approaches were used to estimate the total of fish caught. The first approach was to assume that the Soviet Union had no discards (Hylen & Rørvik, 1983) and to adjust the catches from the other countries according to the Soviet catches (Method I). The second approach was to establish the selection curves for the mesh sizes used in the time period, 1946 – 1998, and to adjust the catches according to the selection curves and the age distributions in the population (Method II and III). The details of the catch data are not consistent and different methods were established according to the information available. All the calculations and statistical analyses were performed in Microsoft Excel 2000.

2.1 Method I (No discarding in USSR catches)

In the period 1946 – 1976, landings were available as catch numbers at age by country and area. By assuming that the USSRs vessels had no discards, i.e. that they landed all caught fish, and that the age frequencies in their landings are representative for catches taken in the area and by other countries, it was possible to estimate the actual catches of three-, four- and five-year olds taken by other countries. Provided that the trawls used had similar selection properties and that they fished on the same population, i.e. that the catches overlapped in time and space, the ratio of age *i* over

the sum of ages 6+ can be assumed to be equal in USSRs landings and in other countries catches. The catches, $\hat{C}$, at age *i* by country *E* in area *k* were estimated by:

$$\hat{C}_{i,k,E} = \frac{C_{i,k,R} \cdot \sum_{j=6}^{15} C_{j,k,E}}{\sum_{j=6}^{15} C_{j,k,R}} \qquad (1)$$

where $C_{i,k,R}$ is the USSRs catch at age *i* in area *k*, the ages are denoted by *j* in the summations. Estimated catch, $\hat{C}$, is assumed to be equal to the sum of the landed catch and the discards. The catches were adjusted for all countries in area 1 and 2b in those cases where the estimated catches were larger than the landed catches. USSR has only reported catches in area 2a in 1971 – 1973 and 1976 during this time period. Catches in area 2a were estimated for all countries except Norway for those years. Norwegian catches were not raised in area 2a since the main percentage (60-90%) of the Norwegian catches in this area were taken with other gears than trawl (ICES, 2000).

2.2 The use of selection curves

2.2.1 Method II (The use of selection curves and VPA stock sizes)

The mesh sizes in the cod-ends used by the commercial trawlers have changed during the time series (table 2.1). Each mesh size corresponds to a selection curve, which is sigmoid in shape and characterized by the 50% retention length, i.e. the length of fish that has a 50% probability of being retained in the cod-end, and the selection range, i.e. the difference in length between the fish that has a 75% probability of retention and that with a 25% probability of retention (Wileman et al., 1996). Halliday et al.

(1999) have gathered information from selection studies of cod by different mesh sizes since 1980. They used linear regressions to find the relationship between the 50% retention length, l_{50} (cm), and mesh size, m (mm), and the relationship between the selection range, SR (cm), and mesh size. The relationships are described by the following equations (Halliday et al., 1999):

$$l_{50} = 0.499m - 16.105 \quad (2)$$

$$SR = 0.112m - 4.335 \quad (3)$$

The 50% retention length and the selection range for the mesh sizes used were established from these equations using the mesh sizes in table 2.1 as input (table 2.2).

Table 2.1 Cod-end mesh sizes used in Northeast Arctic cod fisheries. The mesh sizes apply to nylon since 1967. 135 mm apply to all vessels in the Norwegian economical zone, the Svalbard zone and to Norwegian vessels in the "gray zone". 125 mm apply to all vessels in the Russian economical zone and to Russian vessels in the "gray zone". The "gray zone" is an area in the Barents Sea where Norway and Russia have shared jurisdiction.

Year	Norway	Other countries	Sources
1946	80 mm	80 mm	1, 3
1954	110 mm	110 mm	1
1963	130 mm	120 mm	1, 2
1982	135 mm	125 mm	3

Sources: 1 Garrod (1967), 2 Hylen (1965a) and 3 Nakken (1994).

Table 2.2 Mesh sizes and their 50% retention length (l_{50}) and selection range (SR). l_{50} and SR are calculated by equations from Halliday et al. (1999).

Mesh size (mm)	l_{50} (cm)	SR (cm)
80	23.8	4.6
110	38.8	8.0
120	43.8	9.1
125	46.3	9.7
130	48.8	10.2
135	51.3	10.8

The selection curve is assumed to be logistic (Millar & Walsh, 1992; Wileman et al., 1996; Millar & Fryer, 1999) and is parameterized as:

$$r(l) = \frac{\exp(a + b \cdot l)}{1 + \exp(a + b \cdot l)} \tag{4}$$

where *r(l)* is the retention probability of a length *l* fish. The parameters *a* and *b* corresponds to l_{50} and *SR* (Millar, 1993; Wileman et al., 1996; Millar & Fryer, 1999) and are given by:

$$a = -l_{50} \frac{2\ln(3)}{SR} \tag{5}$$

$$b = \frac{2\ln(3)}{SR} \tag{6}$$

The selection curves were then established by the values in table 2.2 and equations (4) through (6), *r(l)* was calculated for each centimeter. The selection curves are illustrated in figure 2.1.

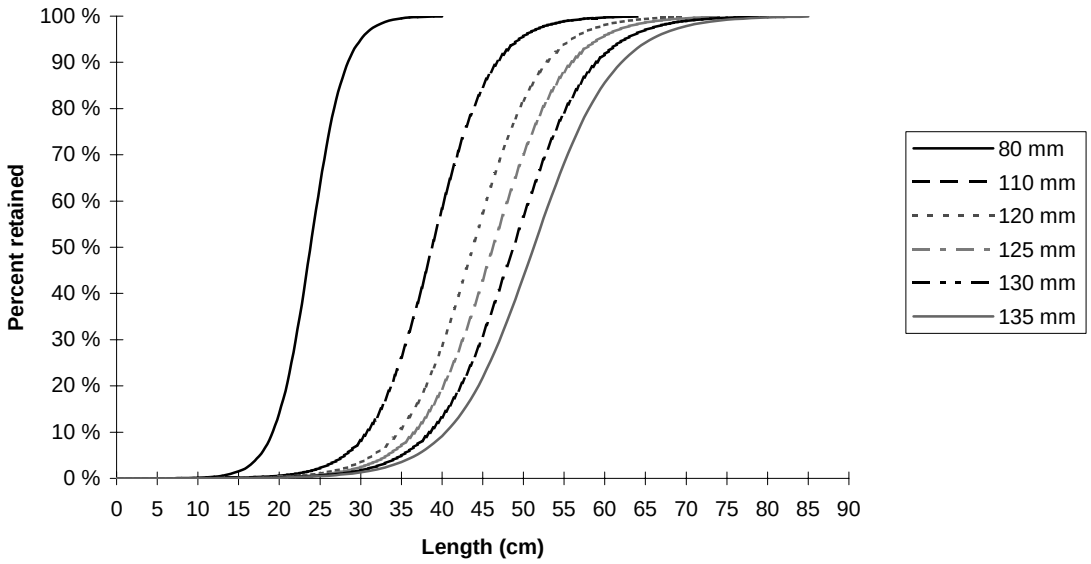

Figure 2.1 Mesh selection curves with different mesh sizes, based on the logistic equation.

The available catch data were given in numbers at age and the selection is length dependant. To be able to use selection curves in the estimation of discards it was necessary to find the length distributions at age in the population. No data including this information were available for the years 1946 – 1982 and the length distributions at age had to be estimated. The length distributions at age in the population were assumed to be normal with mean lengths, μ_i, and standard deviations, σ_i.

Norway has conducted bottom trawl surveys in the Barents Sea each year since 1981. The surveys have been carried out in January – March, lasting for 4 – 6 weeks (Mehl, 1999). The data are given in numbers at length group and age matrices, where each length group has a five cm interval. The indices from the Norwegian bottom trawl surveys have been revised for the years 1983 – 1999 (ICES, 2000). The mean length at age, $\mu_{i,j}$, and the standard deviation, $\sigma_{i,j}$, where i denotes the age and j the year, were calculated for the period 1983 – 1999 by the methods for grouped data (Bhattacharyya & Johnson, 1977).

In the estimates of the length distributions at age in the population it was necessary to take into account that the fish grows during the year and that the catches are distributed throughout the year.

The length distributions at age in the survey data were assumed to be normal and represent lengths at the start of the year. The length distributions at age through the year were estimated by a method for a mixture of two normal distributions. This method uses the mean length of a cohort (year-class) in one year and the mean length of the same cohort for the next year with their respective standard deviations to

estimate a new mean, $\hat{\mu}_{i,j}$, and standard deviation, $\hat{\sigma}_{i,j}$, for the mixture (McLaughlin, 1999).

$$\hat{\mu}_{i,j} = p\mu_{i,j} + (1-p)\mu_{i+1,j+1} \quad (7)$$

$$\hat{\sigma}_{i,j} = p\left[\sigma^2_{i,j} - (p-1)(\mu_{i,j} - \mu_{i+1,j+1})^2\right] - (p-1)\sigma^2_{i+1,j+1} \quad (8)$$

where *p* is a variable that weighs the two distributions. The philosophy behind and the calculation of *p* are explained later in the text. The result of a mixture of two normal distributions is illustrated in figure 2.2, where the distribution of the mixture is calculated by the equation for a normal distribution with mean = $\hat{\mu}$ and standard deviation = $\hat{\sigma}$ (Bhattacharyya & Johnson, 1977).

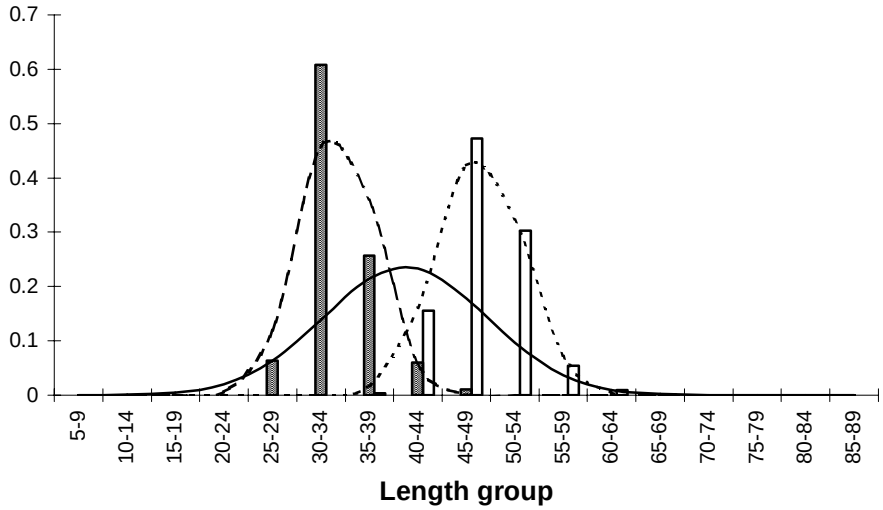

Figure 2.2 Distribution of length groups in three-year old fish (1983), shaded bars, and in four-year old fish (1984), open bars, with the respective fitted normal distributions. The solid line is the mixture of the two distributions. Data are collected from the Norwegian bottom trawl surveys.

Assuming that the fishing mortality and the natural mortality are constant through the year, catch per day decreases with a negative exponential factor. This means that the catches of a cohort are larger in the beginning of the year and that half of the total catch is caught earlier than the middle of the year (figure 2.3). The equations for the

mixture of two normal distributions method need therefore a variable that weighs the two distributions accordingly.

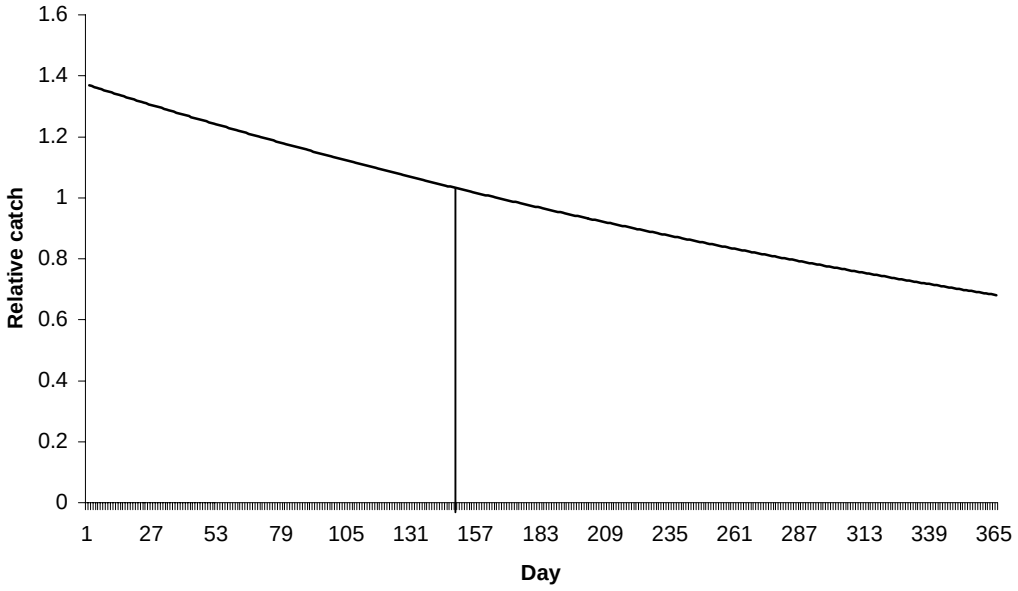

Figure 2.3 Catch per day with constant fishing mortality rate, $F = 0.5$, and natural mortality rate, $M = 0.2$. The straight-line marks when half of the total catch is caught. Catch = a*exp(-b*day).

When both the fishing mortality rate, F, and natural mortality rate, M, are assumed to be constant throughout the year, the catch equation is given as:

$$C(t-t_0) = \frac{F}{Z} N(t_0)(1-e^{-Z\cdot(t-t_0)}) \tag{9}$$

where C denotes the catch of a cohort from time t_0 to time t, $Z = F + M$ and $N(t_0)$ denotes the number of fish at time t_0. By setting $t - t_0$ equal to one year the total catch of a cohort in a year is found. To simplify the equation, t_0 is set equal to 0. To find the time of the year when half of the catch is caught, $t_{0.5}$, $0.5C(1)$ is set equal to $C(t_{0.5})$:

$$0.5C(1) = \frac{F}{Z} N(0)(1-e^{-Z\cdot t_{0.5}}) \tag{10}$$

Solving with respect to $t_{0.5}$ gives the equation:

$$t_{0.5} = -\frac{\ln(1-0.5\frac{C(1)\cdot Z}{F\cdot N(0)})}{Z} \tag{11}$$

Since equation (9) gives:

$$\frac{C(1)\cdot Z}{F\cdot N(0)} = 1 - e^{-Z} \tag{12}$$

equation (11) can be written as:

$$t_{0.5} = -\frac{\ln(1-0.5(1-e^{-Z}))}{Z} \tag{13}$$

$Z = F + M$ where F and M are taken from the AFWG report (ICES, 2000) for the respective years and ages. Assuming linear growth, and setting $\hat{\mu}_{i,j}$ in equation (7) equal to the length of the cohort at time $t_{0.5}$, we get:

$$\begin{aligned}\hat{\mu}_{i,j} &= \mu_{i,j} + (\mu_{i+1,j+1} - \mu_{i,j})t_{0.5} \\ &= \mu_{i,j}(1-t_{0.5}) + \mu_{i+1,j+1}t_{0.5}\end{aligned} \tag{14}$$

Thus, p in equation (7) and (8) should be $1 - t_{0.5}$. The means and standard deviations used to establish the length distributions at age in the population for the years 1946 – 1982 were the results from equations (7) and (8) averaged over the time period 1983 – 1998. The distributions were established for the ages three through seven years. It is assumed that all fish eight-year and older are retained in the cod-end, thus length distributions are not necessary for those ages. The length distributions, $f_i(l)$, at age were calculated, for each centimeter, by the equation for a normal distribution (Bhattacharyya & Johnson, 1977)

$$f_i(l) = \frac{1}{\sqrt{2\pi}\hat{\sigma}_i} e^{-\frac{(l-\hat{\mu}_i)^2}{2\hat{\sigma}_i^2}} \tag{15}$$

where l denotes the length and i the age. The proportion, $r(i)$, of age i retained in a cod-end, i.e. caught, with a given mesh size was then found by the expression:

$$r(i) = \sum_l r(l)\cdot f_i(l) \tag{16}$$

where r(l) is the retention probability of length l and $f_i(l)$ is the length distribution at age i. The age proportions, $\hat{c}_i$, in the estimated catches were found by the equation:

$$\hat{c}_i = \frac{n_i \cdot r(i)}{\sum_j n_j \cdot r(j)} \qquad (17)$$

where n_i denotes the numbers at age, i (j in the summation), from the traditional Virtual Population Analysis (VPA) table in the AFWG report (ICES, 2000). The proportions were calculated for each year with their respective mesh sizes according to table 2.1 and the catch numbers were adjusted for the ages three to five years for each country by:

$$\hat{C}_i = \hat{c}_i \cdot \sum_j C_j \qquad (18)$$

where C_j is the landed catch at age, j. The catches were adjusted only in those cases where the estimated proportions were bigger than in the reported catches. Catches in ICES area 2a were not adjusted since the abundance of small fish is less there than in the other areas (Hylen & Rørvik, 1983). Young fish are generally distributed farther east than older age groups (Nakken & Raknes, 1987). The spawning fishery is also conducted in area 2a in the first quarter of the year and results in a large proportion of mature cod in the catches.

New stock numbers were estimated with the results from method II for the ages three through five by the methods for traditional VPA (Hilborn & Walters, 1992). Large discard rates cause the stock numbers for the ages three through five in the AFWG report to be too low. This influences the estimated catches from method II. The new VPA stock numbers were used as input in equation (17) to minimize this problem.

The catches were then adjusted once again. This process was repeated twice, i.e. the catches were in all adjusted three times.

Method II was run for the time period 1946 – 1992, but due to differences in the available catch data the method was modified for the years 1977 – 1981 and 1983 – 1992. For the years 1946 – 1976 and 1982 the catch numbers at age were stratified by country and area. Method II was not run any further than 1992 because of the uncertainties in the VPA for the most recent years of a time series.

2.2.1.1 The years 1977 – 1981

For the years 1977 – 1981, no catch at age data by country and area were available. Total catch numbers at age, nominal catch (tonnes) by countries and total nominal catch (tonnes) by trawl and other gears for each area were available (ICES, 2000). The catch numbers at age were divided into Norwegian catches and catches by the remaining countries by the nominal catch by countries table. It is assumed that only Norway uses other gears than trawl. The Norwegian catches were divided into Norwegian trawl catches and catches by other gears by the table for nominal catch by trawl and other gears. The Norwegian trawl catches and catches by remaining countries were adjusted by method II with the respective selection curves from 130 mm and 120 mm mesh sizes as input.

2.2.1.2 The years 1983 – 1992

For the years 1983 – 1998 catch numbers at age by country for each area were available, including data from the Norwegian bottom trawl surveys (1983 – 1999). For the years 1985 – 1998 the total Norwegian catch numbers at age by trawl were

also available. The catches were adjusted by method II using length distributions calculated by (15) with the results from equations (7) and (8) as input. The Norwegian catches in area 1 and 2b (1983 – 1984) and total Norwegian trawl catches (1985 – 1992) were adjusted with 135 mm mesh size as input. Russian and other countries' catches were adjusted with 125 mm as input in area 1 and 135 mm in area 2b (1982 – 1992). Catches in area 2a were not adjusted except for the Norwegian trawl catches, which were summed over all areas in the available data.

2.2.2 Method III (The use of selection curves and bottom trawl survey abundance indices)

2.2.2.1 Method IIIa (The use of abundance indices)

Uncertainties in the catch data affect the results from the VPA and will therefore influence the estimation of catches in method II. This can be avoided by using the stock numbers at age indices from the Norwegian bottom trawl surveys. Method IIIa is practically the same as method II, but instead of using the VPA numbers at age as input (n_i) in (17), the indices from the Norwegian bottom trawl surveys were used. This is a modified and slightly simplified method of the one used by McBride & Fotland (1996). Method IIIa was run for the years 1983 – 1998.

2.2.2.2 Method IIIb (The use of adjusted abundance indices)

The Norwegian bottom trawl surveys have been carried out in January – March (Mehl, 1999). Most of the mature fish have at this time started their migration towards the spawning grounds along the Norwegian coast (Bergstad et al., 1987; Nakken, 1994). These fish may have migrated out of the survey area and the entire mature

portion of the stock will not be covered by the survey (ICES, 2000). If this portion of the stock is added to the indices, one will get more accurate indices of the whole population.

There were a few mature fish in the survey data. These fish were subtracted from the indices, I_i, and the new numbers were adjusted according to the maturity proportions at age from the AFWG report (ICES, 2000). The adjusted indices, $\hat{I}$, for the ages, i, three through seven were then found by the equation:

$$\hat{I}_i = \frac{I_i - m_i I_i}{1 - Mat_i} \qquad (19)$$

where m is the proportion mature at age in the survey data and Mat is the proportion mature at age from the AFWG report. Since Mat cannot equal to one in equation (19), the indices, $\hat{I}_{8+}$, of eight year and older fish were found by the equation:

$$\hat{I}_{8+} = \frac{p_{8+} \cdot \sum_{j=3}^{7} \hat{I}_j}{1 - p_{8+}} \qquad (20)$$

where $\hat{I}_j$ is the adjusted indices at age, j, three through seven and p_{8+} is the proportion of eight year and older fish in the VPA stock numbers from the AFWG report. The adjusted indices at age 3 – 7 and 8+ were then used as input in (17).

For the years 1990 – 1994 unreported catches are estimated and added to the total catch by the AFWG. These catches were neither adjusted with method II nor III.

2.3 Discard rates

Norway, USSR and England were the most important countries in the fisheries for Northeast Arctic cod during the period from 1946 to 1976. During the years 1977 – 1998 Norway and USSR (Russia since 1991) have been the most important countries. Other countries that contributed to the total catches were gathered in one group. Discard rates were calculated for the countries mentioned above and for all countries combined. The catches were summed over area, *k*, and the discard percentages, *D*, at age and by country were calculated by:

$$D_{i,E} = \frac{(\hat{C}_{i,E} - C_{i,E}) \cdot 100}{\hat{C}_{i,E}} \qquad (21)$$

where $\hat{C}$ denotes the estimated catch, *C* the landed catch, *i* the age for *i* = 3, 4, 5 and 3+, and *E* the country. By summing the catches over countries, *E*, the total discard rates were found and the methods were compared.

The English discard rates from method I and II were compared with the values from Garrods work (1967) for the years 1950 – 1959. Norwegian discard rates from the different methods were compared with observations done by Hylen (1965b; 1967a; 1967b), Hylen & Smedstad (1974), Hylen (1987) and McBride & Fotland (1996).

2.4 Virtual Population Analysis (VPA)

The catches estimated by method II (1946 – 1982) and IIIb (1983 – 1998) were used as input in the traditional VPA (Hilborn & Walters, 1992) and new stock numbers at age were estimated. The percent increase from the AFWG stock numbers at age to the new stock numbers at age were calculated for the ages three, four and five.

2.5 Computing F_{med}

An increase in recruits, i.e. stock numbers at age three, as indicated by the estimates of discards will have an affect on the calculated relationship between spawning stock biomass and recruitment, and on the reference points which are based on this relationship. To demonstrate this, a spawning stock – recruitment plot was made with both new and old recruitment numbers and the reference point F_{med} was calculated by the method explained by Sissenwine & Shepherd (1987) and Jakobsen (1992). F_{med} is defined as "the level of fishing mortality where the accessions to the stock due to recruitment in half of the observed years have been more than sufficient to balance the losses due to mortality" (Jakobsen, 1992).

The spawning stock biomasses, *SSB*, (1000 tonnes) from 1946 – 1994 were plotted against the recruitments, *R*, (millions) from 1949 – 1997. *SSB/R* were calculated for each year, sorted ascending and the F_{med}-line is passing through the *SSB/R* middle point. The values in table 2.3 were used as input in the formula:

$$SSB / R = \frac{\sum_{i=3}^{15} (N_i \cdot SWt_i \cdot Mat_i)}{N_3} \qquad (22)$$

where N_i is stock numbers at age *i*, *SWt* is stock weights at age and *Mat* is the proportion mature. N_3 was set to 1000 and *N* for the ages 4 to 15 were found by:

$$N_{i+1} = N_i \cdot e^{-(F_i \cdot M_i)} \qquad (23)$$

F is the fishing mortality and equals to the exploitation pattern, F_{expl}, multiplied with F_{med}. *M* is the natural mortality. F_{med} was then found by "Goal Seek" in Excel when the *SSB/R* middle point was given by the *SSB* – *R* plot. The "Goal Seek" program varied the F_{med} value until the requested *SSB/R* value was found.

Table 2.3 Input parameters for computation of F_{med}. The parameter values are taken from Motos (1998). *SWt* is stock weights at age, *Mat* is the proportion mature, *M* is the natural mortality including cannibalism and F_{expl} is the exploitation pattern when $F_{5\text{-}10} = 1$.

Age	*SWt* (kg)	*Mat*	*M*	F_{expl}
3	0.21	0.00	0.67	0.02
4	0.53	0.01	0.40	0.16
5	1.14	0.04	0.23	0.46
6	1.93	0.20	0.20	0.72
7	2.94	0.45	0.20	0.96
8	4.58	0.83	0.20	1.24
9	7.42	0.93	0.20	1.20
10	10.37	0.98	0.20	1.42
11	11.74	1.00	0.20	1.39
12	11.85	1.00	0.20	1.09
13	12.50	1.00	0.20	1.20
14	13.90	1.00	0.20	1.55
15	15.00	1.00	0.20	1.55

3. Results

The catch numbers at age from the Arctic Fisheries Working Group (AFWG) are given in the appendix (table A) together with the adjusted catch numbers at age estimated by the different methods. The catches are listed for the countries, which have the major contributions to the Northeast Arctic cod fishery. The remaining countries are grouped in "Others". For the years 1977 – 1981 and 1985 – 1998 the Norwegian trawl catches are listed. The Norwegian catches caught with conventional gears are included in the total catches, but are not adjusted. For the years 1990 – 1994 the Working Group has added some unreported catches to the statistics, these catches are included in the totals, but are not adjusted. The total catch numbers at age, received from a member of the AFWG, deviates some from the numbers in the AFWG report (ICES, 2000). The deviations are mostly small (less than 1%), but there are a few years where the deviations are larger and may be caused by typing errors. The deviations in 1983 and 1996 – 1998 are caused by revisions of the catch data by the AFWG.

3.1 Method I (No discarding in USSR catches)

In method I the catches were adjusted according to the USSR landings and discard rates were calculated.

England and Norway have high discard rates of three-year old fish, but the variation is large (figure 3.1). The group of other countries has a negative trend in the discard rates of three-year olds. Norway and England do not have any trends.

The discard rates of four- and five-year old fish are high with large variances. England and the group of other countries have a peak in the 1950s and a negative trend for the later period. Norway has higher discard rates at the end of the time period than the other countries, which may be caused by the difference between the mesh sizes used by Norway and USSR.

The English and Norwegian total discards by number have very high peaks several times in the period. There are no trends in the discard rates for these countries. The group of other countries has a negative trend after the peak in 1953.

The AFWG has for some years lacked the age distributions for some countries' catches and they have then assigned the catch numbers at age according to another country's catch numbers at age. An example: in 1948 the age distributions in area 1 and 2b catches by England and the group of other countries were raised by USSRs catch at age. This influences the results and causes in some years the estimated discard rates to be zero. The AFWG has in 1967 and 1968 raised the age distribution in the Norwegian catches in area 2b from the English catches, this is an error since Norwegian trawlers used 130 mm mesh size and English trawlers used 120 mm mesh size.

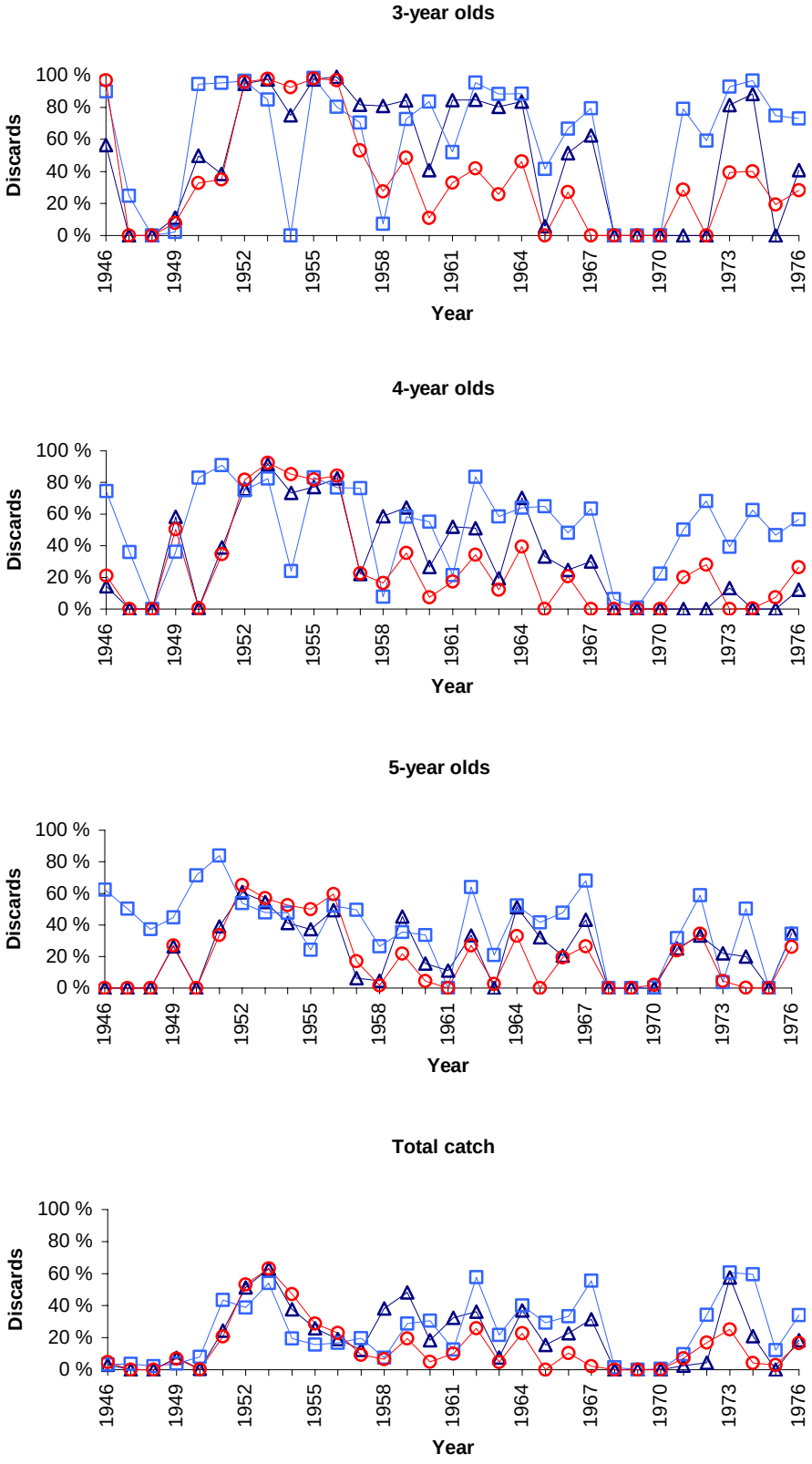

Figure 3.1 English (Δ), Norwegian (□) and other countries' (○) total discards by number estimated by method I (1946 – 1976).

3.2 The use of selection curves

3.2.1 Length at age and cod-end retention

The values of mean lengths at age and standard deviations calculated from the Norwegian bottom trawl survey data for the years 1983 – 1999 are given in the appendix (table B) together with the other variables used to calculate the mean lengths at age and standard deviations by the method for a mixture of two normal distributions (1983 – 1998). The variations in the mean lengths from the results of the mixture are large between the years, ± 5-15% from the averaged values in table 3.1. The variations are largest for the youngest ages.

Table 3.1 Averaged mean lengths at age and standard deviations from the results of the mixture of two normal distributions. Data from Norwegian bottom trawl surveys, 1983 - 1999.

Age (years)	Averaged mean length (cm)	St.dev
3	39.25	7.27
4	49.70	6.98
5	59.02	7.24
6	68.14	7.77
7	76.37	7.08

The averaged mean lengths and standard deviations (table 3.1) were used as input in the estimation of the percentages of retained fish at age in cod-ends with the different mesh sizes used in the time period 1946 – 1982 (table 3.2). The percentages of retained fish were used in method II to estimate the age proportions in the catches for the years 1946 – 1982. The 80 mm mesh size has very little selection and catch almost all three-year and older fish that enters the cod-end. An increase in mesh size improves the selection and the improvement is largest for the youngest ages. The retention of the fish eight year and older, was set to be 100% with all mesh sizes.

Table 3.2 Percent retained fish at age in cod-ends with different mesh sizes. Averaged mean lengths at age and the respective standard deviations from table 3.1 were used as input.

	Age (years)				
Mesh size (mm)	3	4	5	6	7
80	97	100	100	100	100
110	52	87	98	99	100
120	33	72	93	98	100
125	25	63	89	97	100
130	19	53	83	95	99
135	14	44	76	93	98

Table 3.3 shows the estimated percentages of retained fish at age in cod-ends with mesh sizes of 125 mm and 135 mm for the years 1983 – 1998. These were used in method II and III, and were found by using the results from the mixture of two normal distributions (appendix, table B) as input. The retention rates at age vary between the years and the variation is largest for the ages, which lengths are within the selection range. An example: the retention at age three with a 125 mm mesh size change from 12% in 1988 to 51% in 1991. This change is as large as the decrease when the mesh size is changed from 110 mm to 135 mm in table 3.2. The differences between the maximum and minimum values for three-, four- and five-year olds are 39%, 47% and 27%, respectively, for the 125 mm mesh size (table 3.3). For the 135 mm mesh size the differences are 27%, 47% and 39% for the three-, four- and five-year old fish. The variations are caused by the variations in the mean lengths at age and in the standard deviations. The mean lengths have the biggest influence on the retention rates.

Table 3.3 Percent retained fish at age (years) in 125 mm and 135 mm mesh sized cod-ends using lengths given in the appendix (table B) as input.

	125 mm					135 mm				
Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 3	Age 4	Age 5	Age 6	Age 7
1983	32	66	90	98	100	20	48	78	93	99
1984	34	78	91	98	100	21	62	82	95	99
1985	45	78	97	99	100	28	60	90	98	100
1986	18	75	96	97	100	9	57	88	94	100
1987	12	41	86	98	97	6	24	71	95	94
1988	12	36	70	91	100	6	20	51	81	98
1989	29	51	74	92	99	17	34	57	82	96
1990	46	74	89	96	99	30	57	77	90	97
1991	51	83	95	99	100	33	67	87	96	99
1992	47	79	95	99	100	30	62	88	97	99
1993	27	75	93	99	100	16	57	83	96	99
1994	18	61	87	96	99	10	43	75	91	98
1995	15	48	87	97	100	8	30	73	91	98
1996	14	47	77	96	99	8	30	60	89	98
1997	14	49	79	95	99	7	31	62	87	97
1998	14	47	81	95	99	8	29	65	87	97

3.2.2 Method II (The use of selection curves and VPA stock sizes)

3.2.2.1 1946 – 1976

The discard rates of three- and four-year old fish are high for all countries during the time period 1946 – 1976 (figure 3.2). However, the discard rates of four-year olds are in general lower than the discard rates of three-year olds. There is a negative trend in the discard rates after the late 1950s, but the inter-annual variation is large and there are some high peaks in the 1960s and in the 1970s. USSR does in general have lower discard rates than England and Norway, with few exceptions. The differences between the countries are large during the time period 1951 – 1976.

The discard rates of five-year olds are low except for some years in the beginning of the time period and in a few later years. Norway has high discard rates of five-year old fish in 1946 – 1950.

All countries have a negative trend in the total discards by number and they have similar fluctuations throughout the period, 1946 – 1976. The total discard rates by USSR during this time period have a mean of 18% by number, while England and the group of other countries have a mean of 19% and 18%, respectively. Norway has a lower mean (15%) than the other countries.

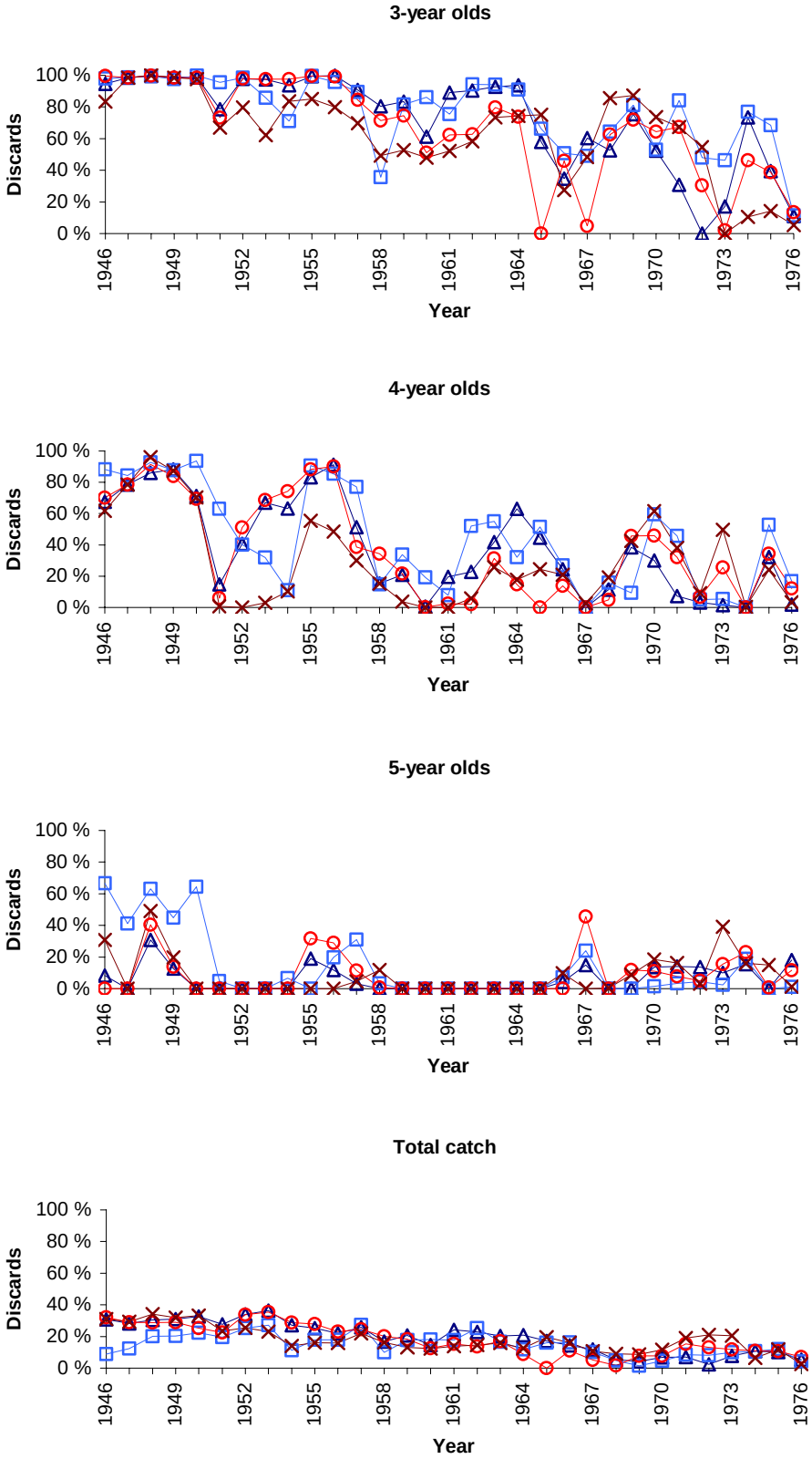

Figure 3.2 English (∆), Norwegian (□), USSRs (X) and other countries' (○) total discards by number estimated by method II (1946 – 1976).

3.2.2.2 1977 – 1981

Both the Norwegian and the group of other countries' discard rates show similar trends for the years 1977 – 1981, but the Norwegian discard rates are lower than for the group of others (figure 3.3). The discard rates of three-year olds have a low point in 1978 before an increase towards the end of the period. The discards of four-year olds are low in 1977 and 1979, but are high the remaining years. In 1978 the discard rates of four-year olds are higher than the discard rates of three-year olds. The discard rates of five-year olds are low in the four first years and a little higher in 1981. The discard rates of the total Norwegian catch are low throughout the period, while the discard rates of the remaining countries' total catches have a positive trend.

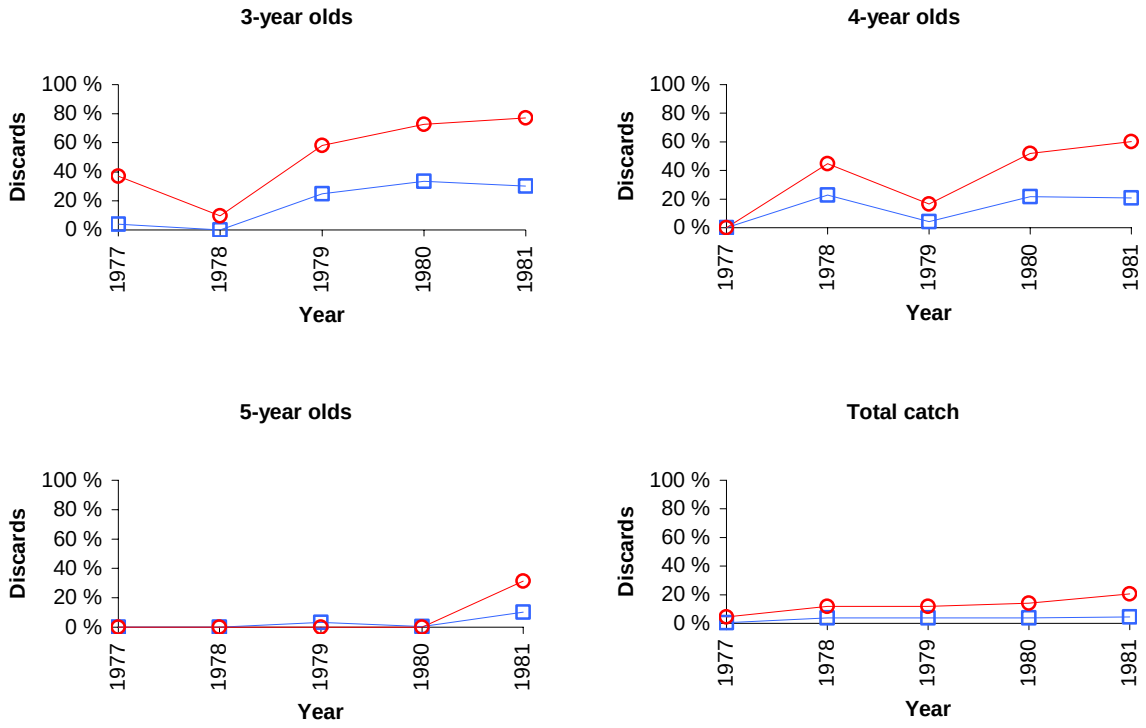

Figure 3.3 Norwegian (□) and other countries' (○) total discards by number estimated by method II (1977 – 1981). The group of other countries includes USSR and England.

3.2.2.3 1982 – 1992

All countries have similar fluctuations in the discard rates of three-year old fish, but there are some differences in what time the peaks occur (figure 3.4). USSRs discard rates of three-year olds are in general higher than the Norwegian and the other countries' discard rates. Norway has low discard rates of four- and five-year old fish throughout the period, 1982 – 1992. USSR and the other countries have a positive trend in the discard rates of four-year olds and in general low values for the five-year olds. The other countries have a few years with relatively high values for the five-year olds. The discard rates of the total catch have similar trends for Norway, USSR and the group of other countries, but Norway has in general lower values and smaller fluctuations.

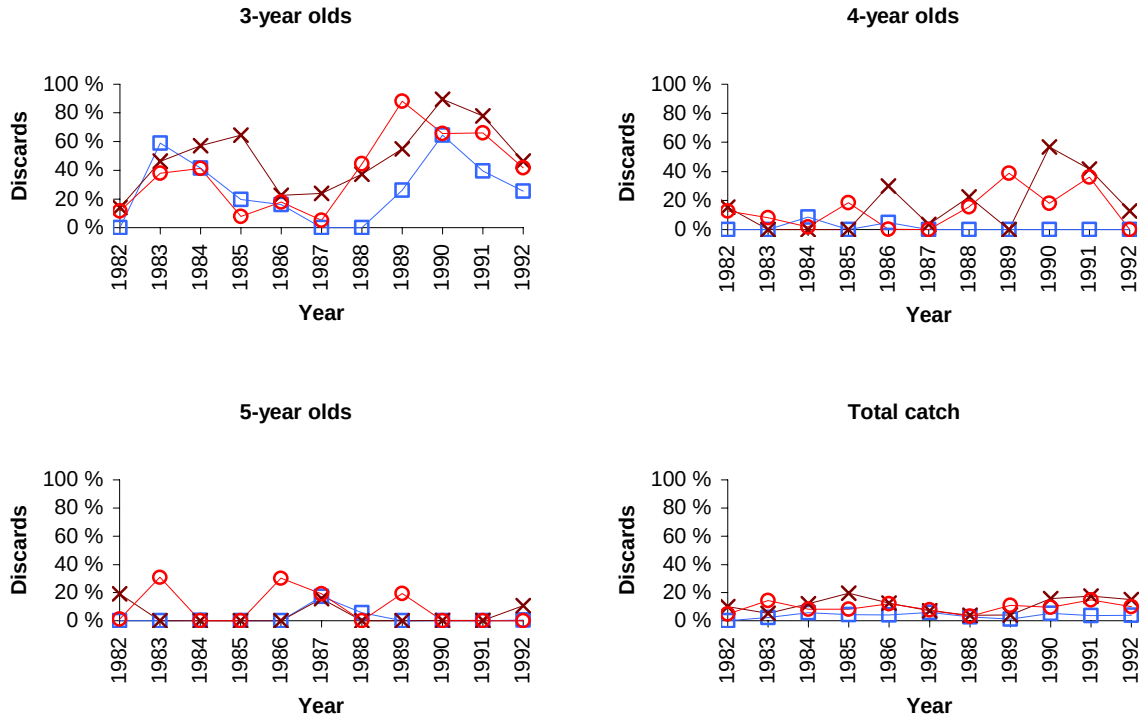

Figure 3.4 Norwegian (□), USSRs (x) and other countries' (○) total discards by number estimated by method II (1982 – 1992).

3.2.3 Method III (The use of selection curves and bottom trawl survey abundance indices)

3.2.3.1 Method IIIa (The use of abundance indices)

The indices from the Norwegian bottom trawl surveys used as input in methods IIIa and IIIb are given in the appendix (table C).

The fluctuations in the discard rates of three-year old fish are large throughout the period, 1983 – 1998 (figure 3.5). Norway has in general lower discard rates of three-year olds than USSR and the group of other countries. All countries have a positive trend in the discard rates of three-year old fish and all countries have similar trends in the discard rates of four-year olds, but the differences between the countries are for some years large. The discard rates of five-year old fish are in general low, but the other countries and Norway have some years with high discard rates. All countries have similar trends in the discard rates of the total catch; increases in the mid 1980s and in the early 1990s, decreases in the late 1980s and in the end of the period. USSR and the other countries have in general higher discard rates than Norway.

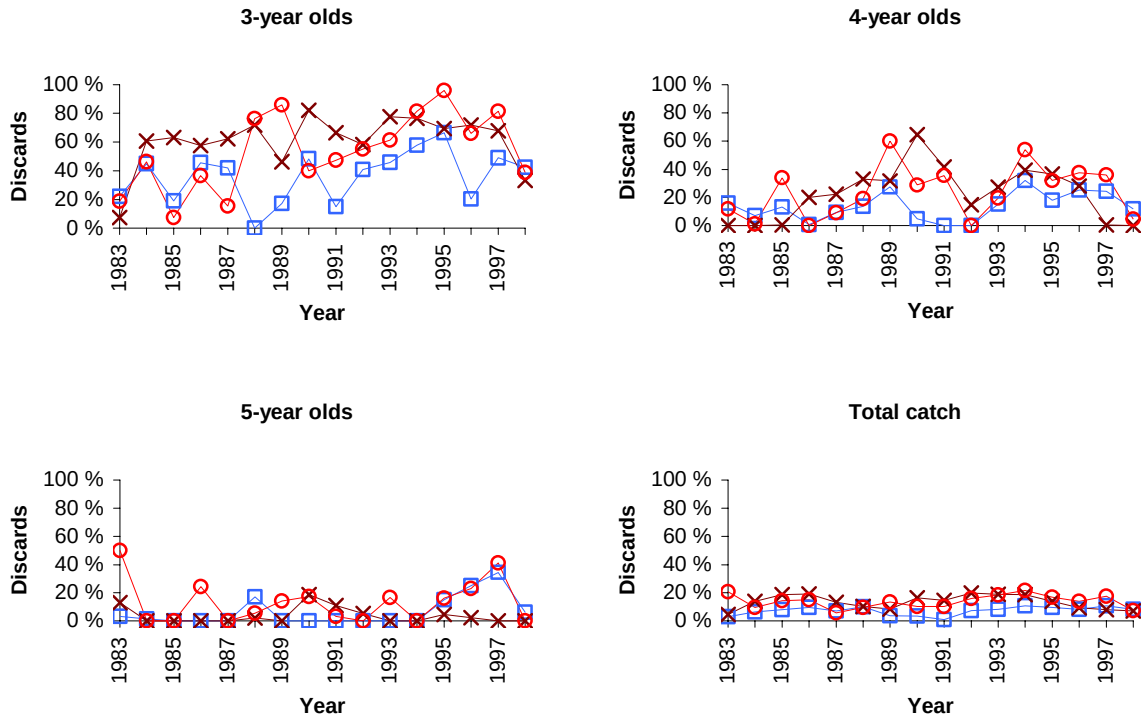

Figure 3.5 Norwegian (□), USSRs (x) and other countries' (○) total discards by number estimated by method IIIa (1983 – 1998).

3.2.3.2 Method IIIb (The use of adjusted abundance indices)

The discard rates estimated by method IIIb for the years 1983 – 1998 (figure 3.6) have the same trends as the discard rates estimated by method IIIa, but the discard rates estimated by method IIIb are in general 0-10% lower than the discard rates estimated by method IIIa. In 1983 are the differences up to 20%. The discard rates of three- and four-year olds were reduced the most.

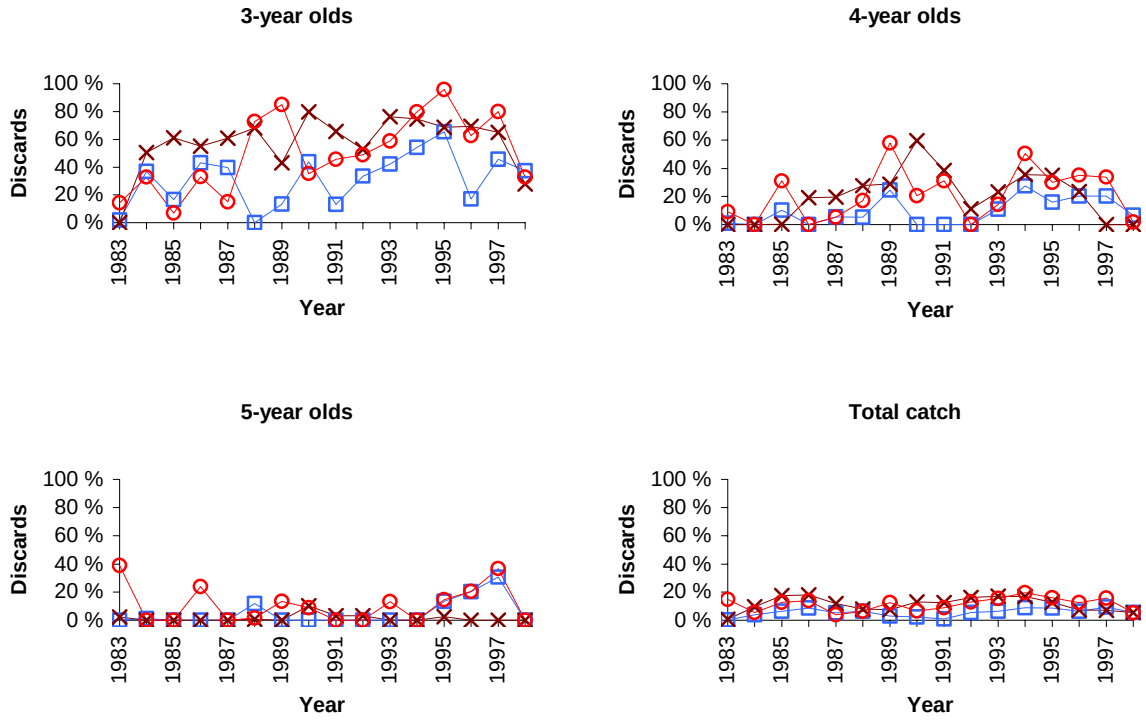

Figure 3.6 Norwegian (□), USSRs (X) and other countries' (○) total discards by number estimated by method IIIb (1983 – 1998).

3.3 Comparison of the methods

The catch numbers at age estimated by the different methods were summed over all countries and the discard rates at age were calculated and plotted in the same graph (figure 3.7). The discard rates of three-year old fish estimated by method I have no trend and are much lower than the ones estimated by method II (1946 – 1976), with few exceptions. The rates estimated by method II have a negative trend, but there are large fluctuations. Discard rates of three-year olds estimated by method II (1977 – 1981) have a low point in 1978 and increases towards a peak in 1980. The discard rates of three-year olds estimated by method II (1982 – 1992) coincides with the rates estimated by method IIIa and b only for a few years. The II value is much higher in 1983 and lower in 1986 – 1988. The discard rates estimated by IIIa and b have a positive trend, but the fluctuations are large. The IIIb values are 1-11% lower than the IIIa values.

Both method I and method II (1946 – 1976) have large fluctuations in the discard rates of four-year old fish. There are no similarities between the methods. The values from method II have a negative trend while the values from method I have no trend. The discard rates estimated by method II (1977 – 1981) are low in 1977 and 1979, but are high the remaining years. The discard rates from method II (1982 – 1992), IIIa and IIIb coincides fairly well, except for in 1989 when II has a lower value. The discard rates are low in the early 1980s, have large fluctuations in the late 1980s and in the 1990s with high peaks in 1989 and 1994. The IIIb discard rates are 0-7% lower than the IIIa discard rates.

The discard rates of five-year olds estimated by method I are in general higher than the discard rates estimated by method II (1946 – 1977). The II discard rates are low except for some years in the beginning of the period and some years in the end of the period. The II (1977 – 1981) discard rates are low except for in 1981. The discard rates estimated by method II (1982 – 1992), IIIa and IIIb are low throughout the period, with a few exceptions.

The discard rates of the total catch estimated by methods I and II (1946 – 1976) have similar fluctuations, except for the years 1946 – 1950 when the values from method I are low. The fluctuations in the discard rates estimated by method I are larger than the fluctuations in method II. The discard rates estimated by method II (1977 – 1981) are low, except for in 1981. The discard rates estimated by methods II (1982 – 1992), IIIa and IIIb have similar fluctuations, but the values from method II are in general a little lower than the IIIa and IIIb values. The values from method IIIb are 1-4% lower than the values from method IIIa.

3.4 Correlation analysis

By correlation analysis a positive linear relationship ($r = 0.60$) was found between the total discard rates, from method II (1946 – 1982) and IIIb (1983 – 1998), and the new total VPA stock numbers throughout the period, 1946 – 1998. A negative linear relationship ($r = -0.87$) was found in the same period between the total discard rates and the mesh sizes used.

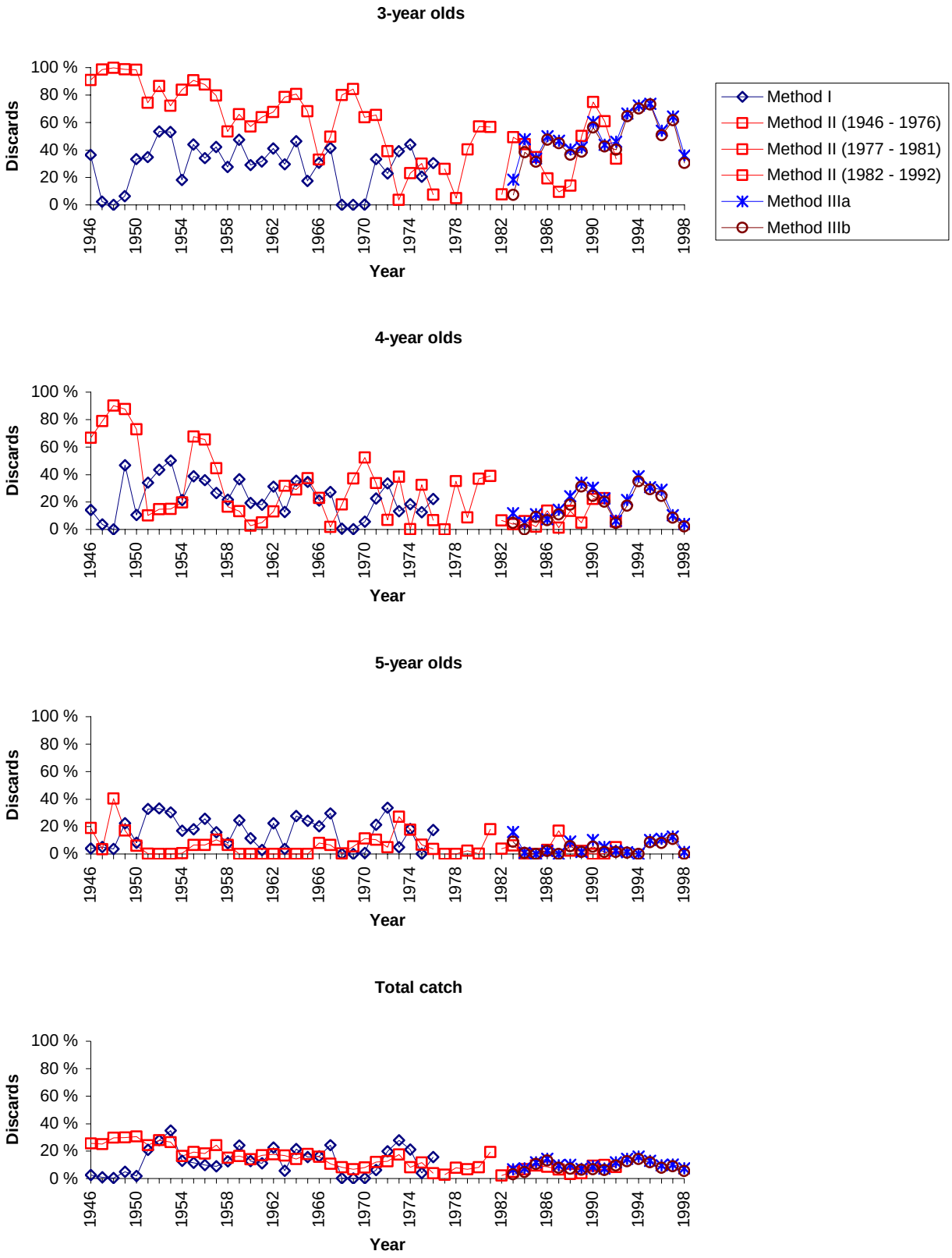

Figure 3.7 Total discards when the catches, estimated by the different methods, for all countries are summed.

3.5 Estimated discard rates compared with discard rates from literature

The English discard rates from methods I and II were compared with Garrods work (1967) (figure 3.8). The years 1950 – 1959 were chosen for comparison because these are the years that Garrod thought would be most accurate. He doubted the accuracy of the English catch per effort in 1946 – 1949 and his assumption that discarding was zero for the 1955, 1956 and 1957 year classes causes some discard values to be negative in the years 1960 – 1963 (Garrod, 1967). His assumption does also cause the discard rates for three-year olds in 1958 and 1959 and for four-year olds in 1959 to be low.

Both methods I and II give similar discard rates to Garrods values for three-year old fish (figure 3.8). Method I deviates the most from Garrods values and especially with the low values in 1950 and 1951. The estimated discard rates of four-year olds have similar trends to the values from Garrod, but both methods have years when the differences from Garrod are large. In the discard rates of five-year olds there are very little similarities between the estimated discards and Garrods values. In general, method I has higher values and method II has lower values than Garrod. The discard rates of the total catch estimated by method II are similar to the values from Garrod, while the discard rates estimated by method I are in general higher than Garrods. On the whole the discard rates estimated by method II have most similarities to the discard rates from Garrods work.

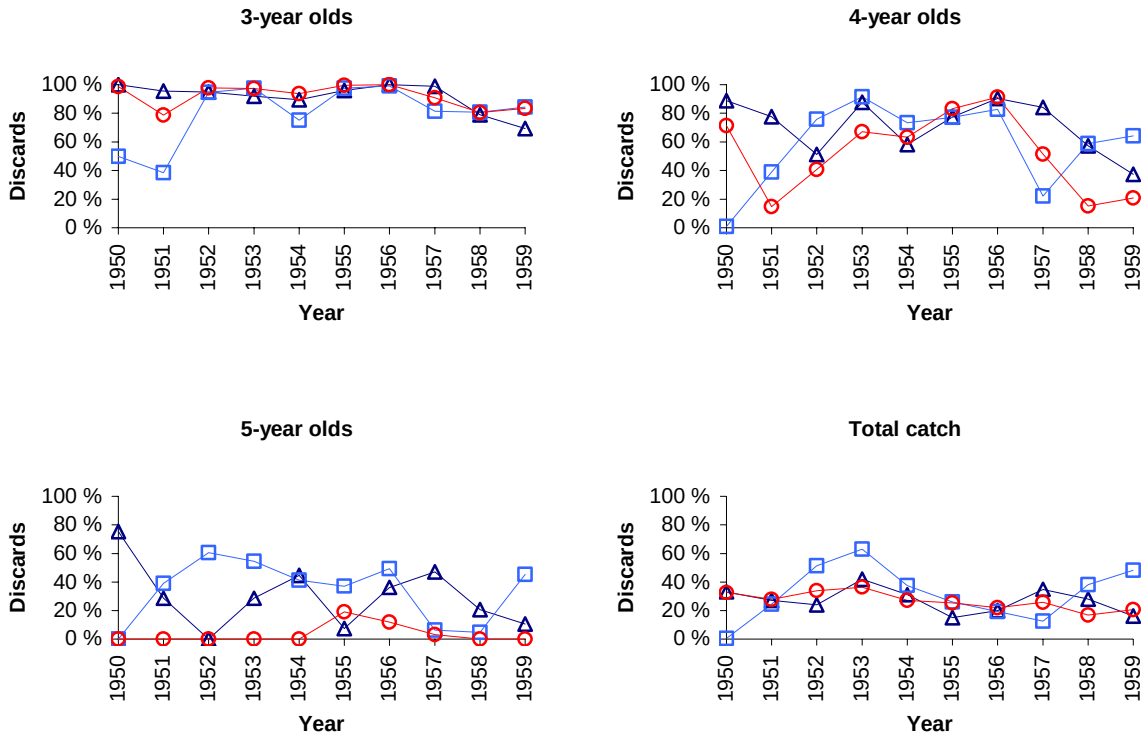

Figure 3.8 English discards at age estimated by method I (□) and II (○) compared with results (Δ) from Garrods work (1967) for the period 1950 - 1959.

Total Norwegian discard rates estimated by the different methods were compared with available information from the literature (table 3.4). Method I give higher values than the maximum values from the literature. The discard rates by method II are above the values from the literature for 1964 and 1966, within the values for 1965 and 1967, and below for 1973. For 1987 all the estimated discard rates in trawl are within the boundaries from the literature and close to the minimum value. For 1989 the discard rate in trawl estimated by method IIIa is above the value from the literature and the discard rates in trawl estimated by method II and IIIa are below. Both the discard rate from method IIIa and the discard rate from method IIIb are close to the value from the literature. It is important to remember that the observations are made in limited areas for a limited time with few vessels. Thus, it is expected that these observations will deviate some from the estimates. The discard rates are calculated for larger areas and all the vessels that had catches in these areas during the year.

Table 3.4 Norwegian discard rates estimated by the different methods compared with earlier observations and estimates from the literature. Sources 1 and 6 have only one value.

	Total discards by number				Discards by number in trawl			Discard rates from literature		
Year	Method I	Method II	Method IIIa	Method IIIb	Method II	Method IIIa	Method IIIb	Min	Max	Source
1964	40 %	12 %							4 %	1
1965	29 %	16 %						1 %	24 %	3
1966	33 %	16 %						1 %	2 %	2
1967	56 %	10 %						6 %	25 %	2
1973	61 %	10 %						23 %	38 %	4
1987		6 %	7 %	5 %	8 %	10 %	7 %	6 %	42 %	5
1989		1 %	4 %	3 %	2 %	8 %	6 %		7 %	6

Sources: 1 Hylen (1965b), 2 Hylen (1967a), 3 Hylen (1967b), 4 Hylen & Smedstad (1974), 5 Hylen (1987) and 6 McBride & Fotland (1996).

3.6 Virtual Population Analysis (VPA)

The catch numbers at age estimated by method II (1946 – 1982) and IIIb (1983 – 1998) were used as input in the VPA and new stock numbers at ages three, four and five were estimated (table 3.5). The estimated discards have a large influence on the stock numbers at age three. The increases in stock numbers at age three have a mean of 26% for the years 1946 – 1949. In the 1950s is the mean increase 19%, but there is a peak at 40% in 1955. In the 1960s, 1970s, 1980s and 1990s are the mean increases 15%, 10%, 5% and 5%, respectively. There is a negative trend, but the increases in stock numbers at age three reflect the large variations in the discard rates. The increases in stock numbers at age four do also have large variations. There are a few periods with high increases in the 1940s, 1950s and 1970s, but for the remaining years the increases are moderate (0-11%). The negative value in 1983 is caused by some minor differences in the catch numbers at age used as input in the estimation of discards and as input in the AFWGs VPA (ICES, 2000). The increases in stock numbers at age five are low (0-5%) except for the years 1973 (11%) and 1974 (9%). The negative value in 1998 has the same explanation as the negative value at age four in 1983.

Table 3.5 Stock numbers at age (in thousands) estimated by VPA with the adjusted catch numbers estimated by method II (1946-1982) and IIIb (1983-1998). The percentages show the increases from the AFWG stock numbers at age (ICES, 2000) to the estimated stock numbers at age.

	Estimated stock numbers (thousands)			Percent increase		
Year	Age 3	Age 4	Age 5	Age 3	Age 4	Age 5
1946	875 346	602 579	407 163	20 %	4 %	1 %
1947	531 993	676 806	465 099	27 %	14 %	0 %
1948	570 356	392 309	497 476	29 %	14 %	5 %
1949	589 367	416 668	285 459	26 %	16 %	3 %
1950	799 732	414 016	291 200	13 %	9 %	1 %
1951	1 235 322	586 054	302 346	14 %	2 %	0 %
1952	1 388 731	889 509	401 768	17 %	3 %	0 %
1953	1 801 114	975 004	600 908	13 %	2 %	0 %
1954	830 653	1 321 053	684 303	29 %	5 %	0 %
1955	381 489	615 696	907 875	40 %	19 %	2 %
1956	567 555	274 235	399 344	29 %	25 %	3 %
1957	914 850	387 496	161 710	14 %	10 %	2 %
1958	552 600	672 221	262 135	11 %	4 %	2 %
1959	757 567	391 906	406 694	11 %	3 %	0 %
1960	855 470	534 350	240 047	8 %	1 %	0 %
1961	1 041 570	620 707	347 043	13 %	1 %	0 %
1962	894 728	739 196	382 556	23 %	4 %	0 %
1963	551 938	614 025	429 068	17 %	10 %	0 %
1964	389 151	396 165	361 790	15 %	5 %	0 %
1965	845 469	293 844	266 134	9 %	8 %	0 %
1966	1 618 188	647 435	203 168	2 %	4 %	2 %
1967	1 404 569	1 249 506	465 035	9 %	0 %	1 %
1968	210 875	1 088 071	876 095	24 %	6 %	0 %
1969	143 791	155 947	699 033	28 %	15 %	2 %
1970	222 635	104 415	92 541	13 %	17 %	4 %
1971	462 474	164 397	65 112	14 %	6 %	2 %
1972	1 221 559	358 357	115 892	20 %	10 %	1 %
1973	1 858 123	947 409	249 400	2 %	19 %	11 %
1974	598 555	1 246 499	583 612	14 %	2 %	9 %
1975	654 442	382 692	627 793	5 %	10 %	3 %
1976	622 230	477 390	233 608	1 %	2 %	1 %
1977	397 826	426 386	280 645	14 %	0 %	0 %
1978	653 256	277 410	198 204	2 %	11 %	0 %
1979	225 935	460 104	164 243	14 %	2 %	1 %
1980	152 937	171 954	300 312	11 %	11 %	0 %
1981	161 752	116 964	116 337	7 %	7 %	4 %
1982	151 642	125 307	81 780	0 %	4 %	1 %
1983	166 310	115 423	82 423	0 %	-1 %	3 %
1984	408 525	133 333	77 728	3 %	0 %	0 %
1985	543 828	324 072	96 327	4 %	2 %	0 %
1986	1 114 252	412 683	219 993	7 %	2 %	0 %
1987	307 425	767 656	268 642	7 %	4 %	0 %
1988	222 819	215 720	490 161	9 %	3 %	2 %
1989	180 066	166 955	151 576	4 %	6 %	0 %
1990	249 968	139 922	114 006	3 %	2 %	1 %
1991	418 955	200 700	105 559	2 %	2 %	0 %
1992	748 962	333 517	151 973	4 %	1 %	0 %
1993	1 002 933	576 112	238 980	10 %	2 %	0 %
1994	896 184	744 062	420 039	9 %	8 %	0 %
1995	733 664	584 808	476 048	10 %	6 %	3 %
1996	467 093	341 918	344 124	3 %	7 %	3 %
1997	765 234	238 202	193 102	3 %	0 %	4 %
1998	836 301	429 147	144 629	2 %	1 %	-1 %

3.7 F_{med}

The estimated and the AFWG stock numbers at age three (*R*) were plotted against spawning stock biomasses (*SSB*) (figure 3.9). The middle points of *SSB/R* were found to be 0.90 for the estimated stock numbers at age three and 0.98 for the AFWG stock numbers at age three. F_{med} was calculated for both series. F_{med} calculated with the adjusted stock numbers was a little higher (0.03) than the F_{med} calculated with the AFWG stock numbers. The AFWG stock numbers at age three and spawning stock biomasses were collected from the AFWG report (ICES, 2000).

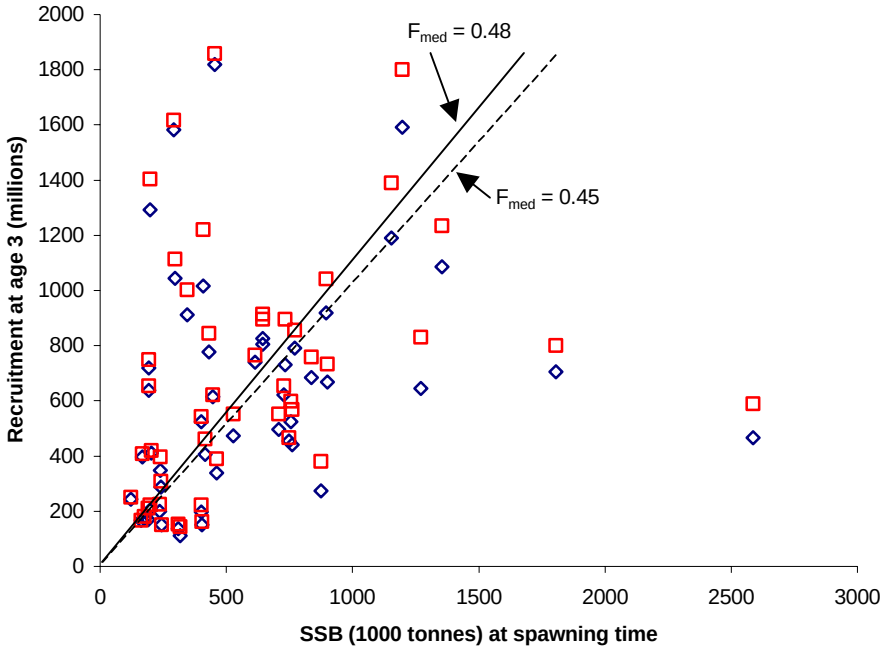

Figure 3.9 Stock numbers at age three from table 3.6 (□) and from the AFWG report (◊) (ICES, 2000) plotted against the spawning stock biomass (*SSB*) (ICES, 2000). The lines go through the middle point of each data series and the respective F_{med}'s are attached. Solid line belongs to the estimated numbers and the broken line to the AFWG numbers.

4. Discussion

The estimations in this work indicate that it is possible to use landings data, stock numbers at age estimates and selection curves to estimate the total catch and thereby the discard rates. Compared with the few data from the literature, my estimates show similar trends in the discard rates. The results indicate that the discard rates in the bottom trawl fishery for Northeast Arctic cod have been substantial in the time period 1946 – 1998 and they also indicate that the USSR had a discarding practice. There is a decreasing trend in the discard rates, but the fluctuations are large. A relationship was found between mesh sizes in use and discard rates, and between total stock size and discard rates. The discard rates are shown to be a large source of error in the VPA and will thus influence research and assessment based on the VPA estimates.

4.1 The available data

The lack of details in the data material is a weakness in these types of analysis. It would be preferable if the catch data at age were stratified by country, area and quarter of the year, if the information on trawls, mesh sizes and selection curves was more detailed, and if population parameters such as distribution and length at age were available for the whole period and for more than one time a year. However, this was not the case.

Members of the Arctic Fisheries Working Group (AFWG) have provided the catch at age data used in this work. Age compositions of the catches from different countries, areas and gears have been available to a varying degree. The age compositions of the catches from countries lacking this information have been calculated, by the AFWG,

using the age compositions available from other countries. Thus, the statistics may not reflect the true landings, for instance if the vessels from the different countries have different discarding practices. This influences the estimated discard rates. In general this problem involves the countries that are included in the group of others, but might be the explanation to the Norwegian and English discard rates close to zero estimated by method I.

Information on mesh sizes in use and selection curves is scarce. I have gathered information on the legal mesh sizes, but the actual mesh sizes in use may be quite different. In the beginning of the period it was common to use a double cod-end or a chafer for protection of the cod-end, which resulted in a decrease of the effective mesh size. Studies in the 1960s showed that the effective mesh size in double cod-ends were up to 20% less than the legal mesh size (ICES, 1965b; Hylen, 1965a). Studies in the 1960s also showed that cod-ends made out of synthetic fibers, which became common in use at that time, have better (<10%) selection properties, i.e. retain less small fish, than cod-ends made out of manila, which was the common material prior to the 1960s (Margetts et al., 1964; ICES, 1965b; Holden, 1971). It is common to apply cod-end mesh selection to the whole trawl, but as pointed out by Dickson (1993), in addition to the cod-end mesh size, the length composition of the catch is determined by the fish available, otterboard effects, sweep and sand cloud effects and ground-gear. Sweep herding is more efficient for larger fish than small ones and the efficiency will vary with visibility (Engås & Godø, 1989b). Relatively more small cod escape beneath the fishing line than larger cod and a larger proportion with bobbins gear than with rockhopper gear (Engås & Godø, 1989a). Their experiments imply that only 50% of three year olds present in the fishing area enter

the trawl mouth when bobbins gear is used, but this will vary with respect to the length distribution at age. Large fish are able to leave the trawl mouth even after entering it (Wardle, 1986), and Huse et al. (2000) suggest a bell shaped selection curve for the total trawl. However, in lack of any better model, the sigmoid selection curve for the cod-end was used as a selection curve for the whole gear in method II and III.

For the years 1983 – 1999 survey data from the Norwegian bottom trawl surveys during winter were available. The bottom trawl survey data was chosen because the bottom trawl indices normally show better correlation with the converged VPA than the acoustic indices (ICES, 1999b) and because the indices are independent of the commercial catches. However it is important to remember that the coverage of three- and four-year old cod is poorer than for the older ages, especially prior to 1993 (Korsbrekke et al., 1999). This affects the indices and might affect the mean lengths at age. The larger fish in an age group conduct more extensive south- and westwards directed winter migration than smaller individuals (Nakken, 1994), thus an incomplete survey coverage of an age group (east- and northwards) will result in that the estimated mean length at age is too large. This may be a problem for three-year old cod prior to 1993 (Michalsen et al., 1998). Another problem is that the entire mature portion of the stock is not covered by the Norwegian bottom trawl survey due to the spawning migration (ICES, 2000). The survey indices were adjusted in method IIIb to avoid this problem. Other survey data were also available, but due to differences in survey methods and coverage it was decided not to use these data.

The general problems with the data material are mentioned above, while problems and scarcities of the data material affecting the different methods will be discussed later.

4.2 Method I (No discarding in USSR catches)

In method I were the different countries' catches adjusted by the USSR catches and the estimated discard rates are high for the ages three, four and five. The assumptions in this method were: (1) that the USSR landings were representative for the USSR catches, i.e. the USSR had no discards, (2) that the catches by the different countries were taken at approximately the same time and place, and (3) that the trawls used had similar selection properties.

In earlier work the assumption of no USSR discards has been made (e.g. Hylen & Rørvik, 1983), which is a reasonable assumption due to the fact that the Soviet Union used most of the fish for their internal market, had fixed prices and the inner market presumably was large enough to absorb all the fish they could get (Jakobsen, 1999). Thus, one should expect that discarding of small fish would be limited or absent. However, very little small fish is present in the catch statistics in relation to the small mesh sizes that were in use. The validity of the USSR age distributions in the catches prior to 1964 was questioned by the AFWG in 1965 (ICES, 1965a). The reason for this was that the USSR applied catch-compositions from scouting vessels on commercial catches. There are also rumors that the USSR caught and landed more small fish than are present in the catch statistics. If this is true or if the USSR had a discarding practice the first assumption is wrong and the discard rates were estimated on false premises.

Fish stocks do in general have patchy distributions (Pennington, 1996) and have a tendency to be clustered by size (Pennington & Vølstad, 1994). The Northeast Arctic cod stock is distributed by size and age; small fish is distributed further north- and eastwards than larger fish (Nakken & Raknes, 1987; Ottersen et al., 1998; Michalsen, 1999), large fish tend to be in deeper water than smaller fish (ICES, 1965a) and the annual migrations vary, as the fish grow older (Bergstad et al., 1987). Thus, to be able to adjust one country's catch by the USSR catch data it is of high importance that the countries fished on the same proportions of the cod stock. This made the assumption that the trawlers from the different countries were distributed equally in both time and space necessary. Method I was run for the time period 1946 – 1976 and this was before the introduction of the national economic zones (NEZ) in 1977 (Halliday & Pinhorn, 1996), and before the quotas became effective. The first total allowable catch (TAC) for cod was introduced in 1975, but according to Nakken (1998) this was far too high and no effective management measures had been in operation for cod prior to the establishment of the NEZ. Thus, prior to 1977 trawlers from all countries could fish freely outside the 12 mile zone except for in some seasonal no trawling zones (Halliday & Pinhorn, 1996). Because the vessels could go where they wanted and because rumors of good fishing in one area spread fast due to the communication between the vessels on open radio bands, it is plausible that the vessels from the different countries were gathered in the same areas. On the other hand it is possible that vessels from the USSR would try to find good fishing grounds closer to their home ports and had a more easterly distribution than the western countries' vessels. This would probably cause differences in the catch compositions, which violates my assumption.

The final assumption was that the selection properties of the trawls used by the different countries were similar. It is not very likely that this was true for each vessel due to the many factors affecting the selection. Factors originating from the vessel, the trawling procedure, the trawl, the environment and the fish are all known to influence the size selection (Wileman et al., 1996). The factors originating from the environment and the fish will be similar if the second assumption is valid. The variance in selection due to vessel factors and trawling procedures will not be of any importance because of the large numbers of vessels and hauls in the pooled data, assuming that there were no general differences between the countries, for instance that one country in general had larger vessels with more engine power than another country. Length and engine power of a vessel are found to affect the catching efficiency (Salthaug & Godø, 2000), better efficiency is equivalent to larger catches and selectivity may be affected by catch size (Wileman et al., 1996). Differences in trawl characteristics such as mesh size, cod-end material and use of chafer will produce different selection properties. The use of chafer was assumed to be similar between the countries, but Norway used larger mesh sizes than the USSR after 1963 and the change from manila to synthetic fibers may have occurred at different times for the countries. The difference in mesh size between Norway and the USSR is a possible explanation to the high Norwegian discard rates for the years 1963 – 1976 estimated by method I.

The strength of this method is that it is direct and easy to apply to the data. However, due to all the problems discussed above the results from method I are not given any credibility, most of all because of the doubts about the validity of the USSR catch compositions. Thus, method I is rejected as an adequate method for estimating

discards. Although the estimates are not reliable, they outline the differences and similarities between the countries in the landings of three-, four- and five-year old fish in relation to the landings of the six-year and older fish.

4.3 The use of selection curves

In lack of any information on selection curves from the trawls in use, it was decided to establish the selection curves by equation (3) and (4) (from Halliday et al., 1999). These linear regression results were established from a number of cod-end selectivity experiments with different mesh sizes conducted on cod in the 1980s and 1990s. All the experiments included in the regressions were concerning cod-end material made out of synthetic fibers and without any type of chafers. The selection curves established are thus not representative for the manila trawls or the trawls with double cod-ends, which both were common prior to the mid-1960s. The lower selectivity in the trawls actually used, will cause the estimated discard rates to be too low. For the time period 1946 – 1953, when the legal mesh size was 80 mm, the effect will not be large since most of the fish at age three, four and five were retained in the cod-end anyway (table 3.2), but the effect may be larger for the years when the minimum mesh size was 110 mm. In this work the minimum legal mesh sizes were used, but in most cases during the recent decades the mean mesh size in a cod-end is larger than the minimum legal. Another problem is the use of sorting grids in the 1990s. Both these factors will cause an upward bias to the estimated discard rates. While the effect of the difference between legal and nominal mesh size is assumed to be small, the effect of a sorting grid is larger. The use of sorting grids was mostly experimental in the early 1990s, but according to Isaksen (1997) most of the Norwegian trawlers used the sorting grid on a voluntary basis in 1996 and it became mandatory both in Norwegian

and Russian zones in 1997. The discard rates are thus overestimated for the years 1996 – 1998.

Cod-end size selection is related to the maximum girth of the fish. However, for most fish species there is a significant linear relationship between girth and length, and in selectivity experiments it is common to measure the length of the fish (Wileman et al., 1996). Thus, the selection properties are calculated with regard to length. The catch data were given in numbers at age, and to be able to estimate catch compositions, the selection curves had to be converted into selection at age. This was done by establishing the length at age distributions in the population and applying the selection curves at these distributions.

The length distribution at age in the population varies interannually and through the year. The annual length distributions at age in the start of the year were found by the survey data and the length distributions at age through the year were found by the method for a mixture of two normal distributions. This method is not common in use, but it seems appropriate in this case when it is assumed that the growth is linear, that the fishing mortality (F) is constant through the year and that the length distributions at age in the population are normal. Jørgensen (1992) suggested that cod has a seasonal growth curve with better growth during summer. However, due to the migration pattern of immature cod; feeding in cold water during summer/fall and feeding on capelin in warmer water during winter/spring (Godø & Michalsen, 2000), and due to the positive relationship between temperature and growth (Michalsen et al., 1998), it is reasonable to assume that cod has a more linear growth curve. Constant F is a common assumption, e.g. in the VPA, although it is wrong when the fishery is

seasonal and for the youngest ages which are recruited to the fishery as they grow. A variable F would influence the magnitude of p, which weighs the length distributions in equation (7) and (8). The values of F used to calculate p are taken from the AFWG report (ICES, 2000) and these values are too small because of the discarded catches. Thus, p is underestimated and the length distributions from the mixture method are biased upwards, which causes the discard rates to be overestimated. However, the errors caused by F are small and negligible. The assumption of normal length at age distributions in the population is reasonable and common.

Prior to 1983 there were no survey data available and averaged mean lengths at age and standard deviations from the mixture method were used. These averaged values are wrong for most years, due to the short-term (1 – 5 years) variation in mean length at age found by Jørgensen (1992). The averaged values may also be overestimated because of the bias in the estimated mean length at age from the surveys prior to 1993, as discussed above. The selection at age is directly dependent on the length at age distribution and any variation or bias in the length at age distribution will influence the selection at age. Thus, if the length distributions from the time period 1983 – 1992 are biased upwards, the estimated discard rates are overestimated both for this period and for the time period when the averaged values were used. However, Korsbrekke (1997) estimated the upward bias in the length at age from the surveys (1986 – 1993) to be less than 2% for age three and less than 1% for age four and five. A low bias like that has little effect on the estimated discard rates. The errors caused by using averaged mean lengths at age prior to 1983 are larger and may have contributed to the short-term variation in the estimated discard rates for these years.

Although there are many factors influencing the selection at age, the mesh size and the length at age distribution are the most important. Both these two factors are shown to influence the selection at age to a great extent (tables 3.2 and 3.3) and any errors in these factors will bias the estimated discard rates and violate the credibility of the estimates. There is little doubt that the mesh sizes and the length distributions used in method II and III are biased. The biases vary with time due to the sources of errors mentioned above and it is thus difficult to quantify the magnitude of these biases.

Other factors than selection at age that are important in estimating catch compositions are the abundance and the availability of the age groups. In method II and III it is assumed that all age groups are equally available to the trawl fleets. This is rarely the case, due to the different distribution of cod by size and age, the fishermen may avoid small fish as they target the larger fish. This is a serious source of error in method II and III, and is likely to be related to the abundance of large fish. However, it is reasonable that while searching for the larger fish they will encounter and catch small fish, but due to experience and communication between the vessels one cannot say that they fish randomly. Thus, it would be favorable if the distribution of the age groups and the distribution of the trawler fleets were included in the models, but the lack of data would cause problems. The area closure system will also contribute to fishermen's avoidance of small fish. However, according to Isaksen (1997), most fishing grounds open for commercial fishing will on average give a by-catch of undersized cod between 5 and 10% in number. The fact that fishermen strive to target large fish to maximize profits violates the assumption and may cause the estimated discard rates to be overestimates. The magnitude of this bias will vary from year to year, relative to year-class strength. Only catches taken in ICES fishing areas 1 and 2b

were adjusted and this may limit this bias. The effect of the abundance estimates, used in method II and III, on the catch compositions will be discussed later.

4.3.1 Method II (The use of selection curves and VPA stock sizes)

For the first decades in the time period dealt with in this work, VPA estimates are the only source for abundance of the Northeast Arctic cod stock and these were used as input in the estimation of catch compositions. An obvious problem rises when VPA stock estimates, which depend on catch data, are used to estimate new catch compositions. Errors in the original catch data, caused by discards, will bias the estimates. To minimize this problem, the adjusting of the catches and the VPA estimates were put in a loop in such a way that the catches were adjusted three times in total. The adjusted catches converged rapidly and the differences between the two last adjustments were in general less than 1%. Thus, the bias caused by discards is small and negligible.

Although there are many sources of errors to the discard rates estimated by method II, the general trends for the time period 1946 – 1976 are corresponding with the expected results: decreases in discard rates due to increases in mesh sizes in use and the tendency towards keeping smaller fish in the 1960s (ICES, 1965a). The estimated discard rates are also similar to the estimates by Garrod (1967) and observations by Hylen (1965b; 1967a; 1967b; 1987) and Hylen & Smedstad (1974). The high USSR discard rates are not as expected, but the apparent lack of small fish in their landings may not be caused by discards. This may just as well be caused by errors in their sampling procedures, for instance will errors in the age determinations cause biases in their landing data.

For the years 1977 – 1981 were the age distributions from the pooled catch data, including all countries, areas and gears, assigned to Norwegian trawl and the other countries' catches. This will cause the estimated discard rates to be incorrect, but it is reasonable to assume that discards occurred during this period too. The differences in discard rates between the two groups are caused by the difference in mesh size. There is a problem occurring at the end of this period, which may cause the discard rates to be overestimated. The problem is that due to cold water in the Barents Sea and that the dominant year-class in the stock was relatively old, the cod stock had an extreme westerly distribution (Midttun et al., 1981) and caused the proportions of the total catches taken by conventional gears to increase. This affects the estimated discard rates because these gears catch relatively more large fish than a trawl and increase the proportion of older fish in the catches. Norway and the other countries used different mesh sizes in the cod-ends, 130 and 120 mm respectively, and the bias will be larger for the countries that used 120 mm mesh size.

The estimated discard rates for the years 1982 – 1992 were more or less as expected, but the low values for three-year olds in 1986 and 1987 were not as expected. These values were expected to be higher due to the strong year-class in 1983 and due to reports of high discards for these years (Mehl, 1991; Nakken, 1994). One explanation to this is the low values for selection at age (table 3.3), but this does not explain it all. It is possible that when the VPA numbers at age are largely biased due to discards, the estimated discard rates were underestimated even though the method was run in a loop. Another factor that affects the results is discarding of fish older than five years due to poor condition.

4.3.2 Method III (The use of selection curves and bottom trawl survey abundance indices)

In method III were the indices from the bottom trawl surveys used as input for the age distribution of the stock. This was done to avoid the problems that occurred when VPA numbers were used to adjust the catches. The results from method IIIa and b were as expected in the 1980s, with higher values for three-year olds in 1986 and 1987 than method II. It was expected that the discard rates would be lower in the 1990s due to the discard ban, but the results showed no effect of the discard ban. There are two factors that may cause the discard rates to be overestimated during this period, the area closure system and the introduction of the sorting grids. The discard rates estimated for Norwegian trawl in 1985 and the following years may also be biased upwards because the pooled trawl catches include catches taken in area 2a. Normally, catches taken in area 2a contain relatively more large fish than catches in area 1 and 2b.

The discard rates estimated by method IIIb, when the mature proportion of the stock were added to the indices, were as expected lower than the discard rates from method IIIa.

4.4 Correlation analysis

The negative relationship between mesh sizes in use and the total discard rates was as expected and supports the validity of the results. The positive relationship between stock sizes and total discard rates may be explained by the fact that larger fish is more marketable and gives better profit than small fish, and that when the stock is large and there is no problem in catching a lot of fish, the fishermen sort out and discard the

small fish in a larger degree than when the stock is small. In ICES (1965a) did the AFWG point out that there had been a tendency towards keeping smaller fish during the period from 1950 to 1963. The stock did also show a strong decline during this period. On the other hand, the fishermen may target the larger fish more effectively when the stock is large and thus decrease the proportions of small fish in the catches. The AFWG (ICES, 2000) suggests that due to reduced abundance of larger cod, the fishery target and catch smaller and smaller fish to fill the quota. This would cause the relationship between stock size and total discard rate to be misinterpreted and the discard rates to be overestimated when the stock is large.

4.5 Virtual Population Analysis (VPA)

New stock numbers at age three, four and five were estimated by traditional VPA using the adjusted catch numbers from method II (1946 –1982) and method IIIb (1983 – 1998) as input. The adjusted catches from these two methods were chosen because these seemed to produce the most reliable results. The estimated discard rates have large influence on the stock numbers estimated by VPA, especially at age three. The large variations in increases reflect the variations in the estimated discard rates.

4.6 F_{med}

The calculation of F_{med} was done as an example to show how errors in the VPA, as indicated by the estimated discards, affect analysis based on the VPA estimates. The increase in numbers at age three caused a small increase in the value of F_{med}. The value calculated with numbers from the AFWG (ICES, 2000) deviates some from the

value in the report (0.46), but this is probably caused by different number of decimals used in the input data.

F_{med} has been used in the management of Northeast Arctic cod for the recent years and is a reference point for calculating the total allowable catch (ICES, 1999a). The F_{med} is thought of as an upper limit for the average exploitation rate of the cod stock (Toresen et al., 2000). The estimated magnitudes of spawning stock biomasses are also important in the calculation of F_{med} and in other spawning stock biomass (*SSB*) – recruitment (*R*) analysis (Jakobsen, 1992). Problems associated with using VPA-based estimates in *SSB* – *R* analysis are discussed in Marshall et al. (1998) and in Marshall et al. (2000) they suggests that the reproductive potential of the stock, i.e. the spawner quality and not only the spawner quantity, should be incorporated in *SSB* – *R* analysis and in the calculation of biological reference points.

4.7 Conclusions and suggestions for further work

The differences between estimated and official catch numbers give numbers of fish caught, but not reported, i.e. discarded fish, fish retained for industrial use or illegal landings. The estimates of discards in the present work are plausible as examined through comparison with earlier published reports on discards in the trawl fishery for Northeast Arctic cod and give some insight into the possible level of discards throughout the period. Results show that it is possible to estimate discard rates by using information on selectivity and stock abundance. Due to the geographical distribution of the Northeast Arctic cod by age and length, more reliable results might be obtained if information on distribution at age and more detailed information on the distribution of the trawler fleet were included in the methods. A factor describing the

availability of an age group to the trawl and a selection curve describing the selectivity of the whole trawl should also be included.

The magnitude of the discards may not be precise, but discards have undoubtedly taken place throughout the period. The results show that discards give a serious bias in the VPA, which is not accounted for in the assessment, and the Arctic Fisheries Working Group need to consider a revision of the catch numbers at age that are used in the VPA.

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Appendix

Table A Catch numbers (1000) at age by country from the Arctic Fisheries Working Group and adjusted catch numbers from method (M.) I, II and III.

	1946			1947			1948			1949		
	Norway			Norway			Norway			Norway		
Age	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
3	55	546	2 820	54	72	4 269	35	35	5 851	146	149	5 948
4	236	927	1 998	876	1 368	5 592	302	302	4 158	533	836	4 335
5	467	1 240	1 399	2 293	4 620	3 896	1 992	3 180	5 397	1 752	3 177	3 177
6	663			3 190			4 153			5 653		
7	810			3 908			8 439			5 635		
8	1 956			2 507			4 335			4 519		
9	20 941			6 964			3 504			2 785		
10	9 246			27 727			4 565			2 544		
11	6 408			11 498			14 334			3 294		
12	7 912			4 344			3 281			8 989		
13	4 666			5 540			1 798			2 085		
14	1 801			3 439			2 243			1 347		
15+	1 074			2 969			2 980			3 886		
Sum	56 236	58 191	61 694	75 310	78 146	85 843	51 960	53 148	65 038	43 168	44 900	54 197
	USSR			**USSR**			**USSR**			**USSR**		
Age	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
3	2 676		16 027	224		15 349	8		18 269	320		22 476
4	4 353		11 358	4 324		20 104	509		12 981	2 072		16 383
5	5 322		7 687	14 613		14 613	8 447		16 603	9 429		11 753
6	8 270			17 148			19 798			24 698		
7	6 200			14 612			27 930			27 730		
8	4 603			3 653			6 682			9 274		
9	9 375			4 250			4 303			3 991		
10	6 879			5 964			1 309			1 033		
11	1 822			6 634			3 200			1 980		
12	511			1 566			1 182			1 033		
13	305			1 044			885			554		
14	-			224			324			158		
15+	301			299			426			316		
Sum	50 617		73 338	74 555		105 460	75 003		113 892	82 588		121 379
	England			**England**			**England**			**England**		
Age	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
3	1 272	2 912	23 594	395	395	25 991	93	93	28 895	456	514	43 176
4	5 430	6 347	16 720	7 328	7 328	34 044	2 892	2 892	20 531	3 683	8 840	31 472
5	12 088	12 088	13 171	24 744	24 744	24 744	19 081	19 081	27 553	21 817	29 663	24 987
6	7 289			29 049			29 102			63 003		
7	6 448			24 744			37 048			45 106		
8	8 171			6 350			9 409			14 455		
9	27 221			7 832			6 670			5 798		
10	6 218			12 981			3 364			1 753		
11	1 802			12 215			10 769			3 020		
12	1 118			3 181			3 047			2 580		
13	489			2 559			1 560			898		
14	126			906			1 127			328		
15+	210			995			995			627		
Sum	77 883	80 440	112 577	133 280	133 280	185 592	125 156	125 156	180 070	163 524	176 585	237 203
	Others			**Others**			**Others**			**Others**		
Age	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
3	6	180	1 734	36	36	2 352	5	5	2 773	68	74	4 443
4	367	464	1 229	663	663	3 081	169	169	1 970	519	1 047	3 239
5	1 028	1 028	1 029	2 240	2 240	2 240	1 533	1 533	2 577	2 216	3 029	2 570
6	374			2 630			2 930			7 143		
7	385			2 237			3 958			4 812		
8	640			565			1 056			1 479		
9	2 308			672			760			633		
10	275			1 007			576			276		
11	60			1 046			1 737			323		
12	33			258			436			553		
13	0			186			248			120		
14	-			53			204			63		
15+	0			63			265			114		
Sum	5 476	5 748	8 067	11 656	11 656	16 390	13 877	13 877	19 490	18 317	19 664	25 765
	Total			**Total**			**Total**			**Total**		
Age	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
3	4 009	6 315	44 175	710	727	47 962	140	140	55 788	991	1 057	76 043
4	10 387	12 091	31 305	13 192	13 683	62 821	3 872	3 872	39 639	6 808	12 795	55 429
5	18 906	19 679	23 286	43 890	46 217	45 492	31 054	32 241	52 130	35 214	45 298	42 487
6	16 596			52 017			55 983			100 497		
7	13 842			45 501			77 375			83 283		
8	15 370			13 075			21 482			29 727		
9	59 846			19 718			15 236			13 207		
10	22 618			47 679			9 814			5 606		
11	10 093			31 393			30 040			8 617		
12	9 574			9 349			7 945			13 154		
13	5 460			9 330			4 491			3 657		
14	1 927			4 622			3 898			1 895		
15+	1 585			4 327			4 666			4 943		
Sum	190 212	194 996	255 676	294 801	297 637	393 285	265 997	267 184	378 489	307 597	323 736	438 544

Table A Continued.

1950			1951			1952			1953		
Norway			**Norway**			**Norway**			**Norway**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
10	174	7 506	514	10 869	11 496	284	8 365	20 345	3 924	25 965	27 471
256	1 507	4 001	2 079	23 099	5 616	8 353	33 420	13 951	10 424	59 213	15 300
1 028	3 596	2 891	2 861	17 776	3 005	12 818	27 782	12 818	20 526	39 395	20 526
2 398			3 366			11 949			10 386		
6 011			5 979			5 437			7 044		
8 201			12 372			5 438			4 956		
7 178			14 609			11 929			5 060		
3 635			7 987			9 788			7 106		
2 326			3 165			5 386			4 411		
2 732			1 149			1 749			1 400		
5 503			907			565			392		
1 221			3 021			445			161		
5 317			2 229			1 952			526		
45 816	49 799	58 922	60 240	106 530	74 903	76 093	124 204	101 752	76 316	166 015	104 739
USSR			**USSR**			**USSR**			**USSR**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
764		31 020	20 927		63 508	22 764		111 679	42 711		113 021
4 904		16 534	44 792		45 114	92 168		92 168	91 822		94 570
12 371		12 371	34 732		34 732	74 677		74 677	67 457		67 457
17 520			20 506			36 716			27 025		
25 507			11 998			22 213			7 901		
12 842			4 871			5 957			4 965		
5 419			1 580			3 237			1 638		
2 426			526			1 335			734		
1 658			384			813			293		
507			-			373			-		
339			-			-			-		
169			-			-			-		
130			-			-			-		
84 556		126 441	140 316		183 218	260 253		349 168	244 546		317 604
England			**England**			**England**			**England**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
451	899	33 819	11 335	18 437	53 082	851	15 954	37 438	603	24 395	22 586
5 166	5 209	18 026	26 848	44 003	31 459	16 593	68 898	27 979	4 148	48 587	12 579
14 077	14 077	14 077	23 030	37 836	23 030	20 269	51 463	20 269	18 327	40 366	18 327
22 910			20 653			19 226			13 591		
27 201			17 524			16 639			5 778		
14 412			14 009			6 915			5 081		
5 680			5 650			6 817			2 735		
2 450			1 479			3 236			1 853		
1 583			470			1 521			621		
581			94			1 064			244		
518			65			58			52		
186			214			14			8		
271			59			63			23		
95 486	95 977	141 714	121 430	160 493	167 788	93 266	191 867	141 239	53 065	143 334	83 479
Others			**Others**			**Others**			**Others**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
57	85	3 860	1 911	2 940	7 135	200	4 779	10 326	174	8 172	7 243
628	631	2 057	4 205	6 436	4 472	3 590	19 612	7 342	1 265	16 636	4 034
1 569	1 569	1 569	3 390	5 110	3 390	5 440	15 720	5 440	5 730	13 350	5 730
2 405			2 342			5 936			4 498		
3 859			2 034			5 099			2 019		
3 582			2 422			2 253			1 861		
1 204			1 671			2 384			1 126		
662			596			1 293			860		
452			192			608			311		
313			44			379			109		
389			30			24			24		
87			86			8			4		
205			45			33			12		
15 410	15 441	20 642	18 969	23 949	24 459	27 245	58 127	41 123	17 994	48 982	27 831
Total			**Total**			**Total**			**Total**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
1 281	1 922	76 204	34 687	53 174	135 220	24 099	51 861	179 787	47 413	101 243	170 321
10 954	12 251	40 618	77 924	118 330	86 661	120 704	214 098	141 441	107 659	216 259	126 483
29 045	31 613	30 909	64 013	95 454	64 157	113 203	169 641	113 203	112 041	160 567	112 041
45 232			46 866			73 827			55 500		
62 579			37 535			49 389			22 742		
39 037			33 674			20 562			16 863		
19 481			23 510			24 367			10 559		
9 173			10 589			15 651			10 553		
6 019			4 211			8 327			5 637		
4 133			1 288			3 565			1 752		
6 749			1 002			647			468		
1 663			3 322			467			173		
5 923			2 333			2 048			561		
241 269	245 774	347 719	340 955	431 288	450 368	456 857	634 452	633 282	391 921	602 878	533 652

Table A Continued.

1954			**1955**			**1956**			**1957**		
Norway			**Norway**			**Norway**			**Norway**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
2 341	2 341	8 072	17	991	5 434	469	2 390	10 959	1 794	6 052	17 131
19 386	25 493	21 807	1 409	8 404	14 962	1 292	5 541	8 930	2 821	11 966	12 271
11 907	22 766	12 743	25 785	33 985	25 785	12 203	25 526	15 194	3 953	7 858	5 730
8 037			19 879			36 211			13 491		
6 085			17 005			12 573			23 006		
5 564			7 389			15 505			9 771		
5 256			5 840			8 385			9 075		
4 485			4 362			4 673			3 448		
4 181			2 156			2 824			1 595		
1 881			1 931			1 266			798		
765			740			1 178			312		
236			319			386			274		
284			251			166			168		
70 409	87 375	79 396	87 083	103 254	106 053	97 131	116 624	118 249	70 503	87 812	97 069
USSR			**USSR**			**USSR**			**USSR**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
8 494		51 458	3 833		25 768	10 068		50 087	12 252		40 454
124 815		139 008	31 611		70 945	21 036		40 817	20 295		28 978
110 965		110 965	127 947		127 947	90 101		90 101	13 850		14 527
63 397			96 264			129 688			32 177		
24 111			37 302			44 803			31 511		
9 618			13 949			15 351			17 236		
4 094			4 721			2 948			3 360		
2 355			2 508			1 457			1 425		
1 308			959			603			930		
185			12			285			231		
19			-			-			-		
19			-			-			-		
19			-			-			-		
349 399		406 556	319 106		380 375	316 340		376 140	133 267		170 830
England			**England**			**England**			**England**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
571	2 291	9 164	36	1 410	7 470	15	1 653	15 650	1 434	7 755	15 640
9 092	34 200	24 756	3 459	15 109	20 589	1 114	6 431	12 834	5 501	7 065	11 316
18 099	30 840	18 099	34 950	55 684	43 125	18 643	36 838	21 128	5 508	5 877	5 682
22 857			29 566			55 213			15 695		
7 485			18 666			16 375			19 298		
3 216			5 347			11 241			6 606		
1 726			1 992			2 047			2 857		
1 203			1 519			736			738		
871			600			259			313		
209			275			32			93		
80			63			70			17		
9			25			34			8		
12			33			6			15		
65 430	104 997	89 687	96 530	130 287	129 270	105 786	130 935	135 627	58 083	66 337	78 278
Others			**Others**			**Others**			**Others**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
66	879	2 699	15	752	3 599	62	1 978	9 000	1 840	3 926	11 940
1 878	12 798	7 291	1 173	6 522	9 908	730	4 681	7 335	5 315	6 867	8 647
5 424	11 448	5 424	13 152	26 295	19 245	8 856	21 917	12 463	3 871	4 660	4 369
6 460			15 627			29 315			9 339		
2 955			11 057			13 033			13 218		
1 315			3 766			8 995			5 600		
715			1 160			1 606			2 455		
513			1 092			600			607		
391			425			266			395		
95			188			73			99		
33			64			44			18		
4			11			28			17		
6			-			7			11		
19 855	37 612	27 900	47 731	66 958	66 141	63 616	82 543	82 765	42 785	47 212	56 715
Total			**Total**			**Total**			**Total**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
11 473	14 005	71 393	3 901	6 986	42 271	10 614	16 089	85 696	17 321	29 986	85 166
155 171	197 306	192 862	37 652	61 646	116 404	24 172	37 688	69 916	33 932	46 193	61 212
146 395	176 018	147 231	201 834	243 911	216 102	129 803	174 381	138 886	27 182	32 245	30 309
100 751			161 336			250 427			70 702		
40 635			84 031			86 785			87 034		
19 713			30 451			51 091			39 213		
11 791			13 713			14 987			17 746		
8 557			9 481			7 466			6 219		
6 751			4 140			3 952			3 232		
2 370			2 406			1 656			1 221		
896			867			1 292			347		
268			355			448			299		
321			284			179			194		
505 092	579 383	603 539	550 450	619 605	681 838	582 873	646 442	712 782	304 639	334 629	402 892

Table A Continued.

1958			1959			1960			1961		
Norway			**Norway**			**Norway**			**Norway**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
10 502	11 322	16 320	2 917	10 672	15 872	1 708	10 424	12 311	5 983	12 481	24 324
29 944	32 481	35 098	9 212	22 060	13 894	10 511	23 416	13 002	25 960	33 013	28 193
14 156	19 235	14 652	22 934	35 519	22 934	9 223	13 885	9 223	26 927	26 927	26 927
11 320			11 541			12 792			7 661		
10 527			4 406			5 260			8 153		
11 761			6 322			1 874			5 370		
6 504			14 513			4 042			2 909		
6 093			6 297			8 918			4 962		
1 769			2 495			3 405			4 747		
602			842			1 267			1 396		
153			194			252			484		
13			98			154			266		
184			77			275			234		
103 528	111 964	114 997	81 847	115 036	99 484	59 679	85 961	72 775	95 052	108 604	115 626
USSR			**USSR**			**USSR**			**USSR**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
16 769		33 011	24 253		51 380	23 416		45 045	35 378		74 146
73 398		86 567	48 273		50 122	52 430		52 430	82 913		82 913
33 202		37 674	77 784		77 784	31 116		31 116	63 697		63 697
17 481			24 971			28 811			28 694		
15 710			7 672			10 070			17 629		
12 283			4 764			3 821			7 932		
3 402			2 817			1 408			1 796		
1 900			1 264			975			942		
739			389			559			242		
164			-			300			153		
-			-			29			242		
-			-			-			-		
-			-			29			-		
175 048		208 931	192 187		221 163	152 964		174 593	239 618		278 386
England			**England**			**England**			**England**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
2 491	12 960	12 727	3 779	24 130	22 738	9 232	15 618	23 823	2 518	16 279	23 309
22 959	55 675	27 112	16 689	46 707	21 076	26 773	36 500	26 918	19 491	40 656	24 238
16 720	17 543	16 720	40 274	73 765	40 274	18 818	22 257	18 818	28 766	32 377	28 766
8 152			12 657			20 702			12 802		
9 024			4 876			5 914			11 274		
7 772			5 251			2 006			3 302		
2 165			4 091			1 353			869		
1 316			1 420			1 172			609		
399			562			388			370		
96			93			157			94		
47			25			44			138		
30			38			13			-		
31			16			28			12		
71 200	115 208	85 589	89 771	173 631	113 117	86 600	106 151	101 336	80 245	118 782	105 783
Others			**Others**			**Others**			**Others**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
1 457	2 010	5 103	1 360	2 642	5 332	3 527	3 958	7 219	1 599	2 390	4 244
7 276	8 708	11 074	3 769	5 843	4 808	8 151	8 808	8 160	4 292	5 198	4 395
6 972	7 089	7 028	7 292	9 312	7 292	5 065	5 297	5 065	4 069	4 069	4 069
3 785			4 311			5 120			2 010		
3 119			1 544			1 874			1 684		
3 970			1 398			727			771		
1 267			1 697			438			217		
1 166			503			611			265		
382			302			151			202		
208			62			119			39		
52			35			29			46		
6			25			25			14		
9			10			27			25		
29 670	31 772	37 170	22 307	27 684	27 318	25 864	27 185	29 566	15 233	16 930	17 981
Total			**Total**			**Total**			**Total**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
31 219	43 060	67 161	32 308	61 697	95 321	37 882	53 416	88 398	45 478	66 528	126 023
133 576	170 262	159 851	77 942	122 883	89 900	97 865	121 153	100 511	132 656	161 781	139 739
71 051	77 070	76 074	148 284	196 380	148 284	64 222	72 554	64 222	123 459	127 070	123 459
40 737			53 480			67 425			51 167		
38 380			18 498			23 118			38 740		
35 786			17 735			8 428			17 375		
13 338			23 118			7 240			5 791		
10 475			9 483			11 675			6 778		
3 289			3 748			4 504			5 561		
1 070			996			1 844			1 682		
252			254			354			910		
49			161			192			280		
224			103			359			271		
379 446	433 992	446 687	386 112	508 537	461 083	325 107	372 261	378 269	430 148	483 934	517 776

Table A Continued.

1962			1963			1964			1965		
Norway			**Norway**			**Norway**			**Norway**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
799	17 449	14 190	345	2 951	5 888	357	3 121	3 977	4 169	7 135	12 329
9 567	58 133	19 923	8 382	20 201	18 656	7 837	21 745	11 547	5 919	16 881	12 206
17 351	48 216	17 351	29 179	36 852	29 179	18 198	38 282	18 260	24 365	41 795	24 365
16 552			14 163			12 476			23 713		
6 527			7 718			4 344			8 434		
8 812			6 614			3 797			3 811		
4 904			7 911			4 577			2 578		
1 866			2 550			2 306			1 171		
2 121			980			443			733		
1 291			959			150			119		
261			450			338			65		
185			125			208			88		
179			116			60			186		
70 416	166 496	94 162	79 492	101 589	95 309	55 091	91 846	62 484	75 351	106 709	89 799
USSR			**USSR**			**USSR**			**USSR**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
37 797		90 599	11 740		44 252	4 485		17 512	6 071		24 327
130 466		138 356	81 167		109 201	32 624		39 610	14 180		18 756
113 812		113 812	136 081		136 081	62 514		62 514	37 903		37 903
48 849			62 793			27 343			25 406		
13 574			20 132			7 768			6 870		
7 297			6 958			2 483			2 244		
1 726			2 160			671			519		
507			872			418			214		
151			-			241			328		
76			-			-			-		
76			-			-			-		
-			-			-			-		
-			-			101			-		
354 331		415 023	321 903		382 450	138 648		158 661	93 735		116 567
England			**England**			**England**			**England**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
2 125	13 943	22 239	690	3 506	9 615	343	2 089	5 535	5 430	5 769	12 913
24 243	49 646	31 397	13 919	17 274	23 889	4 624	15 529	12 533	5 813	8 693	10 482
30 419	45 645	30 419	33 632	33 632	33 632	15 680	32 197	15 693	15 944	23 463	15 944
21 168			15 422			17 897			19 235		
7 274			6 382			7 107			9 762		
4 908			2 162			2 505			2 149		
1 094			1 451			695			343		
290			388			582			38		
267			29			55			23		
156			58			9			9		
39			28			28			-		
39			2			33			2		
32			38			12			4		
92 054	144 501	119 321	74 201	80 372	93 097	49 570	78 739	62 684	58 752	69 490	70 904
Others			**Others**			**Others**			**Others**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
1 695	2 923	4 557	421	567	2 067	112	210	430	55	55	55
6 290	9 570	6 424	3 516	4 000	5 121	827	1 367	971	87	87	87
5 659	7 753	5 659	6 658	6 830	6 658	1 558	2 324	1 558	87	87	87
2 892			3 120			859			157		
922			1 286			423			378		
980			487			377			234		
232			372			253			129		
65			73			247			44		
65			12			45			77		
124			8			13			3		
16			20			21			2		
56			2			23			1		
9			11			12			15		
19 003	25 605	22 000	15 986	16 789	19 237	4 769	6 172	5 230	1 269	1 269	1 269
Total			**Total**			**Total**			**Total**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
42 416	72 112	131 585	13 196	18 764	61 822	5 297	9 905	27 453	15 725	19 029	49 624
170 566	247 814	196 100	106 984	122 642	156 868	45 912	71 265	64 661	25 999	39 841	41 531
167 241	215 425	167 241	205 550	213 395	205 550	97 950	135 318	98 026	78 299	103 247	78 299
89 461			95 498			58 575			68 511		
28 297			35 518			19 642			25 444		
21 996			16 221			9 162			8 438		
7 956			11 894			6 196			3 569		
2 728			3 883			3 553			1 467		
2 603			1 021			784			1 161		
1 647			1 025			172			131		
392			498			387			67		
280			129			264			91		
220			165			185			205		
535 804	690 933	650 507	491 582	520 653	590 092	248 078	315 406	289 058	229 107	271 203	278 538

Table A Continued.

1966			1967			1968			1969		
Norway			**Norway**			**Norway**			**Norway**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
7 348	21 981	14 921	5 081	24 619	9 992	437	437	1 224	254	254	1 349
12 239	23 621	16 753	28 916	79 347	28 916	15 764	16 814	18 729	4 958	5 003	5 470
7 564	14 480	8 145	11 097	34 770	14 615	28 967	28 967	28 967	46 204	46 204	46 204
12 907			5 106			8 872			30 578		
12 587			8 620			3 361			7 803		
8 438			9 882			8 412			5 269		
2 923			4 309			7 088			8 289		
999			1 014			1 609			2 931		
291			485			366			714		
180			191			91			70		
61			200			114			-		
5			33			58			16		
120			46			32			18		
65 662	98 593	78 331	74 982	168 624	83 411	75 171	76 222	78 924	107 104	107 149	108 711
USSR			**USSR**			**USSR**			**USSR**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
38 824		53 526	26 295		50 971	2 150		14 932	1 360		10 636
32 674		41 258	108 732		111 739	138 922		171 988	14 768		25 676
19 940		22 089	51 099		51 099	204 105		204 976	136 108		149 312
20 383			13 915			91 582			107 237		
15 222			14 676			21 196			62 395		
4 151			12 021			6 258			19 418		
894			5 185			3 120			3 763		
157			915			1 407			1 360		
24			90			162			822		
109			90			-			285		
-			-			-			95		
-			-			-			-		
-			-			-			-		
132 378		157 814	233 018		260 701	468 902		515 621	347 611		380 999
England			**England**			**England**			**England**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
9 485	19 558	14 534	2 969	7 911	7 488	1 121	1 121	2 360	610	610	2 484
10 296	13 679	13 640	22 038	31 548	22 038	19 848	19 848	22 417	4 249	4 249	6 911
6 893	8 675	7 192	6 967	12 295	8 194	34 773	34 773	34 773	50 617	50 617	50 617
8 923			2 967			6 577			36 529		
8 999			2 827			2 128			6 562		
5 444			2 967			1 701			1 462		
1 085			1 765			1 340			1 021		
254			367			592			559		
51			103			116			227		
70			22			26			27		
13			23			8			12		
3			7			9			6		
24			9			14			17		
51 540	66 778	60 232	43 031	62 811	48 778	68 253	68 253	72 061	101 898	101 898	106 434
Others			**Others**			**Others**			**Others**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
280	384	518	122	122	128	2	2	5	83	83	296
436	549	505	362	362	362	51	51	53	570	570	1 049
279	345	279	72	97	131	116	116	116	5 583	5 583	6 336
326			73			21			6 895		
362			172			16			2 603		
467			269			28			840		
176			64			49			390		
84			33			49			242		
14			9			13			149		
44			13			5			32		
4			2			2			14		
1			0			3			1		
4			3			1			11		
2 475	2 760	2 783	1 194	1 219	1 260	355	355	361	17 414	17 414	18 861
Total			**Total**			**Total**			**Total**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
55 937	80 748	83 500	34 467	58 947	68 579	3 710	3 710	18 521	2 307	2 307	14 766
55 645	70 523	72 157	160 048	219 988	163 055	174 585	175 635	213 187	24 545	24 590	39 106
34 676	43 440	37 705	69 234	98 260	74 040	267 961	267 961	268 832	238 512	238 512	252 469
42 539			22 061			107 052			181 239		
37 170			26 295			26 701			79 363		
18 500			25 140			16 398			26 989		
5 078			11 323			11 597			13 463		
1 494			2 329			3 657			5 092		
380			687			658			1 912		
403			316			122			414		
78			225			124			121		
9			40			70			23		
148			58			47			46		
252 055	300 508	299 160	352 225	465 672	394 149	612 682	613 732	666 967	574 027	574 072	615 005

Table A Continued.

1970			1971			1972			1973		
Norway			**Norway**			**Norway**			**Norway**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
1 843	1 847	3 917	930	4 431	5 894	7 186	17 572	13 807	9 034	127 718	16 847
2 122	2 733	5 252	3 489	7 003	6 430	10 143	32 032	10 675	23 792	39 213	25 148
9 357	9 395	9 501	4 521	6 623	4 675	8 092	19 626	8 462	17 681	18 367	18 108
49 510			5 297			6 224			5 645		
31 301			34 369			5 662			2 601		
10 595			29 720			27 494			7 386		
4 135			5 691			16 155			16 746		
2 067			1 085			2 465			3 478		
740			545			723			497		
115			266			151			106		
55			71			159			75		
12			-			2			44		
6			-			-			27		
111 858	112 510	117 206	85 984	95 100	94 043	84 456	128 265	91 979	87 112	221 904	96 708
USSR			**USSR**			**USSR**			**USSR**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
2 478		9 400	3 176		9 724	12 620		27 789	256 235		256 235
3 737		9 742	4 760		7 691	23 480		25 861	78 252		155 595
9 073		11 134	4 118		4 912	14 474		14 950	32 264		52 916
36 581			2 068			4 190			10 606		
41 754			9 306			1 406			3 576		
16 631			14 151			4 246			448		
3 843			4 988			4 652			514		
708			1 033			1 848			343		
150			115			439			106		
17			46			179			68		
-			1			128			1		
-			11			93			1		
-			-			33			-		
114 972		129 960	43 773		54 046	67 788		85 814	382 414		480 409
England			**England**			**England**			**England**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
2 071	2 071	4 342	2 663	2 663	3 849	13 240	13 240	13 240	13 554	72 631	16 377
3 482	3 482	4 976	3 681	3 681	3 970	9 114	9 114	9 415	20 415	23 538	20 735
4 752	4 752	5 507	1 808	2 411	2 103	2 824	4 233	3 268	7 385	9 466	8 195
35 017			1 212			1 095			3 156		
12 859			9 113			585			701		
2 336			4 264			2 377			370		
364			624			1 025			1 323		
245			132			127			471		
192			47			22			41		
73			57			10			10		
30			29			17			2		
15			20			15			8		
15			12			9			19		
61 451	61 451	65 972	23 662	24 265	25 433	30 460	31 869	31 205	47 455	111 737	51 407
Others			**Others**			**Others**			**Others**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
773	773	2 169	985	1 379	3 008	2 490	2 490	3 577	15 439	25 514	15 761
1 453	1 453	2 689	1 810	2 267	2 667	2 693	3 744	2 887	9 034	9 034	12 143
2 632	2 689	2 961	1 384	1 817	1 499	1 441	2 199	1 515	3 670	3 843	4 344
16 728			950			580			1 163		
10 509			6 504			264			370		
2 359			3 869			768			124		
592			790			483			546		
229			185			132			206		
151			55			31			34		
56			48			13			11		
21			48			11			4		
12			12			11			6		
14			12			6			14		
35 528	35 584	38 488	16 652	17 937	19 648	8 922	10 732	10 277	30 621	40 869	34 726
Total			**Total**			**Total**			**Total**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
7 165	7 169	19 829	7 754	11 649	22 475	35 536	45 922	58 413	294 262	482 099	305 220
10 794	11 404	22 658	13 740	17 711	20 758	45 430	68 371	48 838	131 493	150 037	213 621
25 814	25 909	29 104	11 831	14 969	13 190	26 831	40 531	28 195	61 000	63 941	83 563
137 836			9 527			12 089			20 570		
96 423			59 292			7 917			7 248		
31 921			52 004			34 885			8 328		
8 934			12 093			22 315			19 129		
3 249			2 435			4 572			4 498		
1 233			762			1 215			678		
261			417			353			195		
106			149			315			82		
39			43			121			59		
35			24			48			60		
323 809	324 517	351 627	170 071	181 075	193 170	191 626	238 653	219 275	547 602	756 923	663 250

Table A Continued.

1974			1975			1976		
Norway			**Norway**			**Norway**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
1 845	56 218	8 021	3 435	13 634	10 862	10 967	40 657	12 385
54 991	146 794	54 991	8 778	16 452	18 596	20 571	47 422	24 716
37 824	76 077	46 642	65 008	65 008	65 008	21 142	32 270	21 390
15 755			30 984			50 653		
4 597			9 969			17 289		
1 691			4 537			6 416		
1 827			1 509			2 520		
4 612			1 207			576		
1 867			1 404			234		
298			475			324		
142			206			93		
76			13			18		
41			32			33		
125 566	309 995	140 561	127 557	145 430	144 801	130 836	198 504	136 647
USSR			**USSR**			**USSR**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
79 764		89 200	31 028		36 196	60 267		63 728
253 970		254 887	35 553		46 851	70 542		73 040
119 723		142 549	92 141		108 227	46 193		46 766
22 747			63 060			37 593		
5 887			14 976			23 800		
2 078			3 585			6 465		
503			841			1 215		
110			243			298		
0			243			273		
0			-			1		
0			-			1		
0			-			-		
0			-			-		
484 782		517 961	241 670		274 222	246 648		253 180
England			**England**			**England**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
1 591	13 656	5 981	4 896	4 896	8 084	6 833	11 575	7 691
37 780	37 780	37 780	7 173	7 173	10 583	12 783	14 569	13 032
14 859	18 535	17 589	34 614	34 614	34 614	5 945	9 102	7 262
3 841			9 526			14 523		
871			1 345			2 336		
208			255			303		
61			50			99		
247			23			17		
89			91			12		
12			36			36		
2			1			22		
2			1			1		
6			4			7		
59 569	75 310	66 689	58 015	58 015	64 613	42 917	52 602	45 341
Others			**Others**			**Others**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
8 655	14 466	16 140	5 923	7 343	9 656	7 269	10 141	8 409
90 636	90 915	90 636	8 294	8 951	12 646	10 445	14 203	11 888
31 367	31 439	40 767	34 882	34 882	35 129	6 713	9 079	7 603
4 663			14 997			15 467		
1 275			3 231			4 447		
392			976			779		
132			221			216		
638			81			44		
171			189			38		
13			64			81		
7			23			23		
5			1			7		
16			1			14		
137 970	144 133	154 856	68 883	70 960	77 216	45 544	54 539	49 016
Total			**Total**			**Total**		
AFWG	M. I	M. II	AFWG	M. I	M. II	AFWG	M. I	M. II
91 855	164 105	119 342	45 282	56 901	64 798	85 336	122 639	92 213
437 377	529 459	438 294	59 798	68 129	88 676	114 341	146 736	122 676
203 773	245 775	247 548	226 645	226 645	242 978	79 993	96 644	83 021
47 006			118 567			118 236		
12 630			29 521			47 872		
4 369			9 353			13 963		
2 523			2 621			4 050		
5 607			1 554			935		
2 127			1 927			557		
323			575			442		
151			230			139		
83			15			26		
63			37			54		
807 888	1 014 221	880 066	496 125	516 075	560 853	465 945	552 293	484 185

Table A Continued.

1977		1978		1979		1980		1981	
Norway trawl		**Norway trawl**		**Norway trawl**		**Norway trawl**		**Norway trawl**	
AFWG	M. II	AFWG	M. II	AFWG	M. II	AFWG	M. II	AFWG	M. II
7 264	7 975	17 938	17 938	2 733	4 635	835	2 041	553	1 583
30 932	30 932	10 332	17 283	24 619	26 951	3 650	6 533	1 536	3 261
25 011	25 011	20 140	20 140	13 878	14 899	17 514	17 699	3 375	5 024
9 709		12 932		10 149		8 558		10 292	
11 341		5 782		5 343		3 773		3 535	
4 281		7 242		2 629		1 590		1 612	
1 038		2 141		3 487		749		692	
279		279		567		683		213	
112		208		136		145		143	
50		102		33		17		18	
22		170		19		5		6	
17		11		12		6		0	
10		12		14		2		0	
90 067	90 779	77 288	84 239	63 618	68 874	37 526	41 800	21 976	26 380
Others		**Others**		**Others**		**Others**		**Others**	
AFWG	M. II	AFWG	M. II	AFWG	M. II	AFWG	M. II	AFWG	M. II
22 582	35 891	37 862	41 982	2 845	6 779	1 523	5 550	1 035	4 491
96 163	96 163	21 808	39 443	25 629	30 697	6 656	13 836	2 876	7 204
77 756	77 756	42 508	42 508	14 447	14 447	31 936	31 936	6 320	9 204
30 185		27 295		10 566		15 605		19 270	
35 258		12 204		5 562		6 881		6 619	
13 310		15 285		2 737		2 899		3 017	
3 227		4 519		3 630		1 366		1 296	
867		589		590		1 245		398	
348		439		141		264		268	
155		214		34		31		33	
70		359		20		9		11	
52		23		13		10		1	
31		24		15		3		0	
280 003	293 313	163 131	184 886	66 228	75 230	68 429	79 636	41 144	51 812
Total		**Total**		**Total**		**Total**		**Total**	
AFWG	M. II	AFWG	M. II	AFWG	M. II	AFWG	M. II	AFWG	M. II
39 594	53 615	78 822	82 942	8 600	14 437	3 911	9 143	3 407	7 893
168 609	168 609	45 400	69 986	77 484	84 884	17 086	27 150	9 466	15 519
136 335	136 335	88 495	88 495	43 677	44 698	81 986	82 171	20 803	25 337
52 925		56 823		31 943		40 061		63 433	
61 821		25 407		16 815		17 664		21 788	
23 338		31 821		8 274		7 442		9 933	
5 659		9 408		10 974		3 508		4 267	
1 521		1 227		1 785		3 196		1 311	
610		913		427		678		882	
271		446		103		79		109	
122		748		59		24		37	
92		48		38		26		3	
54		51		45		8		1	
490 951	504 972	339 609	368 315	200 224	214 481	175 669	191 150	135 440	150 513

Table A Continued.

1982		1983				1984			
Norway		**Norway**				**Norway**			
AFWG	M. II	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
4 098	4 098	1 125	2 737	1 444	1 146	4 750	8 139	8 626	7 534
12 127	12 127	6 887	6 887	8 184	6 952	9 056	9 899	9 750	9 056
13 243	13 246	15 235	15 235	15 748	15 235	12 182	12 205	12 362	12 314
23 215		13 852				16 774			
33 589		14 986				13 813			
6 798		16 182				7 674			
2 462		2 223				5 629			
644		586				711			
229		219				195			
174		68				137			
24		50				41			
5		17				12			
4		4				7			
96 612	96 615	71 434	73 046	73 563	71 519	70 981	75 236	75 732	73 897
USSR		**USSR**				**USSR**			
AFWG	M. II	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
2 850	3 319	512	954	553	512	942	2 189	2 392	1 906
5 203	6 151	2 792	2 792	2 792	2 792	2 234	2 234	2 234	2 234
3 180	3 924	2 354	2 354	2 706	2 410	3 352	3 352	3 352	3 352
2 449		1 059				1 776			
4 558		635				497			
833		480				154			
220		139				85			
24		57				38			
19		32				24			
52		11				4			
-		-				-			
-		-				-			
-		-				-			
19 388	21 549	8 071	8 513	8 463	8 127	9 106	10 353	10 556	10 070
Others		**Others**				**Others**			
AFWG	M. II	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
2 000	2 261	1 267	2 044	1 559	1 476	1 250	2 132	2 327	1 861
3 603	4 132	8 082	8 802	9 169	8 884	2 950	3 006	2 986	2 950
2 922	2 956	3 075	4 440	6 156	5 036	3 273	3 273	3 273	3 273
2 420		2 206				1 536			
4 349		1 250				835			
764		1 178				459			
196		129				274			
40		41				34			
23		8				13			
34		4				12			
3		8				8			
-		3				-			
1		1				1			
16 355	17 179	17 252	20 114	21 713	20 224	10 645	11 583	11 758	11 256
Total		**Total**				**Total**			
AFWG	M. II	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
8 948	9 678	2 904	5 735	3 556	3 134	6 942	12 460	13 346	11 300
20 933	22 410	17 761	18 481	20 146	18 627	14 240	15 140	14 970	14 240
19 345	20 125	20 664	22 029	24 610	22 682	18 807	18 830	18 987	18 939
28 084		17 117				20 086			
42 496		16 871				15 145			
8 395		17 840				8 287			
2 878		2 491				5 988			
708		684				783			
271		259				232			
260		83				153			
27		58				49			
5		20				12			
5		5				8			
132 355	135 342	96 757	101 672	103 739	99 871	90 732	97 172	98 046	95 222

Table A Continued.

1985				**1986**				**1987**			
Norway trawl				**Norway trawl**				**Norway trawl**			
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
4 623	8 286	8 168	7 618	4 844	7 360	15 813	14 737	4 603	4 603	9 378	8 934
9 723	9 730	13 191	12 374	17 326	19 222	17 617	17 326	56 628	56 628	63 868	60 739
4 490	4 490	4 490	4 490	16 356	16 356	16 356	16 356	32 502	42 379	32 502	32 502
4 260				5 066				13 653			
2 258				2 836				1 835			
628				825				1 029			
263				78				185			
82				239				99			
15				83				34			
1				44				54			
11				2				5			
11				1				49			
-				9				3			
26 365	30 035	33 378	32 011	47 709	52 120	58 969	57 602	110 679	120 556	122 693	119 121
USSR				**USSR**				**USSR**			
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
5 041	14 185	13 674	12 984	11 749	15 197	27 593	26 221	4 049	5 320	10 714	10 381
18 499	18 499	18 566	18 547	21 925	31 350	27 396	27 115	48 089	49 832	61 820	59 672
10 182	10 182	10 182	10 182	41 240	41 240	41 240	41 240	37 535	44 516	37 535	37 535
2 863				12 012				34 959			
1 024				2 708				8 574			
291				567				901			
77				87				127			
30				59				95			
6				22				37			
-				3				11			
-				1				2			
-				-				-			
-				-				-			
38 013	47 157	46 713	46 005	90 373	103 245	111 688	110 036	134 379	144 373	154 776	152 294
Others				**Others**				**Others**			
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
4 549	4 931	4 911	4 883	4 685	5 713	7 390	7 011	3 029	3 191	3 579	3 557
4 160	5 112	6 310	6 035	12 065	12 090	12 065	12 065	18 244	18 244	20 076	19 242
2 615	2 615	2 615	2 615	5 515	7 895	7 282	7 239	12 996	16 071	12 996	12 996
2 505				1 460				3 731			
997				1 177				558			
219				246				250			
82				86				34			
52				26				4			
5				39				-			
-				2				11			
5				2				-			
5				-				-			
-				-				2			
15 194	16 528	17 705	17 402	25 303	28 737	29 776	29 353	38 859	42 096	41 241	40 385
Total				**Total**				**Total**			
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
24 634	37 824	37 173	35 906	29 490	36 482	59 009	56 181	13 648	15 081	25 638	24 839
45 769	46 728	51 454	50 343	71 746	83 091	77 507	76 936	137 090	138 833	159 893	153 782
27 806	27 806	27 806	27 806	77 454	79 834	79 221	79 178	98 206	118 138	98 206	98 206
19 418				25 040				61 416			
11 639				11 675				13 717			
3 747				4 058				3 866			
1 527				976				911			
768				726				455			
137				557				187			
36				136				227			
31				28				21			
32				34				59			
8				13				20			
135 552	149 701	153 776	151 398	221 933	242 650	258 981	255 539	329 823	352 931	364 616	357 705

Table A Continued.

1988				**1989**				**1990**			
Norway trawl				**Norway trawl**				**Norway trawl**			
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
5 962	5 962	5 962	5 962	1 437	2 243	1 907	1 788	133	1 898	1 041	892
7 017	7 017	8 532	7 559	3 951	3 951	6 242	5 912	2 167	2 167	2 394	2 167
35 415	38 776	46 757	42 735	7 728	7 728	7 728	7 728	3 585	3 585	3 585	3 585
15 812				16 054				2 966			
6 232				3 360				3 078			
283				711				289			
144				140				47			
25				66				16			
4				18				3			
14				-				-			
26				-				-			
-				4				-			
-				3				-			
70 934	74 295	83 791	78 796	33 472	34 278	36 233	35 784	12 284	14 049	13 419	13 043
USSR				**USSR**				**USSR**			
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
2 194	3 509	7 766	6 913	2 674	5 916	4 973	4 709	383	3 644	2 134	1 888
10 090	13 039	15 103	13 939	9 911	9 911	14 537	13 917	1 466	3 396	4 153	3 638
63 355	63 355	64 679	63 799	18 044	18 044	18 044	18 044	4 776	4 786	5 865	5 320
18 755				29 720				8 957			
7 818				12 786				9 875			
1 730				1 521				2 519			
442				140				204			
215				47				49			
53				11				14			
12				-				2			
3				-				-			
-				-				-			
-				-				-			
104 667	108 931	116 576	113 678	74 854	78 096	81 779	80 895	28 245	33 446	33 772	32 466
Others				**Others**				**Others**			
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
343	619	1 444	1 267	149	1 249	1 053	991	376	1 090	628	582
3 043	3 605	3 755	3 669	1 376	2 253	3 445	3 284	988	1 207	1 388	1 242
16 938	16 938	17 915	17 203	3 073	3 809	3 576	3 543	1 765	1 765	2 134	1 938
5 003				14 738				2 145			
977				2 762				2 601			
138				294				861			
62				30				123			
6				15				33			
1				-				5			
2				-				2			
1				-				-			
-				-				-			
-				-				2			
26 514	27 351	29 304	28 330	22 437	25 150	25 913	25 658	8 901	9 834	9 922	9 534
Total				**Total**				**Total**			
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb
9 828	11 418	16 501	15 471	5 085	10 233	8 758	8 313	1 911	7 650	4 821	4 382
22 774	26 285	30 014	27 791	17 313	18 190	26 299	25 188	7 551	9 700	10 866	9 977
135 347	138 708	148 990	143 375	32 165	32 901	32 668	32 635	12 999	13 009	14 457	13 717
54 379				81 756				17 827			
21 015				27 854				30 007			
3 304				5 501				6 810			
1 236				827				828			
390				290				179			
106				41				59			
69				13				15			
43				-				6			
14				11				5			
5				16				2			
248 510	256 973	276 065	267 199	170 872	177 633	184 034	182 446	78 199	86 098	85 882	83 813

Table A Continued.

1991				**1992**				**1993**				**1994**		
Norway trawl				**Norway trawl**				**Norway trawl**				**Norway trawl**		
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb
1 335	2 663	1 693	1 640	3 758	5 576	7 421	6 431	2 881	5 783	5 396	1 655	4 753	4 347
3 284	3 284	3 284	3 284	5 761	5 761	5 761	5 761	8 436	10 917	10 102	13 420	22 143	20 435
3 280	3 280	3 280	3 280	3 281	3 318	3 281	3 281	8 251	8 251	8 251	23 039	23 039	23 039
1 649				2 287				3 081			11 440		
870				1 538				1 261			1 846		
1 228				1 018				1 121			1 020		
124				1 434				811			761		
6				168				2 007			458		
1				32				460			937		
-				12				58			136		
-				-				3			12		
-				-				1			1		
-				-				-			1		
11 777	13 105	12 135	12 082	19 289	21 144	22 952	21 962	28 371	33 755	32 552	54 726	66 547	64 433
Russia				**Russia**				**Russia**			**Russia**		
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb
1 563	7 087	4 673	4 556	9 132	17 018	21 843	19 418	4 260	18 976	17 973	3 287	13 968	13 050
3 853	6 622	6 621	6 262	14 276	16 391	16 737	16 073	23 357	32 125	30 408	31 137	51 401	48 375
6 915	6 938	7 764	7 148	11 725	13 109	12 373	12 113	39 348	39 348	39 348	42 878	42 878	42 878
10 887				11 232				21 203			30 072		
10 267				7 829				6 467			21 801		
5 059				5 881				3 104			3 647		
791				3 852				2 019			1 237		
71				689				1 778			595		
16				62				68			167		
4				10				13			40		
1				-				2			5		
-				-				-			-		
-				-				-			-		
39 427	47 742	46 154	45 062	64 688	76 074	80 508	77 159	101 619	125 103	122 383	134 866	165 811	161 867
Others				**Others**				**Others**			**Others**		
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb
450	1 327	856	831	1 895	3 257	4 209	3 718	1 570	4 056	3 825	760	4 080	3 776
763	1 197	1 183	1 106	3 976	3 976	3 976	3 976	5 430	6 751	6 328	7 558	16 399	15 321
1 243	1 243	1 283	1 243	2 456	2 456	2 456	2 456	4 248	5 092	4 885	19 378	19 378	19 378
1 397				1 072				2 817			7 438		
1 082				904				2 205			2 882		
2 080				736				1 267			2 016		
413				910				885			1 425		
89				200				1 777			1 032		
6				26				296			1 787		
-				18				95			207		
-				2				15			34		
-				4				15			7		
-				-				6			-		
7 523	8 834	8 388	8 247	12 199	13 561	14 513	14 022	20 626	25 277	24 417	44 523	56 685	55 302
Total				**Total**				**Total**			**Total**		
AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. II	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb
4 963	12 692	8 837	8 642	21 835	32 902	40 522	36 617	10 094	30 199	28 578	6 531	23 630	22 002
10 933	14 136	14 121	13 685	36 015	38 130	38 476	37 812	46 182	58 752	55 797	59 444	97 273	91 460
16 467	16 490	17 356	16 700	27 494	28 914	28 142	27 882	63 578	64 421	64 215	102 548	102 548	102 548
20 342				23 392				33 623			59 766		
19 479				18 351				14 866			32 504		
25 193				13 541				9 449			10 019		
3 888				18 321				6 571			6 163		
428				2 529				12 593			3 671		
48				264				1 749			7 528		
12				82				377			995		
1				3				63			121		
1				9				22			19		
2				1				7			4		
101 757	112 712	109 708	108 421	161 837	176 439	183 633	178 804	199 174	232 692	227 910	289 313	344 241	336 800

Table A Continued.

1995			**1996**			**1997**			**1998**		
Norway trawl			**Norway trawl**			**Norway trawl**			**Norway trawl**		
AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb
710	3 423	3 326	1 204	2 342	2 119	1 539	5 395	4 921	3 796	8 660	7 757
8 442	11 357	10 958	3 871	6 299	5 701	3 608	6 232	5 684	12 028	15 356	13 787
22 533	29 133	28 370	9 338	14 997	13 632	6 628	13 660	12 544	6 154	6 857	6 154
19 827			18 584			14 682			8 050		
5 167			10 470			17 715			8 099		
559			1 350			5 227			5 473		
438			298			384			1 217		
70			185			95			138		
35			88			40			20		
223			31			19			2		
-			131			27			6		
-			5			30			1		
-			-			-			4		
58 004	70 233	68 972	45 555	54 780	52 595	49 994	63 506	61 367	44 988	53 883	50 708
Russia			**Russia**			**Russia**			**Russia**		
AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb
3 374	10 990	10 784	2 597	9 191	8 515	6 448	19 971	18 494	22 085	33 159	30 576
21 798	34 395	33 607	18 391	25 616	23 992	24 676	24 806	24 676	55 218	55 218	55 218
58 208	60 921	59 730	53 994	55 287	53 994	50 343	50 343	50 343	32 199	32 199	32 199
40 809			51 612			49 588			22 479		
13 300			16 809			22 518			12 291		
3 023			2 352			4 222			3 821		
684			364			488			559		
345			164			99			88		
146			34			34			34		
21			10			10			13		
1			-			-			1		
-			-			-			-		
-			-			-			-		
141 709	164 636	162 450	146 327	161 439	157 846	158 426	172 079	170 472	148 788	159 862	157 279
Others			**Others**			**Others**			**Others**		
AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb
142	3 462	3 381	700	2 056	1 879	600	3 239	2 984	3 047	4 988	4 541
7 570	11 123	10 817	3 559	5 711	5 492	2 297	3 587	3 473	8 672	9 077	8 841
19 988	23 845	23 397	10 831	14 032	13 622	4 102	6 984	6 482	5 067	5 067	5 067
19 285			14 615			8 042			4 715		
3 809			9 057			8 599			5 258		
557			1 913			6 549			2 414		
523			243			1 490			351		
289			125			363			67		
367			108			15			16		
260			57			67			9		
56			221			28			9		
4			25			57			9		
-			-			-			1		
52 850	63 580	62 745	41 454	48 164	47 357	32 207	39 019	38 147	29 635	31 981	31 298
Total			**Total**			**Total**			**Total**		
AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb	AFWG	M. IIIa	M. IIIb
4 888	18 538	18 153	7 729	16 818	15 741	11 058	31 077	28 870	31 728	49 607	45 674
42 696	61 761	60 267	29 146	40 951	38 510	35 128	39 172	38 379	88 945	92 677	90 873
115 681	128 852	126 448	81 833	91 986	88 918	67 855	77 769	76 150	48 073	48 776	48 073
98 774			101 939			83 914			40 667		
32 126			55 200			69 064			35 053		
7 356			10 654			29 229			26 665		
3 022			2 041			4 688			6 722		
1 730			942			1 180			892		
1 178			470			370			197		
1 926			238			211			61		
223			822			114			42		
41			86			240			25		
1			1			-			36		
309 642	355 528	351 246	291 101	322 148	315 563	303 049	337 026	332 408	279 106	301 421	294 980

Table B Mean lengths at age and standard deviations from Norwegian bottom trawl surveys. The natural mortality rate, *M*, and the fishing mortality rate, *F*, used to calculate *p* are gathered from the AFWG report (ICES, 2000). Mean lengths at age and standard deviations calculated by the method for a mixture of two normal distributions where *p* weighs the distributions.

Year	Age	Grouped data					Mixture	
	(years)	mean length (cm)	st.dev	*M*	*F*	*p*	mean length (cm)	st.dev
1983	3	34.23	3.67	0.2000	0.0208	0.53	41.17	8.33
	4	46.06	4.78	0.2000	0.2049	0.55	50.83	7.62
	5	54.66	4.45	0.2000	0.3296	0.57	59.87	7.46
	6	63.19	5.48	0.2000	0.5030	0.59	68.11	7.63
	7	73.22	4.62	0.2000	0.7803	0.62	75.97	6.60
	8	78.70	6.74					
1984	3	34.90	4.37	0.2006	0.0195	0.53	41.56	8.24
	4	48.92	4.24	0.2000	0.1251	0.54	54.72	7.81
	5	56.67	6.25	0.2000	0.3094	0.56	63.12	9.46
	6	66.63	4.60	0.2000	0.6265	0.60	72.44	8.51
	7	75.08	3.88	0.2000	1.1334	0.66	77.21	5.35
	8	80.42	6.88					
1985	3	40.53	5.30	0.2004	0.0533	0.53	44.98	7.00
	4	49.00	4.19	0.2000	0.1722	0.55	54.05	6.79
	5	61.54	5.05	0.2000	0.3805	0.57	65.45	6.61
	6	71.43	5.64	0.2000	0.6070	0.60	75.14	6.90
	7	81.17	4.78	0.2000	0.9148	0.63	83.50	4.87
	8	81.26	5.42					
1986	3	33.99	4.58	0.3122	0.0328	0.54	37.36	5.90
	4	50.03	4.96	0.2000	0.2134	0.55	52.98	6.36
	5	60.13	3.58	0.2000	0.4981	0.59	62.85	5.30
	6	70.66	4.52	0.2000	0.7135	0.61	72.59	9.73
	7	80.66	4.51	0.2000	0.9458	0.64	81.78	4.10
	8	87.50	-					
1987	3	31.91	3.90	0.2583	0.0554	0.54	35.20	5.26
	4	41.36	4.65	0.2000	0.2282	0.55	44.19	5.69
	5	56.60	6.02	0.2000	0.5108	0.59	56.95	6.34
	6	66.69	4.95	0.2000	0.9443	0.64	69.39	7.02
	7	75.60	14.00	0.2000	1.1596	0.66	76.10	12.51
	8	83.75	2.16					
1988	3	30.12	3.35	0.2087	0.0546	0.53	34.86	6.11
	4	39.05	3.84	0.2000	0.1274	0.54	42.85	5.62
	5	47.70	4.85	0.2000	0.3686	0.57	51.57	6.57
	6	57.46	6.75	0.2000	0.5981	0.60	61.65	8.19
	7	74.11	7.60	0.2000	1.0655	0.65	77.06	7.73
	8	77.06	8.90					
1989	3	34.05	2.97	0.2000	0.0330	0.53	40.38	7.77
	4	40.26	3.49	0.2000	0.1291	0.54	46.61	8.01
	5	47.33	3.80	0.2000	0.2664	0.56	53.44	7.98
	6	56.71	4.79	0.2000	0.3985	0.57	61.93	8.15
	7	67.86	5.86	0.2000	0.7158	0.61	72.13	8.04
	8	82.50	4.21					
1990	3	39.21	4.55	0.2000	0.0087	0.53	45.30	8.08
	4	47.51	4.72	0.2000	0.0627	0.53	53.30	8.01
	5	54.09	4.71	0.2000	0.1351	0.54	60.29	8.59
	6	61.14	4.38	0.2000	0.2317	0.55	66.34	7.78
	7	68.96	6.23	0.2000	0.2485	0.56	72.83	7.64
	8	78.84	6.22					
1991	3	42.96	6.38	0.2050	0.0134	0.53	46.48	6.94
	4	52.06	5.27	0.2000	0.0631	0.53	56.06	6.88
	5	59.90	5.49	0.2000	0.1887	0.55	63.92	7.20
	6	67.62	5.95	0.2000	0.3225	0.56	71.49	7.22
	7	72.80	6.03	0.2000	0.4259	0.58	76.89	7.16
	8	77.66	6.39					

Table B Continued.

Year	Age	Grouped data					Mixture	
	(years)	mean length (cm)	st.dev	*M*	*F*	*p*	mean length (cm)	st.dev
1992	3	40.39	5.22	0.2068	0.0341	0.53	45.47	7.58
	4	50.41	5.22	0.2000	0.1277	0.54	54.55	6.76
	5	60.63	5.52	0.2000	0.2224	0.55	64.25	7.19
	6	68.80	5.88	0.2000	0.4446	0.58	72.18	7.15
	7	76.51	5.41	0.2000	0.5411	0.59	79.27	5.99
	8	82.47	4.18					
1993	3	35.84	4.73	0.2656	0.0127	0.53	40.12	7.04
	4	51.20	5.45	0.2030	0.0944	0.54	53.30	7.08
	5	59.42	4.84	0.2026	0.3468	0.57	61.79	7.20
	6	68.72	6.45	0.2000	0.4630	0.58	70.73	7.18
	7	76.83	6.05	0.2000	0.5685	0.59	78.31	7.15
	8	83.24	4.32					
1994	3	30.64	5.29	0.3967	0.0096	0.55	35.98	7.99
	4	45.03	5.96	0.2942	0.1043	0.55	49.32	7.43
	5	55.74	7.93	0.2266	0.3164	0.57	59.53	9.02
	6	64.89	8.49	0.2048	0.6449	0.60	68.77	9.66
	7	73.52	7.21	0.2000	1.1633	0.66	74.61	7.39
	8	80.48	8.03					
1995	3	29.80	6.13	0.7281	0.0103	0.59	34.44	8.22
	4	42.52	5.50	0.3975	0.0982	0.56	45.71	6.63
	5	54.56	5.41	0.2080	0.3200	0.57	57.69	6.69
	6	64.50	7.87	0.2001	0.5816	0.60	67.63	8.44
	7	74.67	8.23	0.2000	0.8970	0.63	77.38	8.02
	8	76.70	7.29					
1996	3	28.39	5.32	0.6271	0.0229	0.58	33.94	8.36
	4	41.13	5.91	0.4235	0.1167	0.57	45.40	7.35
	5	49.79	5.64	0.2774	0.3202	0.57	53.99	7.18
	6	61.77	5.96	0.2056	0.5157	0.59	65.00	7.02
	7	72.23	7.02	0.2000	0.7606	0.62	74.63	7.07
	8	82.01	4.96					
1997	3	30.78	4.03	0.5287	0.0225	0.57	35.27	6.69
	4	41.58	5.14	0.2943	0.1944	0.56	45.92	6.86
	5	50.97	4.93	0.2097	0.5297	0.59	54.38	6.46
	6	59.65	4.74	0.2018	0.6774	0.61	63.05	6.37
	7	69.63	5.70	0.2000	0.7738	0.62	72.12	6.73
	8	78.46	5.22					
1998	3	31.28	4.82	0.5186	0.0510	0.57	35.42	6.82
	4	41.18	4.55	0.3339	0.2780	0.58	45.40	6.71
	5	51.44	4.37	0.2193	0.4640	0.58	55.21	6.58
	6	59.30	5.08	0.2105	0.6990	0.61	63.79	7.41
	7	68.29	4.80	0.2000	0.6940	0.61	72.16	6.96
	8	76.13	6.32					
1999	3	29.41	4.19					
	4	40.91	4.93					
	5	51.11	4.60					
	6	60.50	5.40					
	7	70.83	4.38					
	8	78.17	5.35					

Table C Data from the Norwegian bottom trawl surveys used in method III.

Norwegian bottom trawl survey indices, I (used in method IIIa).

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991
3	24 945	97 485	166 794	805 001	240 381	148 028	46 370	28 340	45 860
4	52 342	28 276	125 977	143 934	391 143	80 485	75 860	34 870	33 670
5	43 328	21 439	19 922	64 136	54 346	173 309	37 800	34 600	25 660
6	16 961	11 739	7 657	8 297	15 694	20 476	90 190	20 570	21 500
7	5 817	4 069	3 150	1 833	1 722	3 582	9 820	27 230	12 130
8	2 995	291	105	53	265	401	820	1 420	12 140
9	770	-	13	-	-	26	-	20	180
10	13	-	-	26	-	-	20	-	-
Sum	147 171	163 299	323 618	1 023 280	703 551	426 307	260 880	147 050	151 140

Proportion mature at age in the indices.

3	-	0.00	0.00	0.00	-	-	0.02	0.02	0.00
4	0.01	0.00	0.01	0.01	0.01	-	0.01	0.03	0.08
5	0.01	0.02	0.04	0.03	0.04	-	0.05	0.05	0.19
6	0.01	0.05	0.13	0.08	0.06	-	0.15	0.16	0.33
7	0.04	0.05	0.14	0.11	0.21	-	0.34	0.43	0.55
8	0.08	0.25	0.67	0.22	0.61	-	0.57	0.59	0.79
9	0.07	1.00	1.00	0.33	1.00	-	1.00	0.51	0.89
10	-	-	0.33	-	-	-	1.00	1.00	1.00

Proportion mature at age from the AFWG report (ICES, 2000).

3	0.01	-	-	-	-	-	-	-	-
4	0.08	0.05	0.01	0.05	0.01	0.02	-	0.01	0.04
5	0.10	0.18	0.09	0.08	0.07	0.05	0.05	0.05	0.06
6	0.30	0.31	0.36	0.19	0.18	0.33	0.18	0.21	0.28
7	0.73	0.56	0.55	0.53	0.22	0.53	0.41	0.58	0.65
8	0.88	0.90	0.85	0.71	0.46	0.62	0.69	0.77	0.83
9	0.97	0.99	0.96	0.62	0.50	1.00	0.85	0.86	0.97
10	1.00	1.00	0.90	0.90	0.75	1.00	1.00	0.98	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Proportion of 8-year and older fish in the traditional VPA (ICES, 2000).

8+	0.0781	0.0345	0.0123	0.0065	0.0070	0.0081	0.0149	0.0363	0.1151

Indices, $\hat{I}$, adjusted according to maturity and the proportion of 8-year and older fish (used in method IIIb).

3	25 197	97 358	166 460	803 391	240 381	148 028	45 484	27 855	45 823
4	56 592	29 663	126 448	149 919	390 471	82 128	75 170	34 134	32 376
5	47 675	25 515	20 931	67 629	56 327	182 431	37 971	34 669	22 024
6	24 022	16 178	10 375	9 409	17 929	30 561	93 193	21 921	19 935
7	20 788	8 810	6 013	3 478	1 736	7 621	11 040	37 260	15 745
8+	14 763	6 344	4 110	6 723	5 007	3 685	3 964	5 877	17 671
Sum	189 037	183 868	334 338	1 040 548	711 852	454 454	266 822	161 716	153 574

Table C Continued.

Norwegian bottom trawl survey indices, I (used in method IIIa).							
Age	1992	1993	1994	1995	1996	1997	1998
3	158 260	273 900	296 500	274 620	170 040	238 033	395 987
4	57 710	140 130	310 190	241 430	115 380	64 009	181 269
5	17 820	72 480	147 400	255 940	137 170	70 431	36 514
6	12 830	15 810	50 520	76 740	106 130	52 697	25 919
7	7 640	6 090	8 980	18 060	23 360	28 299	17 790
8	3 980	2 970	2 000	1 810	2 140	4 924	8 260
9	1 340	790	940	350	140	478	622
10	50	960	40	80	60	125	-
Sum	259 630	513 130	816 570	869 030	554 420	458 996	666 361
Proportion mature at age in the indices.							
3	0.00	-	0.00	-	0.00	-	0.00
4	0.02	0.04	0.01	0.01	-	-	0.01
5	0.11	0.09	0.09	0.07	0.02	0.01	0.05
6	0.40	0.29	0.23	0.34	0.20	0.13	0.19
7	0.57	0.59	0.45	0.57	0.48	0.50	0.42
8	0.83	0.90	0.75	0.74	0.76	0.89	0.69
9	0.96	0.86	0.87	0.93	1.00	1.00	0.87
10	1.00	0.96	1.00	0.97	1.00	0.90	1.00
Proportion mature at age from the AFWG report (ICES, 2000).							
3	0.01	-	-	-	-	-	-
4	0.01	0.03	0.01	-	-	-	0.01
5	0.12	0.09	0.11	0.07	0.02	0.02	0.04
6	0.43	0.30	0.33	0.33	0.26	0.14	0.19
7	0.75	0.61	0.60	0.62	0.63	0.56	0.44
8	0.93	0.91	0.81	0.74	0.83	0.82	0.82
9	0.97	0.97	0.97	0.95	0.98	0.95	0.93
10	1.00	0.99	0.99	0.98	1.00	0.95	0.98
11	1.00	1.00	0.99	1.00	1.00	0.95	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Proportion of 8-year and older fish in the traditional VPA (ICES, 2000).							
8+	0.0687	0.0372	0.0223	0.0136	0.0186	0.0342	0.0384
Indices, $\hat{I}$, adjusted according to maturity and the proportion of 8-year and older fish (used in IIIb).							
3	159 347	273 900	295 106	274 620	169 989	238 033	395 512
4	57 220	138 974	311 569	239 812	115 380	64 009	181 489
5	17 982	72 735	150 795	256 573	137 758	70 913	36 297
6	13 406	16 142	58 294	75 366	115 237	53 536	25 801
7	13 239	6 327	12 309	20 574	32 742	32 029	18 495
8+	19 276	19 616	18 856	11 956	10 819	16 236	26 225
Sum	280 470	527 694	846 929	878 901	581 925	474 756	683 819