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REPORT OF THE

Workshop on MSVPA in the North Sea

Charlottenlund, Denmark
8–12 April 2002

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1.2 Terms of reference

The **Workshop on MSVPA in the North Sea** [WKMSNS] (Co-Chairs: M. Vinther, Denmark and C.M. O'Brien, UK) met in Charlottenlund, Denmark from 8-12 April 2002 to:

a) update the MSVPA quarterly database to include data up to 2000;

b) produce a new key run of MSVPA for the North Sea using the updated data;

c) define a programme of work and Terms of Reference for two meetings of a study group on the future direction of multi-species work in the North Sea in order to maintain ICES' capability to give multi-species advice.

WKMSNS will report by 30 April 2002 for the attention of the Resource Management Committee and ACFM and ACE.

1.3 Scientific justification for the study group

The ICES Multi-species Assessment Working Group (MAWG) last met in 1997 (ICES 1997a) because it was thought that there was no need for routine multi-species stock assessment and subsequent advice on management issues. Nevertheless, it is widely recognized that the development of viable long-term management strategies depends on a good understanding of species and fleet interactions, and requests for advice reflect the continued interest in this field.

This workshop will produce primarily an updated key run of the North Sea MSVPA (Multi-Species Virtual Population Analysis) and identify the future direction of multi-species work in the context of the North Sea. This is necessary if ICES is to maintain the capability to give multi-species advice. A number of developmental extensions have previously been identified for MSVPA (see, for example, ICES 2001c) but it is necessary to define a feasible and focussed programme of research.

1.4 Overview of the history of MSVPA

The MSVPA has its origins in the North Sea model of Andersen and Ursin (1977). When this model was published it was criticized for containing too many inestimable parameters to be useful in fisheries management and it was therefore considered relevant to develop a simpler model more akin to the single species models used by the ICES Stock Assessment Working Groups. Focussing on the predatory interactions between the commercially exploited fish stocks for which catch-at-age data were available and assuming constant, instead of food dependent, individual food intake and growth it was possible to construct a multispecies model, MSVPA, with only three equations: the catch and stock number equations of the single species VPA plus an equation describing how predation mortality, M2, depends on the biomass of the prey and the total food intake of the predator:

$$N_{i,t} = N_{i+1,t+1} \cdot e^{(F_{i,t,t+1} + M1_i + M2_{i,t,t+1})}$$

$$C_{i,t,t+1} = N_{i,t} \cdot \frac{F_{i,t,t+1}}{F_{i,t,t+1} + M1_i + M2_{i,t,t+1}} \cdot (1 - e^{-(F_{i,t,t+1} + M1_i + M2_{i,t,t+1})})$$

$$M2_{i,t,t+1} = \sum_{All\ predators} \frac{Food_j \cdot \overline{N}_{j,t,t+1} \cdot SUIT_{i,j}}{SUIT_{o,j} \cdot B_o + \sum_{All\ MSVPA\ prey} SUIT_{h,j} \cdot \overline{N}_{h,t} \cdot w_h}$$

where

$N_{i,t}$: Number of prey species age group i at time t

$C_{i,t,t+1}$: Catch of prey species age group i between time t and t + 1

$M2_{i,t,t+1}$: Predation mortality of prey species age group i between time t and t + 1

$M1_i$: Other natural mortality of prey species age group i

$F_{i,t,t+1}$: Fishing mortality of prey species age group i between time t and t + 1

$Food_j$: Food intake mortality of prey species age group i between time t and t + 1

$SUIT_{i,j}$: Suitability of prey species age group i to predation by predator species age group j

B_o : Biomass of other food

$\overline{N}_{j,t,t+1}$: Average population of species age group j in time interval between t and t + 1

w_h : Average weight of prey species age group h

Given suitabilities, food intake and average weights the three equations can be used to provide estimates of fishing and predation mortality by iteration within a specific time interval. Once population numbers have been estimated for the years for which food composition data are available, revised estimates of suitability can be derived. These estimates can then be inserted into the MSVPA, and used to calculate new population numbers. This procedure is repeated until the suitabilities have converged. A more comprehensive account of the mathematical aspects of MSVPA and the underlying assumptions of the model can be found in Magnusson (1995).

The idea of incorporating a model of predation mortality in the single species VPA was initially put forward in two independent papers presented at the statutory meeting of ICES in 1979 (Helgason & Gislason 1979, Pope 1979). The presentations generated enough interest for ICES to convene an Ad Hoc Working Group on Multispecies Assessment Model Testing (ICES 1980). This Ad Hoc Working Group recommended that a stomach sampling programme should be established in the North Sea to provide the food composition and food intake data necessary to estimate the interaction terms in the MSVPA and, in particular, to test the underlying assumptions of the predation model. In 1981, approximately 60000 stomachs were collected from the five commercially exploited fish species (namely, cod, haddock, whiting, saithe and mackerel) assumed to be the major fish predators in the North Sea (Daan 1989). The stomach contents were analysed to provide estimates of the average food composition and total weight of stomach content by predator age, prey age and quarter and the results were given to the ICES Ad Hoc Working Group on Multispecies Assessment who met in 1984 to perform the first quarterly North Sea MSVPA (ICES 1984). The ICES Ad Hoc Working Group on Multispecies Assessment used numerous meetings to refine the model, test a predictive version, the MSFOR model, and add additional food composition data. Fish stomachs were thus collected in 1985, 1986 and 1987 for some of the predators (but in quarters 1 and 3 only). In 1991, an additional year of food composition data was collected for all of the MSVPA predators as well as for a suite of other predators expected to prey on commercially important fish species (Hislop 1991). Today, the total food composition database for the North Sea now contains the results from analysing approximately 200,000 fish stomachs.

Over the period from 1984 to 1997, the ICES Multispecies Assessment Working Group (MAWG) has performed sensitivity analyses of the MSVPA and MSFOR, examined the constant suitability assumption, the difference between single and multi-species long- and short-term predictions of effort and mesh changes, added additional other predators, developed alternative simpler models and tried to reduce the parameters of the model describing the food selection of the major fish predators. An overview of the most important results obtained during the 1980's is given in Pope(1991).

The major conclusion of the work is that natural mortality is much larger for the younger ages of the species exploited for human consumption than previously assumed. The MSVPA was found to be quite robust to changes in input parameters. A 10% change in an input parameter always produced a smaller change in the response variables (Finn *et al*. 1991). MSFOR predictions were found to be most sensitive to the assumed future recruitment. Suitability is reasonably constant over time (Rice *et al.* 1991), albeit with a tendency for predators to be more conservative in their diet choice than predicted by the model (negative switching; Larsen & Gislason 1992), but the MSVPA was able to provide reasonable predictions of the food composition in 1991 when only 1981 food compositions were used to estimate the predation parameters.

Most importantly, it was found that the long-term predictions of the MSFOR model differed significantly from single species predictions. The conclusion was that the North Sea fisheries generally operate at a level of effort below $\mathbf{F}_{max}$, a result very much at odds with single species yield per recruit calculations in particular for the larger gadoids. Multi-species equilibrium yield curves with constant recruitment thus show that cod and whiting are currently fished below $\mathbf{F}_{max}$ (Gislason 1991) and fitting a multi-species yield surface to results from fleet based yield predictions from MSFOR (in which constant recruitment was assumed) showed that current effort levels are close to $\mathbf{F}_{0.1}$ and would need to be increased by between 8% and 100% to generate the maximum yield (Pope 1991). Due to the high natural mortality of the younger age groups and to the increase in their predation mortality when the biomass of older fish (their predators) increase, attempts to protect young fish will not generally result in increased landings, provided recruitment is constant. Mesh size increases in the roundfish fishery were found to result in comparatively smaller increases in the biomass of older fish than predicted by single species models due to reductions in recruitment caused by increased predation of young fish. The relatively modest increases in the biomass of older fish were too small to compensate for the loss of small fish escaping through the meshes, resulting in an overall decrease in yield as mesh size increased. Generally speaking, the major conclusion of the multi-species work undertaken in the MAWG is that growth over-fishing is much less important than previously thought leaving recruitment over-fishing to be the main concern in routine fish stock assessment and management.

Outside the North Sea the MSVPA has been applied in the Baltic (e.g. Sparholt 1994, ICES 2001d), in the Barents Sea, and recently also on Georges Bank (Tsou & Collie, 2001) and in the Berings Sea (Livingston & Jurado-Molina, 2000).

The MAWG has mostly been concerned with biological interactions. However, from a management point of view technical interactions between fleets and species are also important. In 1989 and 1991 data on landings-at-age by fleet by ICES statistical rectangle were collected by the STCF working group and the availability of these data spurred the development of a new version of the MSVPA/MSFOR programs - the so-called 4M model - in which the impact of technical interactions could be evaluated. Unfortunately, however, detailed data on the catch composition of the various North Sea fleets has not been made available since and the model has therefore not yet been used to its full potential. Apart from including technical interactions, the 4M model has much better features for data handling than the old MSVPA/MSFOR programs. It is possible to tune the terminal fishing mortalities to CPUE (catch-per-unit-effort) and effort data by linking to the tuning packages (XSA, SXSA and ICA) and effort time series used by the single species working groups. Furthermore, the model provides possibilities for studying the effect of area closures.

1.5 Structure of the report

The terms of reference (ToRs) are addressed within the four main sections of the report. Specifically, ToR a) is addressed within Section 2 of the report, ToR b) is addressed within Sections 3 and 4, and ToR c) is addressed in Section 5.

Section 2 details the input data to the North Sea MSVPA. In addition, the 4M (Multi-species, Multi-fleet and Multi-area Model) package is introduced which combines features from the ICES multi-species VPA computer program MSVPA, the corresponding prediction program MSFOR (Gislason & Sparre 1987) and the STCF prediction program ABC (Lewy *et al*. 1992) and database facilities for the input to, and the results of, these models. The 4M package is a computer program for analysis of historical data and predictions including biological and technical interaction models.

In Section 3, the details of the set-up and input data for a North Sea 4M run are presented – the so-called, key run. Section 4 presents the results of the North Sea 4M key run in some detail. Further work is discussed in Section 5.

2 UPDATE AND REVISION OF MSVPA PROGRAM AND INPUT DATA

2.1 The 4M package

The 4M package (Multi-species, Multi-fleet, Multi-area Model-package) (Vinther *et al*. 2002) was used to run the MSVPA at this working group. The aim of 4M has been to create an integrated software system handling model input, the models, and analysis and presentation of output. Basically 4M combines the modules (MSVPA and MS-FORECAST) written in ANSI C and a SAS environment for data management, analysis and presentation.

The 4M system was tested for North Sea data at the 1997 meeting of MAWG (ICES 1997a) where it was used to give overview figures of output. It produced the same results as the old Fortran version of MSVPA used at that meeting.

For the Baltic area the 4M package has been used for historical analysis (ICES 1997b; ICES 1999) and for projections (ICES 2001d). Additional features like bioenergetics models for calculation of food intake, variable growth and stochastic stock-recruitment relationships have been incorporated within the 4M package and tested at the cited working groups for the Baltic area.

2.2 Catch data and population numbers

The set-up with respect to species, age groups and management area for both the ICES single species assessment and the MSVPA 1995 key-run are presented in Table 2.2.a. Both stock areas and age group ranges are different for the two kinds of assessments. Compared to the single species assessment data, MSVPA has more age groups defined for a species, with the exception of Norway pout. To facilitate the use of multi-species VPA tuning (Vinther 2001) and for direct comparison of the two catch-at-age data sets, the current MSVPA adhered to the single species assessment data and procedures, wherever possible.

The initial set-up of the North Sea MSVPA included stocks within ICES area IV. This spatial division was in accordance with the stock distribution area for most of the species in the traditional single species assessment. However, the more recent single species assessments for roundfish stocks, mackerel and herring refer to the stock in an extended area, such that the North Sea contributes only to a part of the stocks' total distribution area. The current MSVPA again applies to ICES area IV; data have been selected accordingly, by the subtraction of catches from areas outside of the North Sea. The actual procedures to derive the required geographical breakdown are detailed below for each species.

The catch-at-age data supplied by the single species working groups do provide information by quarter. However, revisions of historical data often lack the quarterly break down. In these cases, (revised) annual data have been broken down over quarters either: a) in proportion to the quarterly distribution used in previous MSVPA runs; b) in proportion to the known break down in later years; or c) assuming a constant total mortality rate over the quarters within each year.

The key run at the 1997 MAWG (ICES 1997a) includes data for the period 1974-1995. This meeting’s key run extends the time series up to 2000 and back to 1963. The period prior to 1974 covers the collapse of the North Sea mackerel stock and the so-called *gadoid outburst*, such that the full period 1963-2000 includes highly variable predator stock sizes. This gives the opportunity for further evaluation of the model assumptions’ and input data.

An overview of the data sources and the correction procedures adopted is provided in Table 2.2.b. The text in the following Sections gives a short description by species - further details are presented in WD1 (Vinther).

2.2.1 Cod, haddock, whiting, saithe, plaice and sole

Annual catch data are available for the whole period 1963-2000 from the ICES’ roundfish database except for saithe, for which data for 1963-1966 were copied from ICES (1978). Quarterly catch-at-age data for the North Sea by species are available for the period 1996-2000. The same quarterly pattern was assumed for other years.

In previous runs of the MSVPA, the quarterly mean weights in the sea were assumed constant over the years. In the current analysis, the quarterly pattern of previous runs was conserved, whilst the trend in annual mean weights were taken from the ICES database. These mean weights in the sea are most often based on observed mean weights in the catch. For the youngest age group, mean weights in the catch are most often higher than in the stock. For ages up to two, the original MSVPA mean weights were preferred.

2.2.2 Herring

Annual MSVPA catch numbers in the period 1974-1995 were not updated with the single species values as these were not available for the North Sea separately. For the years prior to 1974, the annual catch data were taken from the ICES' database, neglecting the fact that part of the herring catches were taken outside of the North Sea. MSVPA includes just the North Sea component of the of the *North Sea stock*, even though herring from this stock migrates and are fished in the combined areas IV, IIIa and VIId. Quarterly catch data from the North Sea are available for the period 1996-2000. The quarterly pattern in the years prior to 1974 was assumed to be equal to the average pattern observed in the later years.

2.2.3 Norway pout

The single species assessments of Norway pout are made using quarterly data from the North Sea and Skagerrak combined. The catches in the Skagerrak comprise in general less than 10% of the total catches and are mainly taken by Danish fishermen (ICES 2001e). Catch numbers were taken from the single species assessment but reducing all catches by age group to take into account the Danish Skagerrak catches. For the period prior to 1974, total yields were separated by ages and quarters, based on the post-1974 distribution.

2.2.4 Sandeel

The catch data by half-year were copied from the ICES' database. More than 97% of the catches in 1991-1995 were taken during the second and third quarters, such that the half-yearly data represent the quarterly data well. The same quarterly distribution was assumed in other years. Catch mean weights were assumed to be constant within each half-year. For the years prior to 1972, the age distribution was assumed to be the same as that in the period 1972-1981.

2.2.5 Sprat

The single species assessment provided for sprat is based upon a biomass model (ICES 2000a) because the age information is considered to be unreliable. In the 1997 MSVPA key run sprat was not included. However, there have been large fluctuations in the sprat stock size and although the information is rather uncertain, the workshop decided that the inclusion of sprat as a VPA species (and not as part of *other food*) was to be preferred.

The annual catch numbers were derived from the various sources listed in Table 2.2.b. The quarterly distribution was assumed to match that in 1974-1975. The age distribution for the years 1974-1993 was extrapolated to other years.

2.3 Terminal fishing mortality

Terminal fishing mortalities (in the fourth quarter) for use in MSVPA have previously been chosen such that the sum of the estimated quarterly MSVPA Fs was close to the annual F values produced by the single species assessment groups. This process of trial and error has been laborious. A first attempt to incorporate XSA tuning in MSVPA was made at the Multispecies Assessment Working Group meeting in 1992 (ICES 1992a). It was concluded that the method was applicable, but discrepancies in the way which XSA and MSVPA treat the plus-group prevented final testing of the method. Ways to solve the discrepancy were proposed in the Working Group report, but have never been implemented.

Multi-species tuning can be considered as a successive exchange of natural mortalities (M) and terminal fishing mortalities (F) between MSVPA and tuning modules for individual species, until equilibrium is obtained. This is not integrated in the MSVPA program, but is made through calls to separate external tuning modules. This is not efficient with respect to run time, but the approach allows use of existing tuning software, e.g. the Lowestoft VPA package (Darby & Flatman 1994) or ICA (Patterson 1998) without re-writing the MSVPA program or tuning modules. The basic principle for *ad hoc* multi-species tuning is:

1) Perform a MSVPA run using dummy terminal F's.
2) For each species write a file on Lowestoft format (or other tuning specific format) including multispecies natural mortality rates.
3) Perform single species tuning for each species, using multispecies M values.
4) Read output F's from tuning and convert terminal annual F's into quarterly F's for each species.
5) Read all quarterly terminal F values into MSVPA and perform a new MSVPA run.
6) If $\Sigma (F_{new} - F_{old})^2 >$ limit go to 2).

The tuning modules and MSVPA program use separate catch-at-age data sets, which ideally should be identical with respect to annual catch numbers. It is however technically possible to use different data sets where stock definitions differ between the single- and multi-species assessment. As an example: the cod stock as defined in the single species assessment includes area IV, IIIa and VIId, whilst the MSVPA cod stock just includes area IV. When the single species assessment cod data are used for multi-species tuning, it is assumed implicitly that the two *stocks* have the same fishing and natural mortality, which in this case might be reasonable.

This *ad hoc* multi-species VPA tuning (Vinther 2001) was applied for the years available by the single species assessment data (Table 2.3) using the same set of options and CPUE time series as used in single species assessments. For the years not included in the single species assessment, terminal F values were postulated primarily from the annual landings.

For the youngest ages not included in the single species assessment (e.g. cod age 0), the terminal Fs in the year 2000 were set such that the estimated stock numbers were close to the average values for the year-class in the most recent years. Where additional information like survey indices time series were available from the single species assessment or ACFM report, the terminal F was set such that the estimated stock number in year 2000 obtained a size in accordance to the previous year's survey indices and multi-species stock numbers.

2.4 Biomass of other species

MAWG (ICES 1997a) revised the estimates of biomass for species other than those discussed in Section 2.2 of this report. At this workshop only limited new data were available to revise those estimates of biomass. Hence, in this Section 2.4, extensive details are only provided for those species where substantial revisions were possible – namely, seabirds (Section 2.4.2), grey gurnard (Section 2.4.3), starry ray (Section 2.4.4), mackerel (Section 2.4.5) and horse mackerel (Section 2.4.6).

2.4.1 Grey seals

The numbers of grey seals estimated by the previous multi-species working group (ICES 1997a) for the period 1974-1995 were not changed. It was assumed that the stock has increased by 6% per year since 1995 (F. Larsen, pers.comm.). For the period before 1974 the population was assumed to increase by 2% per year, a rate similar to the rate given in Summers *et al*. (1978).

2.4.2 Seabirds

Numbers of breeding seabirds around the North Sea have recently been re-evaluated by the Working Group on Seabird Ecology [WGSE] (ICES 2002c). A large part of this revision has been the result of *Seabird 2000*, a joint British and Irish project. The majority of colonies appear to have declined since the last censuses that took place between 1985-1987. This is contrary to the situation perceived by MAWG (ICES 1997a), where the main source of information was Hunt & Furness (1996) who in turn were basing many of their calculations on data during the mid-1980s. Table 2.4.2 shows the change in numbers for the nine MSVPA seabirds. Overall, the number of MSVPA seabirds at breeding colonies has decreased from 4 million to 3.4 million birds between the two large censuses (approximately 14 years). This equates to a yearly decrease of 1.18%.

Seabird numbers as used within MSVPA are based upon counts of breeding birds at colonies round the North Sea and therefore generally represent numbers in the spring and early summer months. Previously, MAWG have attempted to account for the numbers of non-breeding birds and breeding birds absent from the colony at the time of census by multiplying by 1.5. These counts were assumed to hold for 2nd and 3rd quarters while numbers in the 1st and 4th quarters were estimated by comparing total food consumption in quarters one and two, and in quarters four and three, respectively (Tables 2.19 in Hunt & Furness (1996)). This procedure results in smaller population sizes in the winter months. WGSE (ICES 2001b) give wintering population estimates for the North Sea which were up to 6 times larger than the breeding population (Table 2.4.2). Basing seabird population size on breeding numbers alone may therefore severely underestimate consumption rates.

As the Workshop did not have the exact details of the models used by MAWG (ICES 1997a) to determine quarterly seabird numbers, it was not possible to properly update the input numbers. As an approximation, the existing dataset was therefore modified and extended by projecting the 1985 quarterly values forwards with a 1.18% reduction per year.

2.4.3 Grey gurnard

The time series of biomass estimates of grey gurnard used in the 1997 key-run has been completely revised based on IBTS data (1966-2001). In exploring these data, we observed that records of grey gurnards were completely absent in several early ship/year data sub-sets. Although it cannot be ruled out that grey gurnards had not been caught by these vessels, systematic differences among specific vessels suggest that they may simply not have been recorded. Therefore, ship/year sub-sets with zero catches were excluded for the time being.

The remaining hauls (14600) were analysed using a generalised linear model, GLM (assuming a Poisson distribution and a log-link function), with year, quarter, gear and roundfish area as explanatory variables of the numbers caught by size class. The use of a Poisson distribution does allow for zero observations without additional model assumptions, while assigning less weight to zero and near-zero observations, in comparison to the gamma or log-normal distribution, which are often applied. The size classes (<10; 10-20; 20-30, and >=30cm) matched those used for stomach content information. With the exception of the model for the smallest size category, which did not converge, most factors investigated contributed significantly. Figure 2.4.3.1 provides the estimated annual, quarterly, gear and roundfish area indices, relative to the year 2001, quarter 4, GOV, and roundfish area 7, respectively. Again with the exception of the <10cm class, the patterns for the different size classes were quite similar for all factors. The annual indices indicate variable biomasses until the late 1980s, followed by a gradual increase in abundance up to the present.

The parameter estimates for the model were used to calculate the biomass by size class, year and quarter, assuming an average biomass of 205 000 t over the entire period. This estimate is derived from Daan *et al.* (1990) and has been based on English Groundfish Survey data for the period 1977-1986. We have assumed that this average biomass applied to the entire period 1967-2001 (1966 was excluded, because data were considered too limited in this case). Figure 2.4.3.2 provides the total biomass (summed over size classes) by year and quarter.

To complete the time series, values for 1963-1966 were input in the MSVPA as the average of 1967-1969.

The series obtained is not entirely satisfactory. First of all, the up-scaling is entirely based on old analyses of the total biomass of gurnards in the 1980s (Yang 1982, Sparholt 1987). Given the amount of new survey material collected after those years, a re-analysis along those lines would seem highly appropriate. In addition, there is a need to investigate seasonal changes in catchability more closely. Large fish suddenly appear and disappear again, which does not make much sense in terms of population dynamics. If there are truly seasonal variations in catchability, which is not unlikely because of major differences in distribution between seasons (Knijn *et al.* 1993), it might be more appropriate to smooth the quarterly biomass values. However, there was no time available to investigate these problems in more detail.

2.4.4 Starry ray

The time series of biomass estimates of starry ray has also been completely revised based on IBTS data (1966-2001). The analysis largely followed the methods described for grey gurnard. Ship/year sub-sets with zero catches were excluded and so were hauls in roundfish areas 5 and 6 because catches in those areas were extremely small. The remaining hauls (numbering 9034) were analysed using GLM (assuming a Poisson distribution and a log-link function) with year, quarter, gear and roundfish area as explanatory variables of the numbers caught by size class.The size classes (<20; 20-30, and >=30cm) matched those used for stomach content information. The model did not converge for the two smallest size classes, most factors investigated contributed significantly. Figure 2.4.4.1 provides the estimated annual, quarterly, gear and roundfish area indices, relative to the year 2001, quarter 4, GOV, and roundfish area 7, respectively. Patterns were generally consistent across size classes.

The parameter estimates for the model were used to calculate the biomass by size class, year and quarter, assuming an average biomass of 100 000 t over the entire period. This estimate is derived from two sources: Daan *et al.* (1990) who used English Groundfish Survey data for the period 1976-1986; and Sparholt & Vinther (1991) who used data from the IBTS 1983-1988 and the Dutch Beam Trawl survey, 1985-1987. We have assumed that this average biomass applied to the entire period 1967-2001. Figure 2.4.4.2 provides the total biomass (summed over size classes) by year and quarter.

To complete the time series, values for 1963-1966 were input in the MSVPA as the average of 1967-1969.

The same reservations as mentioned for grey gurnard (see Section 2.4.3) apply to starry ray.

2.4.5 Mackerel

There are two components to the mackerel stock in the North Sea, a resident population and a migratory population. Historically the resident population was very large (c.a. 2.5 million tonnes, Hamre (1978)), but since the 1970s has been low (36 – 110 thousand tonnes SSB, ICES (2002a)). This has been partially compensated for by influxes of the Western Mackerel stock into the northern North Sea during the second half of the year since the 1970s. It is not possible to distinguish between the two stock components in the catches, however due to the differing time scales of residency, MSVPA treats the two stocks components differently.

Western Stock

Stock size estimates come from the Mackerel, Horse Mackerel, Sardine and Anchovy Working Group [WGMHSA]. For the Western Component the assessment goes back to 1972, prior to which immigration was considered to be minor. There are no strong indications for changes in the fraction of the Western stock which migrates into the North Sea, so the fractions applied since 1986 have been carried forwards. Data for stomach contents come from analysis of area IVa only.

North Sea stock

In order to obtain stock abundance estimates for the North Sea stock between 1963-1985, a new assessment was made at the workshop.

For the period 1963-1968, quarterly catch numbers-at age were provided by IMR Bergen for the Norwegian fishery for ages 1-8+. These numbers were based on Norwegian samples from the fishery which accounted for 45-95% of the international landings and were assumed to be representative of the international landings. For 1969-1973, catch numbers were as given by the 1985 Mackerel Working group. For 1974-1985 catch numbers were as previously used in MSVPA were used.

Egg survey estimates of the spawning biomass were available for the years 1980 – 1984 (ICES 2002a).

A separable model was fitted for the years 1980-1985 ($F_7 = 1.2* F_4$). For the earlier period a simple VPA using Pope's cohort approximation was used. Assumptions regarding the plus group have a significant effect on the assessment due to the domination of older ages in the early catches. In this model the plus group was assumed to be a dynamic pool, with a fishing mortality 1.64 times that of the oldest true age. This was because of a strong increasing trend in the residuals for the plus group, indicating a higher mortality for the plus group than for the oldest true age. The mean weights at age assumed in previous runs of MSVPA were retained.

The resulting assessment gives an SSB of just over 3 million tonnes in 1963-1964, somewhat higher than the 2.5 million tonnes estimated by Hamre (1978). Quarterly stock numbers were generated by assuming an even spread of fishing mortality in each quarter.

2.4.6 Horse mackerel

The ICES stock assessment working group [WGMHSA] considers horse mackerel in the North Sea as two stocks. The North Sea stock spawns in the southern North Sea and migrates partly westwards through the English Channel in winter. The western stock spawns off the western slope of the European shelf and migrates partly into the North Sea in the autumn (ICES 2001f). Analytical assessment is done for the Western Stock, while catch figures only are available for the North Sea Stock (ICES 2001f). For the period 1991-1998 the assessment WG has provided quarterly proportions of the two stocks present in the North Sea (Table 2.4.6.1)

The presence of the *Western stock horse mackerel* in the North Sea was probably triggered by the exceptionally strong 1982 year class (Borges *et al*. 1996) and was assumed to be present in the North Sea from 1986 and onwards. The 1991 distribution was applied for the Western stock back to 1987 and for 1986 a lower percentage was applied (Table 2.4.6.1). The 1999 proportion in the fourth quarter was guessed to be the double of that for 1998, and that for 2000 was assumed to be very low. This reflects both the development of the fishery, the availability of Western horse mackerel in the North Sea (Iversen *et al*., 2001) and the recent decline in the stock abundance. The analytical assessment produces stock numbers back to 1982. These numbers and the proportion present in the North Sea were used to calculate stock numbers. To produce quarterly stock numbers the 1. January stock numbers from assessment (ICES 2001f) were reduced proportionally by the annual Z, however, the assessment's annual mean weight in the catch was used as mean weight for the whole year.

For the *North Sea horse mackerel* stock few data on stock size exist and no assessment is made by the Working Group. Egg surveys for horse mackerel have been carried out in the North Sea in the period 1988-1991 and the SSB was estimated between 217 and 255 thousand tonnes during the last three survey years (Eltink 1992). As almost pure guesswork, the North Sea stock size was assumed to be 7% of the average of 1982-1999 western stock, which gives a SSB of 230 thousand tonnes. According to Postuma (1978), data are inconclusive as to whether the increase in the North Sea horse mackerel catches after 1946 (up to 1973) were caused by an increase in abundance or by an increase in fishing intensity. The guess on the stock size therefore is assumed to cover the whole period up to 1963 - 2000. For the period before 1985 it was further assumed that the North Sea horse mackerel was the only horse mackerel stock present in the North Sea.

2.4.7 Anonymous other predators

The group of *Other predators* was incorporated into the North Sea MSVPA by the MAWG at the meeting held in 1997 (ICES 1997a) and represents various unspecified cetaceans and piscivorous fishes in the North Sea. The diet of this group was assumed to be the same as the average of the sum of calculated food intake in 1991 of the five traditional MSVPA predators (cod, haddock, North Sea mackerel, saithe and whiting). The intention was to estimate a part of the residual natural mortality (M1) given as input; however, these values were not lowered in the key run made.

This workshop considers that the estimate of the diet for *other predators* seems to have been very *ad hoc* and as a consequence the *other predators* have been left out of the up-dated key run.

2.5 Stomach content data

The 1997 report of MAWG (ICES 1997a) provides an extensive overview of historic uses of different sets of stomach content data at different occasions and of various major revisions over time. Because no new flaws have been detected and no new data have been collected, the stomach content database has been kept exactly the same as in 1997 and the reader is referred to the 1997 report for details.

2.6 Consumption rates

The workshop discussed consumption rates within the MSVPA and considered that previously the MAWG (ICES 1997a) may have over-estimated consumption rates. This conclusion was based upon a presentation to the workshop of the results from the CORMA project (Contract No. FAIR-CT 95-0604 entitled: Consumption rates of predatory fish relevant for multispecies assessment in the North Sea and the Atlantic off Spain and Portugal). The basic model to describe gastric evacuation is presented below in Section 2.6.1 and the corresponding revisions to food consumption rates adopted at this workshop are presented in Section 2.6.2.

2.6.1 Introduction

The general applicability of the square root model to describe gastric evacuation in predatory gadoids independently of meal size has been verified through experiments on whiting, saithe and cod (Andersen 1998, 1999, 2001). Mean consumption rate over time and population may therefore be estimated by

$$\hat{C} = \overline{\rho S^{0.5}} \qquad (1)$$

where S and ρ are the total mass and evacuation rate constant, respectively, of the stomach content of each individual sampled in the field. The rate constant ρ has been expanded as a function of the major variables influencing gastric evacuation by

$$\hat{C} = \overline{\rho_{LTE} L^{\lambda} e^{\delta T} E^{-\mu} S^{0.5}} \qquad (2)$$

where L is the length of the individual predator from which the stomach content of total mass S and overall energy density E is recovered, and T is the water temperature experienced by the predator at the time of sampling (Andersen 2001). Assuming that the fractions made up the different prey types is maintained throughout evacuation, the evacuation rate of prey type i in a stomach is $dS_i/dt = a_i \rho S^{0.5} = a_i \rho_{LTE} L^{\lambda} e^{\delta T} E^{-\mu} S^{0.5}$, and the estimated mean rate of consumption of individual prey types becomes

$$\hat{C}_i = \overline{a_i \rho_{LTE} L^{\lambda} e^{\delta T} E^{-\mu} S^{0.5}} \qquad (3)$$

where the overall energy density of the content of each stomach $E = \sum a_i E_i$ (a_i is the fraction constituted by prey type i of energy density E_i in the stomach). The considerations given here presumably apply only to consumers of fish prey and smaller crustaceans such as krill. The description of evacuation of mixed meals including crustaceans or other invertebrates with a thick exoskeleton, seems to be more complicated because more prey characteristics (i.e. both prey energy density as well as exoskeletal barrier) influence the evacuation process. Research on modeling evacuation of mixed meals that include prey with resistant exoskeletons is therefore going on presently.

Information about stomach content data has however usually been pooled, and quarterly mean values by age group for total stomach content and rate constant of evacuation are applied to calculate consumption rates (e.g. Jones, 1978):

$$\hat{C} = \bar{\rho}\, \bar{S}^{0.5} \qquad (4)$$

However, the values of $\overline{S^{0.5}}$ and $\bar{S}^{0.5}$ differ unless all values of S are equal (e.g. Ursin *et al.* 1985). Consumption rates as estimated by application of equation (3) are therefore likely to be biased by the frequency distribution of S. A factor k correcting for $\overline{S^{0.5}} \neq \bar{S}^{0.5}$ may be introduced into equation (4) to remediate for this bias:

$$\hat{C} = \bar{\rho}\, k \bar{S}^{0.5}$$

The correction factor can be estimated from individual stomachs of predators by the expression $k = \overline{S^{0.5}} / \bar{S}^{0.5}$, grouping data on total mass of stomach contents into predator length classes.

Further, prey composition of individual stomachs sampled in the field is not necessarily similar to the mean value obtained from the pooled stomach contents. The rate constant ρ may be heavily influenced by prey composition - e.g. by energy density of fish prey and exoskeleton of invertebrates. Therefore, estimated consumption rates of individual prey types - and in consequence the prey composition of *ingested* food - may be biased by application of mean value of ρ which is based on the quarterly mean prey composition (Andersen 2001).

2.6.2 Revision of food consumption rates

For the present, only the consumption rates of mackerel (Table 2.6.2) are revised at this workshop using the gastric evacuation rates obtained in the CORMA project (Contract No. FAIR-CT 95-0604 entitled: Consumption rates of predatory fish relevant for multispecies assessment in the North Sea and the Atlantic off Spain and Portugal). A proposal for further revisions is presented in the Section 5.1.1.1.

Using the 1997 key run estimate of mackerel consumption, approximately 8 million tons of sandeel were eaten in 1963 according to the MSVPA output. This high biomass eaten seems unrealistic. Mackerel ate the main part of this sandeel biomass in the first quarter. The available stomach data revealed that 97% of the stomach contents of the larger mackerel in quarter 1 was sandeel age 1. However, looking into the stomach database, almost all mackerel stomachs sampled were empty except one where one sandeel was found. As the input to MSVPA is the relative stomach contents this single sandeel in combination with a number of almost empty stomachs resulted in an estimated diet consisting of 97% sandeel.

The high number of empty stomachs observed in quarter 1 seems inconsistent with the relatively high estimate of consumption previously used, and the CORMA project’s revised and much lower consumption rates were used instead for the key run.

2.7 Proportion mature

Maturity ogives were copied from the relevant single species working groups (ICES 2001, ICES 2002ab). For the period after 1963 that was not covered by the single species data, the data from the first year in the single species assessment were applied.

2.8 Mean weight

The quarterly MSVPA mean weights-at-age were scaled to the annual SSVPA values (ICES 2001, ICES 2002ab) which represent weight-at-age in the sea during the spawning period. The spawning period was assumed to take place in quarter 1.

The SSVPA mean weights-at-age were divided by the MSVPA mean weights-at-age in quarter 1 to calculate a raising factor for each year, species and age. Then the MSVPA quarterly mean weights-at-age were multiplied by the corresponding raising factors to produce the new set of MSVPA mean weights-at-age.

The SSVPA mean weights-at-age in the sea are most often based on observed mean weights-at-age in the catch. For the youngest age group mean weights-at-age in the catch are most often higher than in the stock. Hence, the original MSVPA mean weights-at-age for ages up to two years were kept unchanged to avoid bias.

2.9 Residual mortality

Residual mortalities were taken from the last MAWG (ICES 1997a) and copied forwards in time.

Table 2.2.a. Set-up of single- and multi-species assessment for the North Sea.

	Single species assessment 2000		MSVPA key run 1997		MSVPA 1963-2000
	ICES area	Age groups	Age groups	Predator/ Prey	Remarks
VPA species					
Cod	IIIan, IV, VIId	1-11+	0-11+	Yes/Yes	Human consumption only
Haddock	IIIa, IV	0-10+	0-11+	Yes/Yes	Human cons., industrial and discards
Whiting	IV, VIId	1- 8+	0-10+	Yes/Yes	Human cons., industrial and discards
Saithe	IIIa, IV, IV	1-10+	0-15+	Yes/(Yes)	includes IV and IIIa
North Sea Mackerel	no separate assessment		0-15+	Yes/No	Moved to "other predators" new age group 0-6+
Herring	IV, IIIa, VIId **	0-9+	0-9+	No/Yes	
Norway pout	IIIa, IV	0-4+	0-3	No/Yes	
Sandeel	IV	0-4+	0-4+	No/Yes	
Sprat	IV	biomass model	excluded	No/Yes	Included, age 0-4+
Plaice	IV	1-15+	0-15+	No/(Yes)	
Sole	IV	1-15+	0-15+	No/(Yes)	
Other predators			Size or age groups		
Grey gurnards			0-3	Yes	
West mackerel	VI, VII, VIIIa,b,d,e	1-15+	0-1	Yes	
Raja radiata			0-3	Yes	Size 0 and 1 combined into one
Grey seals			1	Yes	
Horse Mackerel		0-15+	excluded		Included, size groups 1-3+
Sea birds			1	Yes	
Other species			1	Yes	Excluded

* Prey (Yes) indicates very low predation mortality
** Herring catch data include all autumn spawners in ICES areas IV, IIIa and VIId

Table 2.2.b Catch at age and/or population number data: overview of data sources and conversion methods

year	Cod	Haddock	Saithe	Whiting	Plaice	Sole	Herring	Norway Po	Sandeel	Sprat	NS Macker	W. Macker	NS Horse	W. Horse	Gurnards	Raja radiat	sea birds
1960				SS+2	SS+2	SS+2											
1961				SS+2	SS+2	SS+2											
1962				SS+2	SS+2	SS+2											
1963	SS+2	SS+2	10	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+3	ICES+2+3	14	absent in N	9	absent in NS			17
1964	SS+2	SS+2	10	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+3	ICES+2+3	14	absent in N	9	absent in NS			17
1965	SS+2	SS+2	10	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+3	ICES+2+3	14	absent in N	9	absent in NS			17
1966	SS+2	SS+2	10	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+3	ICES+2+3	14	absent in N	9	absent in N	IBTS	IBTS	17
1967	SS+2	SS+2	SS+2	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+3	11+2	14	absent in N	9	absent in N	IBTS	IBTS	17
1968	SS+2	SS+2	SS+2	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+3	11+2	14	absent in N	9	absent in N	IBTS	IBTS	17
1969	SS+2	SS+2	SS+2	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+3	11+2	15	absent in N	9	absent in N	IBTS	IBTS	17
1970	SS+2	SS+2	SS+2	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+3	11+2	15	absent in N	9	absent in N	IBTS	IBTS	17
1971	SS+2	SS+2	SS+2	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+3	11+2	15	absent in N	9	absent in N	IBTS	IBTS	17
1972	SS+2	SS+2	SS+2	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+1	11+2	15	SS+5+6	9	absent in N	IBTS	IBTS	17
1973	SS+2	SS+2	SS+2	SS+2	SS+2	SS+2	ICES+2	SS+2	SS+1	11+2	15	SS+5+6	9	absent in N	IBTS	IBTS	17
1974	SS+2	SS+2	SS+2	SS+2	SS+2	SS+2	MS	SS+16	SS+1	11	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1975	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	11	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1976	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	11	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1977	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	11	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1978	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1979	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1980	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1981	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1982	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1983	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1984	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1985	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	MS	15	SS+5+6	9	absent in N	IBTS	IBTS	MS
1986	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	MS	4	SS+5+6	9	interpolated	IBTS	IBTS	MS
1987	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	4	SS+5+6	9	SS+5+7	IBTS	IBTS	18
1988	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	4	SS+5+6	9	SS+5+7	IBTS	IBTS	18
1989	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	4	SS+5+6	9	SS+5+7	IBTS	IBTS	18
1990	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	4	SS+5+6	9	SS+5+7	IBTS	IBTS	18
1991	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	4	SS+5+6	9	SS+5	IBTS	IBTS	18
1992	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	13	4	SS+5+6	9	SS+5	IBTS	IBTS	18
1993	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	13+Dk	4	SS+5+6	9	SS+5	IBTS	IBTS	18
1994	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	12	4	SS+5+6	9	SS+5	IBTS	IBTS	18
1995	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	MS	SS+16	SS+1	SS	4	SS+5+6	9	SS+5	IBTS	IBTS	18
1996	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	SS	SS+16	SS+1	SS	4	SS+5+6	9	SS+5	IBTS	IBTS	18
1997	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	SS	SS+16	SS+1	SS	4	SS+5+6	9	SS+5	IBTS	IBTS	18
1998	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	SS	SS+16	SS+1	SS	4	SS+5+6	9	SS+5	IBTS	IBTS	18
1999	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	SS	SS+16	SS+1	SS	4	SS+5+6	9	SS+5+8	IBTS	IBTS	18
2000	SS+1	SS+1	SS+1	SS+1	SS+1	SS+1	SS	SS+16	SS+1	SS	4	SS+5+6	9	SS+5+8	IBTS	IBTS	18

Legend for notes in Table 2.2.b.

SS	Single species working group report, most recent
MS	MAWG 1997
ICES	ICES data bases and/or Bulletin Statistique
IBTS	IBTS data base, annual trend derived from fitting a GLM of year, quarter, roundfish-area and gear
1	Annual data (or half-annual), split over quarters based on quarterly distribution given in MAWG report 1997
2	Annual data, split over quarters based on average quarterly distribution in later years
3	Age composition assumed equal to that in later years
4	Assumption: 100,000 tonnes in 2nd quarter
5	Annual data, split over quarters assuming a constant mortality throughout the year
6	Whole stock data, fraction in the North Sea taken from Iversen & Skagen (1999), ICES CM 1990/Assess:19 and ICES CM 1997/Assess:3
7	Whole stock data, fraction in the North Sea assumed equal to the 1991 situation
8	Whole stock data, fraction in the North Sea as in 1998, raised by the increase in catches in IVa in 1999
9	Assumed constant, at a value of 7 % of the 1982-1999 Western Horse Mackerel Stock
10	ICES CM 1978/G:3
11	ICES CM 1978/H:3
12	ICES CM 1999/ACFM:12
13	ICES CM 1994/Assess:13
14	Hamre (1978)
15	ICES CM 1987/Assess:11
16	Single species working group report, the Skagerrak catches subtracted
17	Assumed constant, at same value as in 1974
18	Trend reported in ICES CM 2002/C:04, interpolated
19	Number in 1974 given in Summers *et al*. (1978), extrapolated by 2 % increase per year before 1974 and 6 % later on
20	F. Larsen, pers. comm.

Table 2.3 Year range used for application of multi-species tuning.

Species	First year in MS-tuning
Cod	1963
Haddock	1963
Saithe	1973
Whiting	1963
Plaice	1963
Sole	1963
Herring	1963
Norway pout	1983
Sandeel	1976
Sprat	1974
Sole	1963
Plaice	1963

Table 2.4.2 Numbers of individual breeding birds for the nine MSVPA bird species as used by MAWG in 1997 (data from the mid-1980s) and the recent update by WGSE (ICES 2002c). Wintering numbers from WGSE (ICES 2001b).

	1980s	2000	annual % change	Wintering	Wintering/ Breeding 1980s
Fulmar	614914	592400	-0.26	3744000	6.32
Gannet	87556	127000	3.22	157800	1.24
European Shag	39608	8400	-5.63	29115	3.47
Herring Gull	474248	408200	-0.99	971700	2.38
Great black-backed Gull	48872	27820	-3.08	NA	
Black-Legged Kittiwake	830854	562140	-2.31	1032690	1.84
Common Guillemot	1360868	1150400	-1.10	1562400	1.36
Razorbill	146230	82800	-3.10	324000	3.91
Puffin	451914	428720	-0.37	74600	0.17
Total	4055064	3387880	-1.18	7896305	1.97

The Workshop had no new information to update quarterly consumption rates.

Table 2.4.5.1 Percentage of Western Stock mackerel in the North Sea area

	Age group											
	1				2				>2			
	quarter				quarter				quarter			
	1	2	3	4	1	2	3	4	1	2	3	4
year												
1972	0	0	0	0	0	0	0	0	0	0	20	5
1973	0	0	0	0	0	0	0	0	0	0	65	10
1974	0	0	0	0	0	0	0	0	0	0	30	5
1975	0	0	0	0	0	0	0	0	0	0	70	10
1976	0	0	0	0	0	0	0	0	0	0	15	5
1977	0	0	0	0	0	0	0	0	0	0	5	5
1978	0	0	0	0	0	0	0	0	0	0	10	5
1979	0	0	0	0	0	0	0	0	0	0	25	10
1980	0	0	0	0	0	0	0	0	10	5	40	25
1981	0	0	0	0	0	0	0	0	10	5	45	35
1982	0	5	10	10	5	5	10	10	10	5	45	35
1983	0	10	10	10	5	5	20	20	10	5	45	35
1984	0	15	25	25	5	5	30	30	10	5	45	35
1985	0	20	30	30	5	5	30	30	10	5	45	35
1986-00	0	20	30	30	10	10	50	70	10	5	50	70

Table 2.4.5.2 Percentage of North Sea mackerel stock in the North Sea area

	Age group											
	1				2				>2			
	quarter				quarter				quarter			
	1	2	3	4	1	2	3	4	1	2	3	4
year												
1963-71	70	70	80	85	70	70	80	85	30	100	100	80
1972-84	70	70	80	85	70	70	80	85	30	90	80	55
1985	95	95	80	90	95	95	80	90	45	80	80	65
1986-00	100	100	100	100	80	100	100	80	80	100	50	70

Table 2.4.6.1. Percentage of Western Horse mackerel stock in the North Sea area

	Age group							
	1-4				>4			
	quarter				quarter			
	1	2	3	4	1	2	3	4
year								
1963-85	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	5	10
1987	0	0	0	0	0	0	5	40
1988	0	0	0	0	0	0	5	40
1989	0	0	0	0	0	0	5	40
1990	0	0	0	0	0	0	5	40
1991	0	0	0	0	0	0	5	40
1992	0	0	0	0	0	0	10	55
1993	0	0	0	0	0	0	5	65
1994	0	0	0	0	0	0	5	65
1995	0	0	0	0	0	0	5	65
1996	0	0	0	0	1	0	0	10
1997	0	0	0	0	1	0	0	50
1998	0	0	0	0	1	0	0	10
1999	0	0	0	0	1	0	0	20
2000	0	0	0	0	1	0	0	5

Table 2.6.2. Mackerel Consumption rates (kg/individual) used in the 1997 and 2002 key runs.

1997 Key run

North Sea Mackerel

Age	Quarter 1	2	3	4
0	_	_	0.055	0.072
1	0.171	0.462	0.430	0.252
2	0.330	0.613	0.563	0.307
3	0.384	0.706	0.624	0.342
4	0.426	0.767	0.667	0.367
5	0.461	0.820	0.703	0.391
6	0.491	0.870	0.738	0.411
7	0.524	0.913	0.773	0.430
8	0.548	0.956	0.802	0.450
9	0.576	0.991	0.830	0.466
10	0.603	1.026	0.858	0.479
11	0.625	1.060	0.885	0.495
12	0.647	1.088	0.912	0.508
13	0.669	1.110	0.935	0.518
14	0.687	1.138	0.961	0.528
15+	0.708	1.154	0.983	0.536

Western stock Mackerel

Age	Quarter 1	2	3	4
0	0.244	0.532	0.491	0.277
1	0.461	0.820	0.706	0.391

2002 Key run

North Sea Mackerel

Age	Quarter 1	2	3	4
0	_	_	0.050	0.067
1	0.020	0.059	0.100	0.007
2	0.014	0.121	0.259	0.020
3	0.001	0.156	0.305	0.039
4	0.011	0.180	0.273	0.071
5	0.004	0.188	0.239	0.161
6+	0.039	0.240	0.264	0.177

Western stock Mackerel

Age	Quarter 1	2	3	4
0	0.017	0.087	0.170	0.012
1	0.014	0.191	0.270	0.112

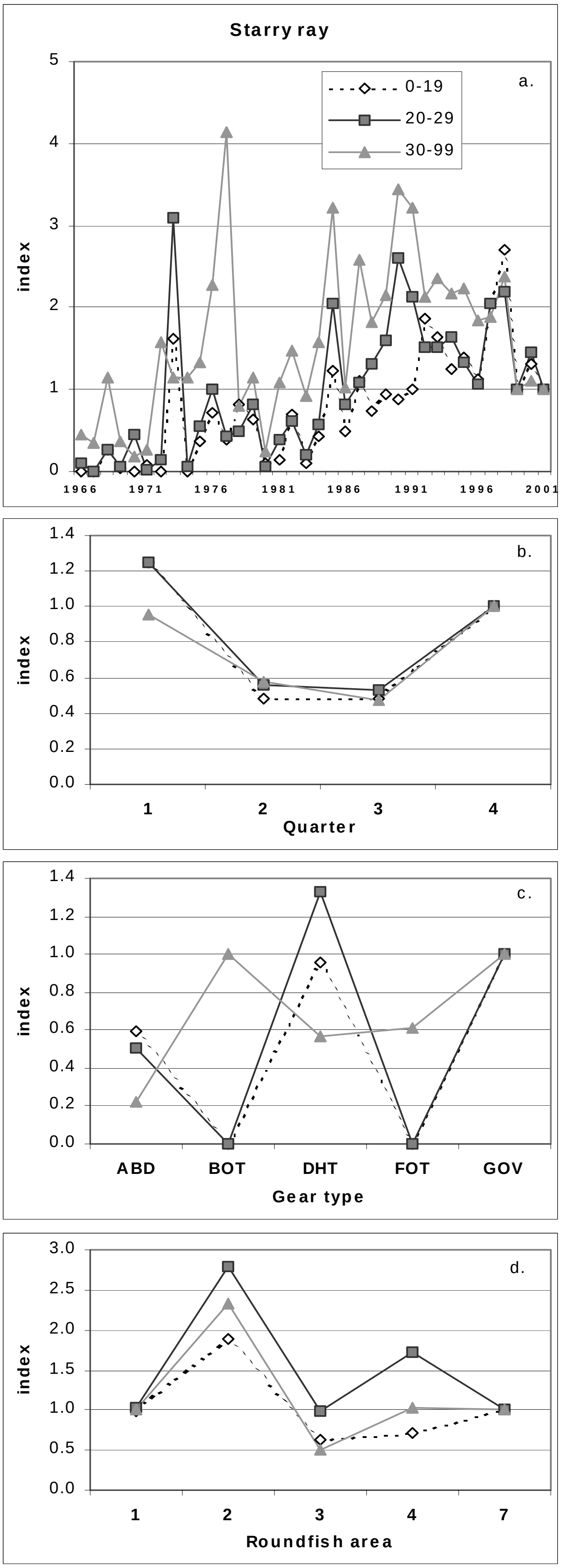


Figure 2.4.4.1. Parameter estimates for a GLM model with starry ray: a) annual indices, b) quarterly indices, c) gear type indices, and d) roundfish area indices.

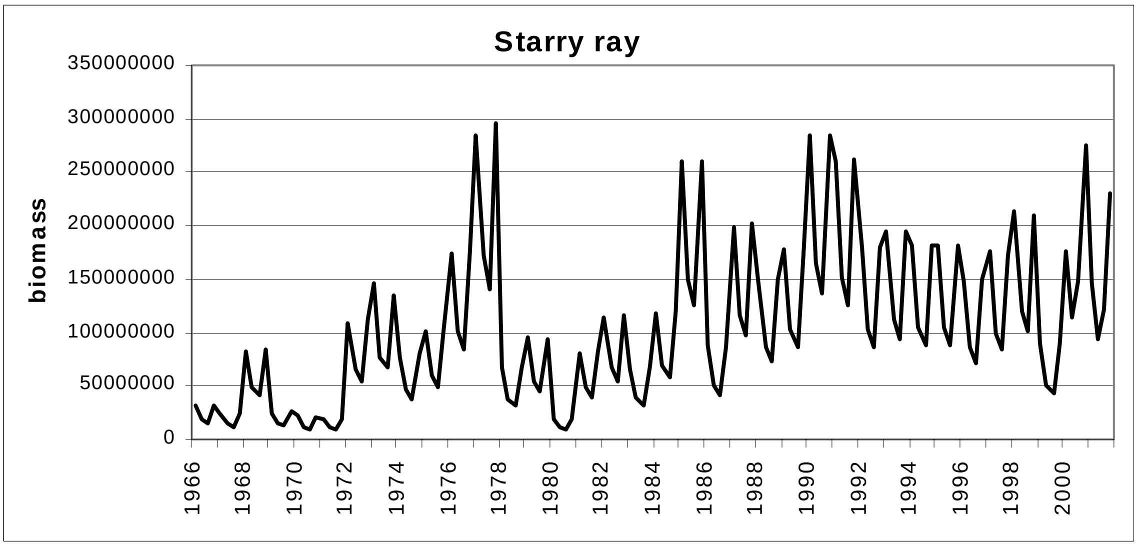


Figure 2.4.4.2. Time series of estimated total biomass of starry ray by year and quarter.

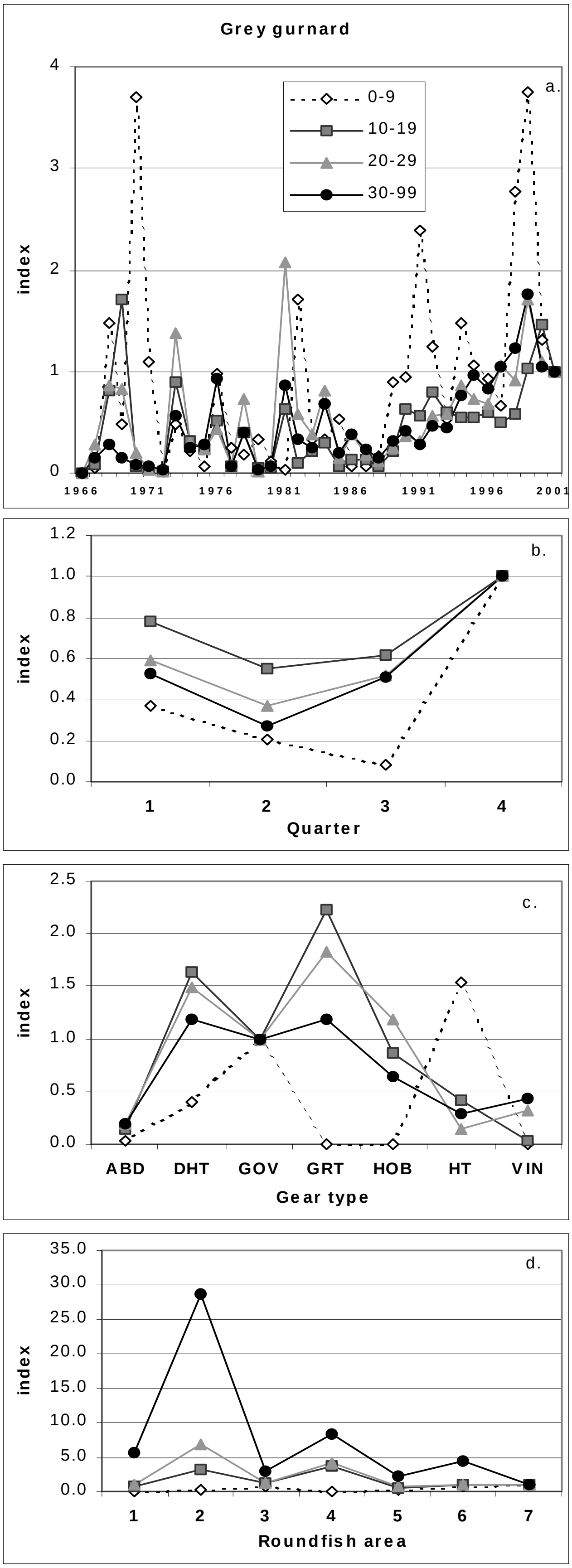


Figure 2.4.3.1. Parameter estimates for a GLM model with grey gurnard: a) annual indices, b) quarterly indices, c) gear type indices, and d) roundfish area indices.

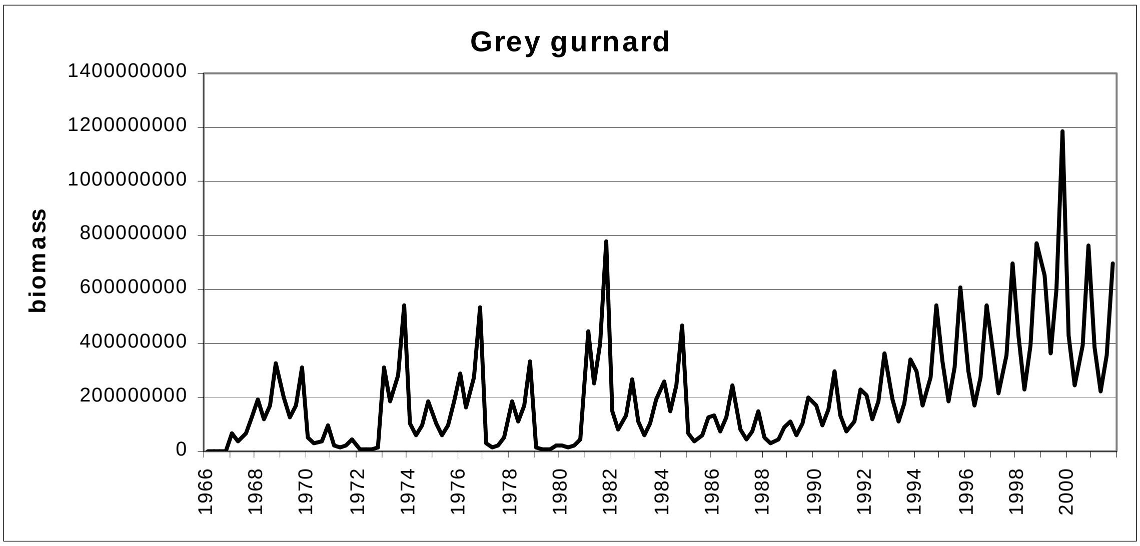


Figure 2.4.3.2. Time series of estimated total biomass of grey gurnard by year and quarter.

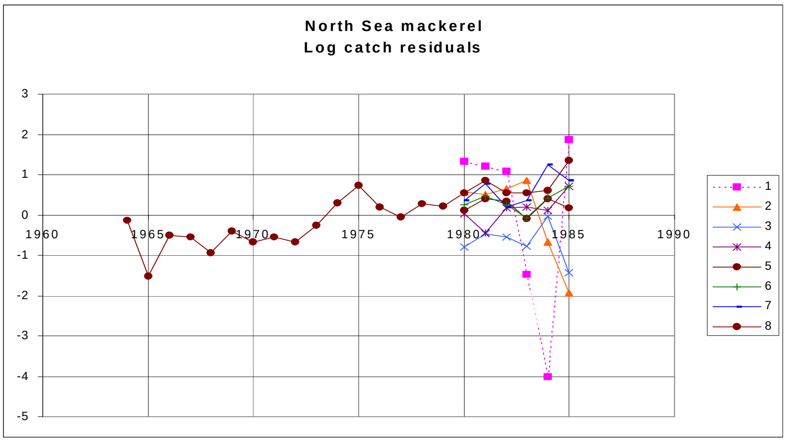


Figure 2.4.5.1. Catch residulas in assessment for North Sea mackerel.

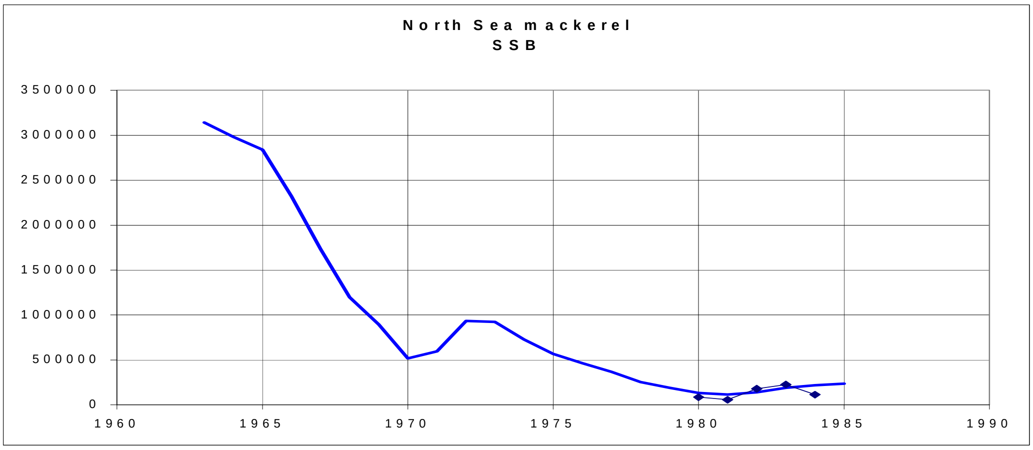


Figure 2.4.5.2. SSB for North Sea mackerel from the present assessment.

3 SET-UP FOR NORTH SEA 4M RUN

3.1 Key run

The MSVPA key run included 10 fish species for which catch-at-age data are available (cod, whiting, saithe, haddock, herring, sprat, Norway pout, sandeel, plaice, and sole), and seven other predators for which stock size at age or length are available (grey gurnards, grey seals, North Sea mackerel, raja radiata, sea birds, Western Mackerel, and horse Mackerel).

In contrast to the 1997 key run, horse mackerel and sprat were included in the 2002 key run. The workshop considered that the assessment of horse mackerel has improved, and that the inclusion of sprat as named prey species might serve to improve the estimation of prey abundance.

The input data and their sources are as described in Section 2 of this report. Detailed input datasets will be made available at the ICES web server at www.ices.dk.

The chosen options are documented in Table 3.1.

Table 3.1 Options used in the North Sea 4M key run

Options		
VPA mode		= multi-species
Weight in stomach		= use weight in stomachs
Plus group	Cod	= Yes, ICES
Plus group	Whiting	= Yes, ICES
Plus group	Saithe	= Yes, ICES
Plus group	Haddock	= Yes, ICES
Plus group	Herring	= Yes, ICES
Plus group	Sprat	= Yes, ICES
Plus group	Norway pout	= no
Plus group	Sandeel	= Yes, ICES
Plus group	Plaice	= Yes, ICES
Plus group	Sole	= Yes, ICES
Food model		= constant other food
Consumption		= Taken as input
Include VPA species	Cod	= yes
Include VPA species	Whiting	= yes
Include VPA species	Saithe	= yes
Include VPA species	Haddock	= yes
Include VPA species	Herring	= yes
Include VPA species	Sprat	= yes
Include VPA species	Norway pout	= yes
Include VPA species	Sandeel	= yes
Include VPA species	Plaice	= yes
Include VPA species	Sole	= yes
Incl other predator	Grey Gurnards	= yes
Incl other predator	Grey Seals	= yes
Incl other predator	NS. Mackerel	= yes
Incl other predator	Raja radiata	= yes
Incl other predator	Sea birds	= yes
Incl other predator	Horse Mackerel	= yes
Incl other predator	West Mackerel	= yes
Include as predator	Cod	= yes
Include as predator	Whiting	= yes
Include as predator	Saithe	= yes
Include as predator	Haddock	= yes
Include as predator	Grey Gurnards	= yes
Include as predator	Grey Seals	= yes
Include as predator	Horse Mackerel	= yes
Include as predator	NS. Mackerel	= yes
Include as predator	Raja radiata	= yes
Include as predator	Sea birds	= yes
Include as predator	West Mackerel	= yes
Include as prey	Cod	= yes
Include as prey	Whiting	= yes
Include as prey	Saithe	= no
Include as prey	Haddock	= yes
Include as prey	Herring	= yes
Include as prey	Sprat	= yes
Include as prey	Norway pout	= yes
Include as prey	Sandeel	= yes
Include as prey	Plaice	= no
Include as prey	Sole	= no
First and last VPA year		= 1963 to 2000
Year range stomach content		= 1981 to 1996

4 RESULTS AND DISCUSSION OF NORTH SEA KEY RUN

4.1 Key run output

Annual stock size, fishing mortality and predation mortality

Table 4.1.1 shows the output from the key run in terms of stock sizes in numbers-at-age (thousands), the annual fishing mortality F-at-age, and the annual predation mortality M2-at-age. The abundance estimates for the ages group 3+ did not differ substantially from the 1997 key run. For most species, the difference was below 10% and there were no systematic time trends evident. For Norway pout and sandeel, the deviations from the 1997 key run were higher which was due to the revision of the catch data and terminal fishing mortalities, and the relatively small number of age groups.

Partial predation mortality

Figure 4.1.1 presents the estimated trends in predation mortality for each prey species-age-group, separated by predator species. The data are documented in Table 4.1.2. Current estimates are in accordance with those of earlier MSVPA runs, with the exception of predation mortality on sandeel which is now estimated to be considerably lower. This is due to the lower consumption rate for mackerel applied in this run. The upward trend in the abundance of gurnards and seals in the previous data has continued in the current data set, leading to rising estimates of predation mortality on 0-group cod and whiting (gurnards) and 3+ cod and whiting (seals). The decline in the cod stock results in gradually lowering estimated partial predation mortality in almost all prey species.

In Figure 4.1.2, the quarterly pattern of predation mortalities are presented for each prey species-age-group, split out by predator species, averaged over all years analysed. In contrast to the quarterly-average trend over the years, the year-average trends over the quarters shows rather large fluctuations, e.g. saithe exerting a high predation mortality on 1-group haddock in the 1st and 3rd quarter, switching to Norway pout and cod in the 2nd quarter. It seems likely that this is mostly due to limitations of the stomach sampling. However, because of the accumulating character of cohort analysis models, most of these data shortages will have been straightened out in the analysis of trends over the years. Consistent patterns are found in the predation on sandeel, showing considerably higher mortality in the 2nd quarter from age 1 onwards. Cannibalism in whiting occurs in four consecutive quarters from the 3rd quarter of age 0 onwards.

Predator-prey relationship

Figure 4.1.3 shows the important predator-prey relationships by identifying the percentage contribution of the various predator to the average predation mortality experienced by each prey age-class over all years and quarters.

The estimated predation mortality on 5 and 6 year-old cod appears to have increased in recent years to 0.08 and 0.17, respectively. This mortality is accounted for entirely by grey seals, which are assumed to increase by 6% per year. Although it is not unlikely that grey seals consume a substantial quantity of cod, the distribution of the predation mortality over the age groups is unrealistic. The original food composition data assign a higher proportion of the diet to age 6 cod than age 5 cod, suggesting that this age-class is factually a plus-group. In the MSVPA, however, it has not been used as a plus-group, which might explain the unrealistic pattern. This problem has to be looked into at a later stage, but for the time being it seems prudent not to accept the high predation mortalities on age 6.

For herring, estimates of recruitment may be misleading because most of the catch at the younger ages is take outside the North Sea.

The data range in the current MSVPA has been extended back in time by ten years to 1963, in comparison to previous runs. Comparison of the 1960s to later years shows high predation mortalities on sandeel and sprat due to the high abundance of gadoids, especially in the 1-group and older. Additionally, the high saithe abundance in the early 1970s generates a high estimate of the predation mortality on 1-group haddock and Norway pout. The North Sea mackerel abundance in the mid-1960s leads to somewhat higher predation mortality estimates for sprat and considerably higher estimates for sandeel, especially for the 1-group and older.

Summary and comment

An output summary by species is given in Table 4.1.3. The data are visualized in Figure 4.1.4. Detailed output datasets, as well as the input data, will be made available at the ICES web server at www.ices.dk. Averages of the annual predation mortalities (summed over predators) by species and age are documented in Tables 4.1.4 (for the period 1963-2000) and 4.1.5 (for the period 1995-2000).

Table 4.1.6 gives a time series of the gross properties of the key run. Totals of consumption are for the entire year, while the average stock biomass of other predators is the average across quarters due to the large seasonal fluctuations in stock sizes.

With the exception of VPA yield and VPA SSB, all the series undergo a period of decline followed by an increase. *Other predator biomass* dropped rapidly to the late 1970s following the decline of the mackerel and horse mackerel stocks, but has been increasing since. The consumption series and VPA total biomass all decreased until the early 1990s since when they have increased slightly. Thus the ratio of *Other food* to *VPA food* has remained fairly constant through time. VPA yield and VPA SSB have steadily declined over the entire period. This decoupling from the predation trends is a product of the fishery targeting older fish that are less prone to predation effects.

There is considerable uncertainty about the present estimates of predation mortality and stock abundance at age 0.

In the MSVPA, the stock numbers-at-age are basically generated as the amount needed to account for subsequent catches and consumption for the year-class, taking the additional residual mortality into account. At the youngest ages, the predation generally will dominate the loss, while the fishery takes over at the older ages. The estimates of predation mortality on age 0 may suffer from such discrepancy, sometimes leading to strange results. As an example, cod was considered in more detail.

According to the stomach data, gurnards prey on 0-group gadoids, and are responsible for about 60% of the predation mortality on cod of that age. The amount of 0-group cod needed to cover that consumption can in some years be high compared to the recruitment at age 1 derived mainly from the catches and the consumption by other predators. Thus, one may get the impression that the recruitment at age 0 is a function of the amount of gurnards, while the recruitment at age 1 reflects how the year-class has showed up in the fishery and in surveys used for tuning.

The Figure 4.1.5 illustrates this problem. Recruitment estimated at age 0 is significantly and positively correlated with the abundance of gurnards (here represented by the biomass in the 4^{th} quarter for convenience), and not correlated with the SSB. In contrast, recruitment at age 1 is weakly but negatively correlated with the amount of gurnards, as one would expect if the gurnards remove a considerable part of the 0-group, and positively correlated with the SSB. Recruitment at ages 0 and 1 are poorly correlated. Although gurnards appear to have an impact on the recruitment of cod, their quantitative influence is not well represented by the model.

Table 4.1.1 Stock numbers ('000') at age - Species Cod

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	168136	375974	494884	655884	673307	245751	297623	1134826	1102359	200792
2	117034	84399	174238	192674	240992	225687	95325	109148	338496	389524
3	24762	48809	40693	72039	71531	91445	80256	40651	36135	89018
4	10058	13186	20890	15913	28887	25775	33073	32577	14037	12447
5	7829	5226	7142	9135	7615	13773	10308	14960	14794	5589
6	2870	4063	2682	3786	4563	3427	6033	4480	6763	5999
7	552	1319	1801	1361	1973	2026	1568	2408	2106	3165
8	905	387	599	927	716	874	929	789	1160	977
9	49	342	222	241	449	288	455	404	469	565
10	15	29	205	139	92	253	109	249	174	193
11	3	10	22	206	39	54	184	102	212	30

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	423978	284342	447644	208629	830501	520801	566503	1064635	441781	704066
2	81448	133844	104434	185208	94623	305997	190607	196306	355868	121388
3	107619	26064	36735	33050	50161	26251	76016	55903	51927	86734
4	27059	34339	9571	12557	10979	17625	8508	21932	16454	14366
5	5218	9977	14208	3968	4790	5211	6818	3873	8566	6470
6	2221	2375	4162	5517	1846	2067	1753	2729	1723	3561
7	2134	859	1085	1710	2015	814	834	800	1143	722
8	1179	866	332	534	674	753	350	360	297	454
9	284	557	375	116	334	255	294	172	128	129
10	135	166	175	129	43	64	88	112	78	50
11	380	389	117	87	162	78	36	51	45	29

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	327438	588312	129582	648050	250326	166154	248883	117434	134545	248599
2	225715	112149	213269	49862	215052	99433	58371	98972	45135	57153
3	29938	50131	28832	53730	15193	61411	26667	16946	29163	15116
4	19240	6984	13794	7782	14417	4891	14170	7181	5079	8479
5	5107	6466	2556	5003	2886	4612	1753	4305	2418	1943
6	2402	1886	2453	1033	1755	1114	1658	688	1709	894
7	1179	868	671	944	365	545	378	514	310	506
8	279	467	349	257	338	116	203	116	201	90
9	180	102	178	139	80	112	43	56	62	59
10	44	84	34	80	61	25	46	16	7	28
11	36	37	60	43	21	34	18	6	15	15

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	115780	270310	186933	138727	354596	50343	121318	190848
2	107246	55395	123413	82666	61472	162297	23800	52987
3	18430	36587	21244	40398	31015	23759	54185	10398
4	4882	5360	9780	6126	10978	8256	5859	13040
5	2763	1661	1777	3505	2436	3551	2284	1722
6	819	959	624	743	1294	915	895	726
7	302	310	300	250	245	389	288	216
8	171	85	139	120	82	65	124	63
9	33	57	23	78	23	29	25	31
10	17	12	21	7	26	7	13	7
11	22	28	11	10	15	24	2	1

Stock numbers ('000') at age - Species Haddock

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	11759250	181657	1016849	2899659	6023202	32235600	3169484	2139844	12837730	14696550
2	676536	4007463	52782	54714	162058	1158298	8944408	419443	172299	1234415
3	47224	216444	1838240	24667	16585	37104	458016	3202102	97993	61090
4	27209	19006	52690	863600	13369	8457	11830	91234	783198	33730
5	11019	10204	7127	15677	312610	7183	4894	2635	20098	254213
6	1386	3673	3392	1578	3676	91520	3449	1742	1032	6728
7	1253	670	838	982	341	784	32724	545	325	411
8	1136	452	296	288	274	90	356	9911	220	96
9	120	428	160	147	89	32	37	113	2806	50
10	37	46	72	41	52	12	10	50	297	774

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	5660438	12509300	15075750	1643930	1597495	3053684	4167434	7260822	2293980	3020440
2	1555818	337180	1161696	2122692	184961	256196	387419	736533	1337469	280038
3	390396	604153	90435	301208	645353	47217	64922	108952	254191	585210
4	12604	95525	179672	19813	59182	177324	12022	15722	26146	77851
5	8098	4509	27613	46780	7196	13300	47149	3289	4008	7896
6	64235	2516	1905	8059	10397	2062	3415	13510	1005	1453
7	2277	17128	829	656	2228	3071	590	843	4195	467
8	170	771	4539	139	359	716	817	265	199	1255
9	49	45	421	1366	49	178	254	259	117	53
10	281	79	129	114	343	145	129	192	111	50

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	2037460	4720246	1593623	1677355	3608748	389709	644373	768549	2019426	1782888
2	583662	373067	1298804	309937	456317	978981	75279	164514	154374	519145
3	124831	209096	137139	497460	78930	131489	312145	27448	37963	51249
4	202637	35187	61198	41549	113188	21841	27799	92015	6935	10848
5	25786	51161	9269	16620	9564	31412	5910	7028	24673	2555
6	3315	6136	12143	2626	4602	3234	8155	2319	2211	7912
7	547	1182	1669	3344	1031	1166	1232	2989	1105	947
8	142	197	449	531	1170	370	403	576	1301	562
9	342	65	92	180	227	255	164	155	301	531
10	120	235	201	234	257	184	108	137	134	282

Table 4.1.1 (Continued)

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	2717676	886103	3447470	1066163	1666691	1817835	1387304	7985154
2	511915	740606	230648	1075245	246489	390814	237119	151617
3	183804	167328	302839	101801	498594	112841	153665	72585
4	13418	51439	44880	94533	31706	207249	46415	45633
5	3205	4616	15308	13476	27520	12125	69413	15276
6	902	942	1712	4625	3389	6791	3623	15685
7	2085	330	235	905	984	1054	2171	833
8	386	707	101	83	95	222	436	365
9	201	191	126	44	22	26	58	53
10	406	148	73	60	42	26	15	28

Stock numbers ('000') at age - Species Herring

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	15136340	15570140	22157630	11915610	8572869	16370630	13793340	7192866	13625400	10590110
2	15205860	6820489	5846108	8595235	5084333	3508454	5608033	4943097	3047509	4210000
3	925937	8222926	3208225	1910518	3268500	2185406	667916	1681667	1278730	884438
4	986632	585388	4422896	1238135	723863	1105005	272894	200412	356591	294243
5	756012	695096	357516	1824734	607418	254372	344851	100515	47295	97124
6	1659792	555225	439648	163773	691899	231343	67360	108488	36164	14113
7	101360	1211177	367973	221090	93081	219644	62729	8462	30438	2391
8	172627	70323	851150	220657	138170	19424	42808	16004	128	1982
9	209518	154163	161402	545478	292191	129923	39154	16239	15896	719

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	6485889	2756292	6016829	928620	917371	1583958	1799687	4873216	5350453	7825073
2	3297349	1657480	983077	1656110	411672	385946	673529	749138	1891296	2016665
3	1253677	777887	408147	202388	300846	229883	240315	386432	356010	785726
4	289172	234447	215290	72183	42829	75014	162464	165621	202962	199626
5	115179	93433	75213	49554	12101	25917	57183	124949	107102	128059
6	47879	39551	25406	10890	9402	3851	20737	44681	80865	58872
7	7035	10127	11245	6189	3173	4329	2985	17075	34112	43357
8	1972	2833	4317	1560	1395	1499	3734	1914	14087	12444
9	843	1497	1717	569	2	7	622	478	2872	3804

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	12172460	11107830	10229890	20485380	26445160	14226620	11047480	8169266	7810832	5603966
2	3201762	5690100	5760888	4857884	9750335	11051990	5783236	3691193	2872796	3355783
3	1036544	1565940	3032272	2684708	2223747	4442290	5066926	3017901	1791159	1295723
4	362803	561944	834385	1258519	1285161	1063512	2257385	2714282	1689395	909088
5	131981	201601	294006	361158	629929	625395	521511	1128404	1501352	920055
6	89261	83203	94292	129076	180989	290121	279156	225564	581108	785839
7	42132	52983	50974	39390	54698	84814	129948	116299	117550	312363
8	31673	25886	24892	27228	16415	26712	40952	56761	53059	69263
9	33614	43492	30015	29346	16635	14245	16905	23324	26741	42926

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	8843557	7467076	5805314	6631977	12345520	6179933	5355784	3629169
2	2684779	4378236	4319764	3250998	3636215	7933596	3668264	3282280
3	1524209	1203747	1831392	1833055	1670445	2127549	4319265	1973005
4	656390	652175	471740	652525	814116	858718	1071021	2170946
5	459278	269393	223470	168213	354969	444436	447271	611962
6	445852	179901	117003	73821	82879	206953	207985	243256
7	341400	177420	65281	48321	43458	47603	93888	105334
8	143328	130563	88067	19699	33059	28878	27829	59985
9	68857	84232	82396	45800	31987	26066	10806	8943

Stock numbers ('000') at age - Species Norway pout

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	21403300	30667600	49130430	64988870	47386610	71481250	133768600	178184500	163631800	160340700
2	4267387	3945953	5626756	8098681	10409810	7164840	5649637	10107710	11471630	11309580
3	2906914	1426589	1179218	1601950	2083640	2527812	618137	814075	1022698	1052570

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	65872230	119755200	85245330	143651100	92961510	42639270	66201950	86897540	37806530	107617600
2	11481760	2761403	7057511	6690141	9151624	8562304	4696062	9395222	11405690	2683625
3	734742	1008126	42941	572595	363436	1074031	782333	301818	626418	843991

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	82376210	66804100	49206470	42476180	55648950	12978280	28924200	31618600	29502820	52699790
2	10649960	10610640	6557063	3037178	2776325	4172386	1599044	3292678	3829550	4064152
3	120250	833605	541505	340840	82850	142762	317137	152842	282706	307164

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	31609290	19973430	101081500	41033280	89829660	36095220	32738230	84773210
2	7369610	3637745	1820689	12772130	3729436	10426220	3444088	3870780
3	407188	646398	238371	274128	1477171	404106	1385276	250235

Table 4.1.1 (Cont'd)

Stock numbers ('000') at age - Species Plaice

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	313532	1016556	307948	303774	275772	244221	325759	368484	274029	233354
2	286952	283695	919817	278643	274866	249529	220980	294756	333346	247934
3	290669	255537	242778	822955	248205	243048	216817	185739	250339	273620
4	262815	242689	192907	179738	683117	195906	181405	153424	119640	180827
5	192632	165014	158338	124220	113914	511254	141171	129996	85692	76579
6	94382	122859	94992	101943	77703	63917	345624	94064	79127	52880
7	48800	55312	76071	57422	66343	49441	41617	216204	51926	49925
8	27694	31998	35079	51457	36345	44723	34950	27806	120988	30981
9	30463	18592	22712	23647	36355	25312	30908	25865	19188	81342
10	19184	20896	13057	16564	15277	26529	19189	20215	19443	11293
11	14050	13703	15307	8015	11831	10942	19376	13824	13770	13238
12	10869	9315	9497	11194	5508	8781	7749	13027	10425	9264
13	9222	7831	6625	6492	7714	4068	6473	5312	9071	7339
14	6897	6368	5649	4344	4337	5747	3106	4699	3719	6400
15	15249	25929	23059	19115	16857	17298	17108	14515	15528	14728

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	539029	449541	333958	322870	469295	428415	442839	658130	424470	1027280
2	209034	486533	404657	301249	289476	421589	386564	399450	594574	383837
3	189772	159111	418353	339533	240743	208018	324142	294861	300017	442483
4	188723	115792	91410	320225	233744	176868	129232	180829	140268	155756
5	113557	101632	64915	53131	198536	149036	108618	70607	90274	72418
6	47488	62770	53097	34687	35037	100447	87446	52976	40258	47863
7	31764	29894	38188	27997	22014	23052	57289	41345	30920	24680
8	31567	20333	19475	23319	16704	14325	15237	28914	24389	18928
9	17717	19245	12417	12017	15053	10362	9790	9850	18159	14412
10	56014	10274	12144	7350	8085	9777	7087	6202	7148	11819
11	6937	37598	5577	7831	4739	5492	6788	4205	4357	5138
12	9290	4687	24446	3399	5088	3057	3886	4392	2904	2904
13	5981	6518	2695	14611	2213	3320	2196	2463	2864	1842
14	5171	3977	4302	1417	8983	1540	2352	1318	1818	1838
15	13750	10788	12623	9657	7167	11786	8581	5611	5075	7110

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	593263	611016	536078	1258151	539992	563243	413469	402433	394476	395929
2	926365	535658	552768	484949	1136838	488605	509644	372929	362647	355549
3	302097	724937	424824	430559	375276	948094	427774	416895	306500	287237
4	202636	164507	396501	247844	234682	229848	620667	286828	285267	199326
5	75137	89619	98183	183549	135507	107107	137638	342644	154777	149598
6	38414	40209	45641	58069	86157	61345	52087	74479	158591	71529
7	27482	22547	23456	26590	29789	45100	31768	28919	41982	69709
8	15150	17093	14283	14722	15261	16119	24937	18746	18208	23782
9	11950	9741	10220	9470	9073	9701	9493	15409	12798	11315
10	8799	7962	6240	6694	5983	6171	5786	6584	10435	8521
11	7187	5173	5228	4186	4140	3764	4003	3634	4846	7024
12	3575	4475	3444	3756	2673	2769	2524	2744	2561	3402
13	1954	2082	2967	2104	2373	1791	1623	1688	2023	1687
14	1123	1218	1453	1997	1141	1647	1143	1047	1220	1457
15	3434	4961	4141	3905	4681	5352	5427	5444	4756	3828

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	272871	232108	309743	238548	796103	246030	232163	359122
2	355126	243789	208752	273415	214902	719737	222445	209573
3	281692	272981	180103	156598	210904	161203	624265	193259
4	181733	165683	155042	89993	86185	114087	84552	423126
5	113331	97300	76265	68447	40290	33631	52302	39998
6	67692	54271	50818	35294	31538	15337	14745	24840
7	33111	33217	29147	28138	17864	13804	7387	6672
8	34341	17006	15264	16351	14666	8439	7265	3677
9	14704	19132	9150	9070	9748	7270	4927	3957
10	7000	9434	11553	5754	5102	6019	4393	2675
11	5372	4236	5959	8411	3348	3306	4138	2532
12	4682	3367	2767	4150	5991	2296	2340	2913
13	2137	3131	2277	1909	2942	4358	1553	1600
14	939	1117	2109	1712	1250	2124	3212	1069
15	4009	2483	4994	6198	4271	9401	7117	3335

Stock numbers ('000') at age - Species Saithe

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	201584	152172	186697	149895	428830	398623	464672	233540	227306	240278
2	58667	165042	124587	152854	122723	351096	326208	380409	190993	185560
3	43936	47243	126794	101936	113298	92697	283988	265461	309411	146504
4	17453	34743	30149	91281	72973	78813	56919	206717	185944	190870
5	12443	9918	23400	12656	50001	47652	47349	34756	101863	103867
6	6636	6023	4066	12096	6445	28740	28261	30190	16622	55729
7	2273	4565	3495	2207	6720	3466	18724	16819	14463	10361
8	6260	1606	3083	2427	1166	4497	2591	10777	10552	8510
9	1795	5039	911	2417	1746	777	3579	1514	7411	6444
10	584	1337	788	1248	1206	708	510	777	2488	5927

Table 4.1.1 (Cont'd)

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	273252	647435	197472	140643	126489	103608	266927	161145	192293	317261
2	196377	219694	526526	161375	114922	101599	83643	217671	130718	152865
3	133434	132140	165351	365378	103211	82075	68088	53205	156906	90468
4	83293	66005	53200	88920	117138	63781	38752	42723	30660	108016
5	99797	38321	25841	22438	26650	48208	29623	20055	24663	19330
6	64308	59309	20480	13013	9270	9801	24528	15305	9047	14633
7	27145	39102	30512	10700	5975	3285	5703	12936	7227	4504
8	5521	15182	19672	13873	5754	2049	1952	2469	6092	3265
9	4498	3026	8558	8508	6986	2011	999	1081	1185	2167
10	7427	3352	6055	6018	7479	7177	3809	3829	4330	2033

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	477673	394763	153298	179848	97730	169765	198097	139527	217877	151931
2	257967	390829	323151	125312	147161	79314	138982	158938	113981	178055
3	98777	182079	287392	257937	96716	94973	60196	105250	126202	82512
4	48931	59688	80178	118113	166225	52965	53309	35798	54021	63906
5	52884	23698	21710	18277	21162	55296	22760	21114	15021	20344
6	8815	20652	8632	7254	4719	6503	16239	8807	8324	6745
7	7279	2904	5928	3942	2401	2271	2881	4827	3771	4231
8	2155	2112	1170	2755	1896	1050	974	1323	1969	1969
9	1622	574	738	520	1400	845	505	376	633	992
10	1420	997	1298	1108	1038	660	588	522	546	700

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	336536	159246	262929	131857	128961	186871	195491	195000
2	124108	275396	130289	215171	107639	105563	152951	160000
3	140440	94560	219189	103967	169053	76734	84342	120000
4	52403	82754	62315	156182	75998	127616	54335	61215
5	25120	26697	34302	28470	93154	46469	77424	32427
6	6328	11209	11235	15669	13354	50344	23877	40549
7	3039	2735	5713	6263	6473	7844	27739	12561
8	2178	1252	1505	1801	2567	3001	4588	14454
9	1033	553	773	720	841	1218	1483	1863
10	1277	1013	1031	1561	801	562	1113	1270

Stock numbers ('000') at age - Species Sandeel

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	172033800	168572900	171004200	131880700	107706200	228535800	107909500	68600630	225760700	107957900
2	40245930	47858100	45659900	46847110	42247030	33764700	53043780	19416250	13609700	75629340
3	16252250	12553680	15776840	14385520	17081390	16967840	12012050	21158520	5871890	4351386
4	6218106	4818524	6096226	5546728	6748467	6808613	4770809	8418094	2350679	3870325

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	230005100	123715300	228553000	118224400	214390500	304351700	191699700	250593000	107996800	382106900
2	26733050	51596220	27998260	63828000	25916310	54652850	69081250	52743710	53780820	19589680
3	28267350	10448100	24807470	8830018	21301220	7861914	15387260	17885680	11704040	13121260
4	2944296	13793580	10084310	5557616	6111807	4334339	6286631	4107707	4428733	6027796

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	75038050	302242100	94692900	503146200	216013800	92289000	294902800	128614900	233917600	265760300
2	120137300	24472060	72007550	28075360	159227500	56258290	24811850	44143020	23702620	53482010
3	4511905	38113890	10382210	7948183	7997329	56510510	6327937	7517606	7888527	4819454
4	1053713	1243388	1706666	175040	1621112	7052015	4811673	2076683	2395370	2566922

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	108965200	244470800	273977900	121696200	608386500	125539800	138469000	306687700
2	69594470	31797300	70437540	68394470	33191010	191229300	30959020	28137840
3	19029340	25595340	9968957	29924590	18503560	13127800	53410370	9085005
4	6158187	7816795	4717870	9096647	4336191	5998208	5329951	12400520

Stock numbers ('000') at age - Species Sole

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	10284	551462	120842	40963	74932	99567	50320	140755	41715	76551
2	11698	9306	498932	109343	37065	67801	89110	45156	126131	37347
3	44556	9945	8273	406878	87318	30049	45122	57994	35049	82552
4	22078	32424	6999	6455	241728	54706	14043	20534	27883	18065
5	134923	11882	23933	4820	4904	138178	25873	7667	10788	13160
6	22267	78368	7147	16922	3244	2589	79071	11691	5249	5518
7	23489	12115	54504	4119	11821	2428	1905	47759	7521	3385
8	6970	14954	8004	37489	3022	8880	1965	1410	31897	4603
9	11536	4014	11818	5769	27937	2016	6479	1547	1043	22035
10	5739	7228	2858	9250	4555	20502	1517	4736	1267	762
11	2895	3711	5715	2218	7644	3613	14381	1099	3636	927
12	2884	1672	2889	4578	1735	6339	3029	10210	835	2509
13	4046	1886	1307	2165	3694	1139	4960	2465	6952	480
14	1258	1979	1258	878	1845	3013	953	3979	2005	4953
15	8717	3658	7521	7230	4564	4292	6581	7814	5878	5630

Table 4.1.1 (Cont'd)

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	105872	110248	41706	113668	139908	46827	11775	154320	148863	152630
2	68927	95131	99661	37487	101865	124940	42346	10646	139032	134296
3	26607	50796	71524	68456	30568	71043	89364	30576	8489	98153
4	39918	11981	25582	37719	35481	16236	36568	41909	15829	4597
5	9652	20804	5650	12062	20870	17624	8892	17893	21097	7827
6	7210	4925	12143	3136	6355	11845	9665	5211	9286	11309
7	3512	4325	2638	7363	1924	4067	6696	5696	3343	4939
8	2568	2237	2413	1639	4856	1439	2035	4406	3075	2128
9	2999	1600	1402	1325	963	3341	724	1070	2653	1944
10	15485	1562	1068	788	797	629	2412	427	620	1676
11	576	10853	837	745	519	522	388	1811	335	375
12	744	312	7584	518	489	382	250	206	1246	202
13	1804	392	184	5060	344	327	229	115	137	976
14	322	1160	325	143	3329	209	196	110	55	37
15	3882	5332	3656	2839	2849	2710	1847	2063	872	975

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	143826	71611	81872	160429	72401	444278	109369	180702	74115	353421
2	135588	129771	64616	73924	144809	65422	401990	98853	162688	66947
3	96500	90126	88339	42741	58040	103569	46717	320101	77765	134368
4	45533	48161	39987	39050	21176	31652	49114	25053	190851	46176
5	2416	21153	22239	16990	18585	10728	14214	23089	13435	99595
6	3737	1596	10822	11226	8046	10652	5544	8417	12051	5888
7	5702	2078	743	6428	4934	4327	5957	3414	4310	7302
8	2881	3314	1072	474	3666	2979	2445	4014	1998	2171
9	1343	1681	2012	611	325	2460	1845	1593	2434	1088
10	1187	850	1025	1218	286	217	1728	1229	875	1505
11	1018	789	540	738	515	161	161	1336	860	485
12	198	520	516	307	332	309	114	103	905	468
13	113	150	333	288	114	163	198	69	38	454
14	692	89	107	212	141	43	108	133	36	17
15	900	902	872	617	418	487	381	454	382	649

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	70664	58653	100014	52650	280562	137706	88331	96000
2	318835	63888	52445	85850	47476	252313	124365	79658
3	53930	239821	50319	35051	59711	37119	173744	97591
4	79526	32598	133978	29387	16343	31644	19028	88787
5	26434	42161	16360	56601	10718	7867	14311	9255
6	54139	10772	20397	8521	25497	4875	3743	7106
7	2996	26332	4343	10885	4001	11043	2507	2176
8	3694	1305	13234	2001	5306	2434	5444	1588
9	1217	2182	744	6300	891	2606	1376	2992
10	575	639	1108	395	2585	477	1349	882
11	902	338	314	674	132	990	199	741
12	273	526	224	223	330	89	501	132
13	203	144	270	131	57	187	38	279
14	284	103	50	198	68	31	112	26
15	266	569	378	327	181	208	202	85

Stock numbers ('000') at age - Species Sprat

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	231244700	228334600	151828700	189188100	217363100	187345300	105890300	67200050	127109000	154906400
2	50981580	50427300	61932540	37314190	54557030	70921330	39890910	30632670	25913300	55760460
3	13757870	13507960	12949610	16927850	9901983	18899750	19958950	12633990	13197660	10835610
4	1231059	1250643	1207679	1628677	892746	1673901	5400717	5439484	6771344	4884571

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	330986500	377570100	194556100	355845900	166947500	152524100	225546400	120969200	83631100	34993840
2	53919370	97865260	157430700	54385710	111527900	51581730	28684590	42048160	17753170	13250480
3	19921930	17875900	36087410	47674890	13461140	31166410	12385870	4935219	4168529	1696604
4	5303239	4290527	2594266	2976622	1332012	4015164	857899	512408	120314	387276

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	16869570	60234970	15191190	16042530	43570370	24285360	56612640	29331730	34315490	56795510
2	6378351	2437499	18877250	4588164	5709558	14733080	6992729	13294590	7229973	10782310
3	1828363	1132138	375108	6021973	1498774	339262	1193979	458243	3181248	1892263
4	148606	170936	118229	134632	43291	28081	432	45104	812350	255470

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	65638690	154539700	55524770	19519500	36313490	42254080	70031490	59624520
2	16675780	19375260	44438350	12505370	7387305	14610510	12741880	16039770
3	3206138	4222711	6557236	10593470	2378870	2653968	3470362	4234267
4	245971	309242	221313	1328521	848515	224867	644623	1659044

Stock numbers ('000') at age - Species Whiting

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	5965540	1637206	3689979	3428260	5426281	10763130	1565374	2225085	3251631	6090760
2	1503942	2169543	487746	930239	700996	1233108	3305579	200365	350393	838023
3	191253	428798	1134200	188059	284049	241736	362338	1171966	53648	129828
4	80369	61753	173695	522609	51772	92355	79415	118156	313131	21576
5	17709	22084	25828	62527	152896	15944	25316	30910	37538	114267
6	3029	5424	7177	11815	13467	52179	5432	7122	12072	15337
7	15	868	1747	2278	1542	3343	13196	2463	2049	6666
8	238	110	306	705	297	218	1529	3070	1761	1928

Table 4.1.1 (Cont'd)

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	9085718	3507251	6887803	5887948	4636748	6006854	6117927	6050506	4664550	2350674
2	1621242	2146727	907942	2196219	1491339	1138673	1522489	1504675	1699024	549058
3	255564	433188	563149	269689	567678	584252	475576	593240	617819	737029
4	52525	63162	108252	152883	58268	176464	228471	166683	192606	215889
5	8792	20159	16684	31948	41488	16587	57288	84631	47834	55035
6	33573	1594	9921	4515	10639	12426	5813	18199	18566	12556
7	4315	9249	164	836	964	3304	3185	1762	4750	3953
8	930	661	2113	971	770	524	595	1276	539	945

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	2143991	3213309	2207457	4308490	3527780	2933427	5358307	3109232	2033292	2043274
2	591730	488136	752990	580156	1097128	1062672	580848	1445947	569986	582472
3	255739	235445	186888	375379	248376	448227	448661	253753	583318	245935
4	313879	87656	75122	73992	132550	77367	173424	165426	76437	269342
5	76546	109821	23038	23660	17606	29139	22514	56748	47340	25421
6	16659	22708	28518	5489	6002	3238	6894	3764	12726	11621
7	3410	4932	5081	6504	1252	786	698	1177	1042	4730
8	1817	1003	1521	942	1430	275	520	184	503	212

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	2393685	2363651	2015348	1476149	944093	2093753	4542356	2399401
2	517633	623411	597180	534911	342611	265976	461051	711747
3	280553	226738	309899	306575	273583	180774	149052	240941
4	107715	105879	88809	133034	139064	128727	92502	67878
5	110667	37823	35188	32452	50111	59339	55118	33774
6	7323	33426	10167	9876	8566	15446	19881	17373
7	2955	1933	8757	2711	2930	3037	5077	7270
8	1554	924	913	2349	1339	838	1601	2006

Fishing mortality - Species Cod

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	0.033	0.024	0.070	0.065	0.041	0.053	0.024	0.133	0.097	0.041	0.157	0.094	0.141	0.050	0.174
2	0.515	0.349	0.439	0.506	0.459	0.591	0.347	0.522	0.841	0.857	0.647	0.777	0.722	0.909	0.868
3	0.351	0.557	0.635	0.602	0.698	0.712	0.573	0.716	0.743	0.892	0.817	0.666	0.767	0.801	0.743
4	0.438	0.396	0.609	0.519	0.522	0.699	0.573	0.566	0.699	0.652	0.777	0.658	0.660	0.742	0.525
5	0.443	0.455	0.424	0.484	0.589	0.615	0.621	0.582	0.690	0.711	0.574	0.659	0.732	0.549	0.625
6	0.552	0.588	0.455	0.430	0.592	0.560	0.694	0.530	0.534	0.810	0.723	0.553	0.661	0.775	0.588
7	0.156	0.589	0.464	0.443	0.614	0.580	0.487	0.530	0.568	0.787	0.702	0.748	0.509	0.730	0.785
8	0.773	0.355	0.708	0.525	0.709	0.451	0.632	0.320	0.518	1.034	0.550	0.636	0.848	0.268	0.769
9	0.312	0.312	0.266	0.757	0.374	0.767	0.403	0.642	0.686	1.229	0.335	0.953	0.866	0.796	1.444
10	0.451	0.475	0.465	0.530	0.580	0.598	0.568	0.518	0.599	0.909	0.565	0.694	0.720	0.630	0.862
11	0.504	0.476	0.466	0.531	0.581	0.599	0.569	0.518	0.600	0.910	0.566	0.694	0.721	0.615	0.871
F 2-8	0.461	0.470	0.533	0.501	0.597	0.601	0.561	0.538	0.656	0.821	0.684	0.671	0.700	0.682	0.700

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.116	0.151	0.140	0.143	0.233	0.184	0.244	0.141	0.328	0.193	0.274	0.182	0.202	0.194	0.188
2	0.979	0.805	0.914	0.948	0.945	1.077	0.982	1.009	0.821	0.913	0.968	0.893	0.881	0.760	0.803
3	0.820	0.932	0.910	0.950	1.178	1.128	0.985	0.989	0.996	0.812	1.153	0.981	0.864	0.882	0.761
4	0.728	0.565	0.717	0.707	0.808	0.863	0.781	0.784	0.762	0.907	0.797	0.956	0.850	0.716	0.871
5	0.873	0.699	0.591	0.657	0.770	0.775	0.749	0.680	0.821	0.721	0.796	0.702	0.687	0.752	0.614
6	0.672	0.549	0.632	0.627	0.863	0.772	0.792	0.702	0.786	0.905	0.825	0.903	0.520	0.929	0.780
7	0.644	0.640	0.791	0.724	0.749	0.726	0.712	0.757	0.825	0.942	0.789	0.983	0.735	1.031	0.885
8	0.739	0.507	0.833	0.627	0.724	0.807	0.763	0.714	0.958	0.900	0.786	1.075	0.422	1.030	0.811
9	0.863	0.758	0.583	0.736	0.881	0.553	0.899	0.598	0.630	0.971	0.685	0.795	1.811	0.579	1.004
10	0.779	0.637	0.715	0.645	0.777	0.768	0.761	0.659	0.762	0.835	0.748	0.858	0.941	0.886	0.851
11	0.783	0.647	0.691	0.651	0.807	0.758	0.763	0.639	0.767	0.826	0.761	0.889	0.938	0.914	0.858
F 2-8	0.779	0.671	0.770	0.749	0.863	0.878	0.823	0.805	0.853	0.871	0.873	0.928	0.708	0.871	0.789

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	0.069	0.090	0.138	0.067	0.088	0.042	0.069	0.071
2	0.753	0.624	0.783	0.617	0.585	0.744	0.473	0.583
3	0.860	0.934	0.845	0.889	0.906	0.969	0.990	0.757
4	0.825	0.848	0.765	0.659	0.863	1.014	0.953	0.745
5	0.806	0.723	0.613	0.735	0.716	1.108	0.876	0.804
6	0.661	0.849	0.592	0.781	0.870	0.810	1.077	0.820
7	1.067	0.598	0.709	0.914	1.118	0.937	1.322	0.983
8	0.883	1.080	0.380	1.425	0.840	0.766	1.186	0.930
9	0.753	0.800	0.973	0.865	0.997	0.570	0.953	0.877
10	0.870	0.808	0.688	0.929	0.870	0.876	1.062	0.899
11	0.858	0.794	0.697	0.924	0.920	0.900	1.062	0.924
F 2-8	0.837	0.808	0.670	0.860	0.843	0.907	0.982	0.803

Fishing mortality - Species Haddock

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
0	0.003	0.050	0.076	0.104	0.004	0.001	0.012	0.032	0.010	0.016	0.002	0.006	0.012	0.028	0.018
1	0.211	0.087	1.664	1.606	0.401	0.080	0.025	0.593	0.624	0.215	0.421	0.343	0.404	0.383	0.433
2	0.856	0.478	0.425	0.843	1.117	0.603	0.667	1.057	0.689	0.828	0.589	0.953	1.029	0.881	1.049
3	0.669	1.166	0.497	0.343	0.398	0.882	1.341	1.115	0.780	1.312	1.136	0.933	1.255	1.366	1.034
4	0.744	0.743	0.964	0.758	0.356	0.294	1.246	1.234	0.847	1.170	0.772	0.978	1.091	0.764	1.245
5	0.855	0.857	1.263	1.203	0.982	0.489	0.782	0.681	0.837	1.127	0.916	0.602	0.978	1.247	0.995
6	0.502	1.253	1.011	1.300	1.311	0.799	1.612	1.432	0.678	0.854	1.092	0.873	0.833	1.057	0.991
7	0.818	0.617	0.867	1.075	1.131	0.589	0.994	0.706	1.020	0.680	0.882	1.128	1.583	0.402	0.935
8	0.775	0.836	0.499	0.970	1.937	0.665	0.948	1.062	1.280	0.471	1.131	0.404	1.001	0.844	0.501
9	0.741	0.863	0.922	1.064	1.151	0.564	1.122	1.020	0.932	0.859	0.958	0.791	1.085	0.856	0.941
10	0.746	0.868	0.928	1.071	1.158	0.567	1.129	1.026	0.937	0.864	0.964	0.793	1.091	0.861	0.924
F 2-6	0.725	0.899	0.832	0.889	0.833	0.614	1.130	1.104	0.766	1.058	0.901	0.868	1.037	1.063	1.063

Table 4.1.1 (Cont'd)

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.023	0.045	0.065	0.067	0.039	0.063	0.022	0.028	0.009	0.008	0.009	0.008	0.013	0.040	0.051
1	0.654	0.237	0.262	0.216	0.252	0.243	0.217	0.376	0.246	0.195	0.272	0.196	0.339	0.282	0.244
2	1.055	0.946	0.743	0.472	0.469	0.703	0.709	0.666	1.079	0.970	0.853	0.725	1.183	0.828	0.772
3	1.114	1.165	1.176	0.923	0.803	1.011	0.985	0.951	1.242	1.051	1.321	0.987	1.139	1.017	1.105
4	1.081	1.051	1.127	0.949	0.856	1.130	1.096	1.069	1.236	1.055	1.080	1.149	1.086	0.770	0.992
5	1.102	0.991	0.923	0.744	0.598	1.162	1.173	0.981	1.004	0.794	1.070	0.641	0.851	0.816	0.702
6	1.022	1.169	0.942	0.532	0.741	0.797	1.072	1.059	0.704	1.142	0.736	0.772	0.505	0.608	1.091
7	1.123	0.601	1.241	1.007	0.985	0.821	0.768	0.944	0.850	0.824	0.860	0.560	0.631	0.475	0.696
8	0.835	0.949	0.613	1.116	1.100	0.583	0.558	0.711	0.650	1.321	0.610	0.752	0.448	0.695	0.830
9	1.057	0.945	0.997	0.886	0.858	0.914	0.949	0.972	0.883	1.029	0.867	0.760	0.726	0.703	0.875
10	1.053	0.939	1.011	0.879	0.884	0.907	0.976	0.962	0.910	1.038	0.870	0.764	0.703	0.718	0.887
F 2-6	1.075	1.065	0.982	0.724	0.693	0.961	1.007	0.945	1.053	1.002	1.012	0.855	0.953	0.808	0.932

Age	1993	1994	1995	1996	1997	1998	1999	2000
0	0.041	0.012	0.065	0.033	0.005	0.002	0.005	0.001
1	0.305	0.275	0.187	0.135	0.227	0.224	0.297	0.133
2	0.858	0.630	0.557	0.490	0.508	0.663	0.906	1.014
3	1.040	1.081	0.928	0.925	0.636	0.647	0.974	1.037
4	0.840	0.986	0.977	1.003	0.729	0.862	0.882	0.999
5	0.878	0.639	0.832	1.007	1.022	0.813	1.092	0.624
6	0.759	1.140	0.389	1.295	0.914	0.882	1.213	0.963
7	0.881	0.981	0.837	2.049	1.286	0.681	1.583	1.295
8	0.505	1.519	0.618	1.112	1.077	1.133	1.895	1.159
9	0.795	1.047	0.728	1.332	1.050	0.886	1.375	1.036
10	0.789	1.052	0.730	1.286	1.047	0.899	1.388	1.049
F 2-6	0.875	0.895	0.737	0.944	0.762	0.773	1.013	0.927

Fishing mortality - Species Herring

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
0	0.016	0.013	0.008	0.027	0.027	0.038	0.010	0.046	0.045	0.072	0.062	0.108	0.147	0.150	0.110
1	0.130	0.329	0.248	0.189	0.319	0.263	0.319	0.267	0.594	0.576	0.731	0.528	0.676	0.227	0.222
2	0.284	0.359	0.709	0.527	0.391	1.222	0.678	0.858	0.758	0.692	0.920	0.975	1.203	1.284	0.145
3	0.244	0.378	0.671	0.643	0.735	1.764	0.819	1.136	1.084	0.705	1.214	0.902	1.434	1.246	1.067
4	0.191	0.324	0.707	0.516	0.848	0.971	0.787	1.217	1.071	0.697	0.892	0.926	1.275	1.587	0.304
5	0.123	0.265	0.583	0.760	0.767	1.118	0.935	0.799	0.980	0.467	0.840	1.093	1.723	1.450	0.933
6	0.160	0.205	0.470	0.356	0.954	1.124	1.759	0.985	2.511	0.489	1.263	0.965	1.187	1.004	0.573
7	0.266	0.253	0.411	0.370	1.467	1.535	1.266	4.088	2.631	0.092	0.809	0.753	1.875	1.389	0.650
8	0.296	0.501	0.715	0.609	0.973	1.357	1.121	1.557	1.711	0.878	1.375	1.220	1.871	1.358	0.721
9	0.295	0.499	0.713	0.606	0.969	1.352	1.117	1.552	1.706	0.875	1.370	1.231	1.853	1.361	0.768
F 2-6	0.201	0.306	0.628	0.560	0.739	1.240	0.995	0.999	1.281	0.610	1.026	0.972	1.364	1.314	0.605

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.051	0.087	0.094	0.512	0.429	0.502	0.140	0.040	0.014	0.093	0.071	0.130	0.032	0.092	0.215
1	0.150	0.123	0.054	0.157	0.206	0.158	0.076	0.222	0.141	0.211	0.246	0.334	0.341	0.275	0.182
2	0.018	0.080	0.256	0.278	0.204	0.274	0.251	0.348	0.373	0.338	0.300	0.240	0.261	0.425	0.443
3	0.032	0.057	0.356	0.243	0.445	0.307	0.375	0.604	0.454	0.456	0.392	0.385	0.352	0.447	0.457
4	0.079	0.074	0.251	0.261	0.213	0.398	0.469	0.650	0.507	0.528	0.529	0.521	0.424	0.440	0.516
5	0.013	0.042	0.223	0.380	0.135	0.252	0.545	0.607	0.480	0.557	0.598	0.628	0.459	0.448	0.522
6	0.059	0.010	0.059	0.397	0.138	0.327	0.329	0.681	0.694	0.594	0.637	0.702	0.486	0.469	0.680
7	0.048	0.344	0.092	0.908	0.214	0.387	0.655	0.527	0.775	0.617	0.628	0.728	0.685	0.429	0.679
8	0.146	0.193	0.259	0.538	0.363	0.481	0.567	0.804	0.724	0.713	0.884	0.778	0.758	0.690	0.859
9	0.157	0.193	0.259	0.540	0.364	0.481	0.568	0.806	0.717	0.715	0.883	0.774	0.760	0.690	0.865
F 2-6	0.040	0.053	0.229	0.312	0.227	0.312	0.394	0.578	0.502	0.494	0.491	0.495	0.396	0.446	0.524

Age	1993	1994	1995	1996	1997	1998	1999	2000
0	0.258	0.199	0.301	0.109	0.034	0.026	0.137	0.062
1	0.192	0.082	0.119	0.137	0.019	0.049	0.019	0.070
2	0.443	0.520	0.529	0.258	0.183	0.200	0.207	0.217
3	0.619	0.673	0.798	0.506	0.376	0.364	0.361	0.327
4	0.718	0.895	0.856	0.411	0.410	0.441	0.359	0.353
5	0.731	0.631	0.897	0.495	0.323	0.533	0.400	0.396
6	0.778	0.860	0.727	0.352	0.364	0.595	0.448	0.422
7	0.861	0.600	1.098	0.280	0.309	0.437	0.348	0.323
8	1.014	0.830	0.972	0.563	0.350	0.450	0.392	0.352
9	1.015	0.832	0.972	0.559	0.350	0.456	0.392	0.349
F 2-6	0.658	0.716	0.761	0.404	0.331	0.426	0.355	0.343

Fishing mortality - Species Norway pout

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
0	0.044	0.013	0.007	0.012	0.028	0.035	0.007	0.018	0.022	0.067	0.032	0.052	0.050	0.040	0.025
1	0.570	0.184	0.096	0.091	0.437	0.873	0.141	0.281	0.349	0.446	1.038	1.242	0.779	0.570	0.625
2	0.332	0.169	0.092	0.084	0.238	1.275	0.349	0.542	0.627	1.017	0.696	2.865	1.257	1.360	0.762
3	0.025	0.025	0.025	0.025	0.074	0.149	0.198	0.397	0.496	0.794	0.894	0.897	0.895	0.895	0.896
F 1-2	0.451	0.177	0.094	0.088	0.337	1.074	0.245	0.411	0.488	0.732	0.867	2.053	1.018	0.965	0.693

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.013	0.012	0.010	0.210	0.009	0.028	0.025	0.009	0.054	0.006	0.051	0.070	0.015	0.033	0.019
1	0.515	0.566	0.636	0.609	0.556	0.600	0.723	0.806	0.607	0.579	0.354	0.670	0.515	0.401	0.541
2	1.056	1.607	1.661	1.103	1.768	1.400	1.835	1.488	2.022	1.429	1.208	1.215	1.247	1.333	1.224
3	0.893	0.895	0.895	0.892	0.893	2.657	1.874	1.228	0.556	0.700	0.201	0.247	0.852	1.722	0.802
F 1-2	0.786	1.086	1.149	0.856	1.162	1.000	1.279	1.147	1.315	1.004	0.781	0.942	0.881	0.867	0.882

Table 4.1.1 (Cont'd)

Age	1993	1994	1995	1996	1997	1998	1999	2000
0	0.027	0.030	0.021	0.017	0.005	0.005	0.008	0.013
1	0.472	0.795	0.304	0.249	0.237	0.159	0.288	0.349
2	1.215	1.462	0.639	0.528	0.812	0.364	1.094	0.701
3	0.744	0.898	0.428	2.278	0.788	0.604	0.624	1.346
F 1-2	0.843	1.129	0.471	0.388	0.524	0.262	0.691	0.525

Fishing mortality - Species Plaice

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	_	_	_	_	_	_	0.000	0.000	0.000	0.010	0.002	0.005	0.003	0.009	0.007
2	0.016	0.056	0.011	0.016	0.023	0.041	0.074	0.063	0.097	0.167	0.173	0.051	0.075	0.124	0.230
3	0.080	0.181	0.201	0.086	0.137	0.193	0.246	0.340	0.225	0.271	0.394	0.454	0.167	0.273	0.208
4	0.365	0.327	0.340	0.356	0.190	0.228	0.233	0.482	0.346	0.365	0.519	0.479	0.443	0.378	0.350
5	0.350	0.452	0.340	0.369	0.478	0.292	0.306	0.396	0.383	0.378	0.493	0.549	0.527	0.316	0.581
6	0.434	0.379	0.403	0.330	0.352	0.329	0.369	0.494	0.361	0.410	0.363	0.397	0.540	0.355	0.319
7	0.322	0.355	0.291	0.357	0.294	0.247	0.303	0.481	0.416	0.358	0.346	0.329	0.393	0.416	0.330
8	0.298	0.243	0.294	0.247	0.262	0.269	0.201	0.271	0.297	0.459	0.395	0.393	0.383	0.338	0.377
9	0.277	0.253	0.216	0.337	0.215	0.177	0.325	0.185	0.430	0.273	0.445	0.360	0.424	0.296	0.331
10	0.236	0.211	0.388	0.237	0.234	0.214	0.228	0.284	0.284	0.387	0.299	0.511	0.339	0.339	0.287
11	0.311	0.267	0.213	0.275	0.198	0.245	0.297	0.182	0.296	0.254	0.292	0.330	0.395	0.331	0.338
12	0.228	0.241	0.280	0.272	0.203	0.205	0.278	0.262	0.251	0.338	0.254	0.453	0.415	0.329	0.327
13	0.270	0.227	0.322	0.303	0.194	0.170	0.220	0.257	0.249	0.250	0.308	0.315	0.543	0.386	0.263
14	0.265	0.240	0.285	0.286	0.209	0.202	0.270	0.234	0.303	0.301	0.320	0.395	0.425	0.337	0.310
15	0.265	0.240	0.285	0.286	0.209	0.202	0.270	0.234	0.303	0.301	0.320	0.395	0.425	0.337	0.310
F 2-10	0.264	0.273	0.276	0.259	0.243	0.221	0.254	0.333	0.316	0.341	0.381	0.391	0.366	0.315	0.335

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.003	0.003	0.002	0.001	0.003	0.002	0.000	0.000	0.001	_	_	0.003	0.004	0.004	0.009
2	0.163	0.171	0.186	0.195	0.139	0.145	0.132	0.150	0.156	0.082	0.033	0.101	0.096	0.133	0.133
3	0.376	0.484	0.643	0.556	0.681	0.508	0.503	0.439	0.507	0.390	0.324	0.300	0.279	0.330	0.358
4	0.388	0.504	0.595	0.561	0.629	0.716	0.416	0.670	0.504	0.684	0.413	0.494	0.517	0.545	0.465
5	0.433	0.618	0.462	0.535	0.534	0.525	0.575	0.425	0.656	0.693	0.621	0.514	0.670	0.672	0.693
6	0.462	0.649	0.438	0.389	0.455	0.433	0.439	0.440	0.567	0.547	0.558	0.488	0.473	0.722	0.670
7	0.314	0.584	0.428	0.391	0.388	0.375	0.356	0.366	0.455	0.514	0.493	0.427	0.363	0.468	0.608
8	0.281	0.336	0.365	0.426	0.360	0.342	0.414	0.311	0.384	0.353	0.429	0.381	0.282	0.376	0.381
9	0.280	0.356	0.221	0.329	0.393	0.306	0.345	0.323	0.359	0.285	0.417	0.266	0.290	0.307	0.380
10	0.265	0.422	0.253	0.230	0.397	0.431	0.321	0.299	0.380	0.363	0.333	0.365	0.206	0.296	0.361
11	0.246	0.335	0.270	0.306	0.262	0.374	0.307	0.231	0.348	0.302	0.300	0.277	0.250	0.254	0.306
12	0.231	0.356	0.327	0.355	0.296	0.441	0.311	0.393	0.359	0.300	0.434	0.302	0.205	0.317	0.365
13	0.245	0.410	0.203	0.343	0.395	0.372	0.259	0.296	0.512	0.265	0.349	0.339	0.224	0.228	0.485
14	0.254	0.377	0.255	0.313	0.350	0.386	0.309	0.311	0.399	0.316	0.397	0.357	0.270	0.337	0.595
15	0.254	0.377	0.255	0.313	0.350	0.386	0.309	0.311	0.399	0.316	0.397	0.357	0.270	0.334	0.600
F 2-10	0.329	0.458	0.399	0.401	0.442	0.420	0.389	0.380	0.441	0.435	0.402	0.371	0.353	0.428	0.450

Age	1993	1994	1995	1996	1997	1998	1999	2000
1	0.013	0.006	0.025	0.004	0.001	0.001	0.002	0.009
2	0.163	0.203	0.187	0.160	0.188	0.042	0.041	0.089
3	0.431	0.466	0.594	0.497	0.514	0.545	0.289	0.257
4	0.525	0.676	0.718	0.704	0.841	0.680	0.649	0.532
5	0.636	0.550	0.671	0.675	0.866	0.725	0.645	0.485
6	0.612	0.522	0.491	0.581	0.726	0.630	0.693	0.480
7	0.566	0.678	0.478	0.552	0.650	0.542	0.598	0.397
8	0.485	0.520	0.420	0.417	0.602	0.438	0.508	0.336
9	0.344	0.404	0.364	0.475	0.382	0.404	0.511	0.276
10	0.402	0.359	0.217	0.442	0.334	0.275	0.451	0.236
11	0.367	0.326	0.262	0.239	0.277	0.245	0.251	0.174
12	0.302	0.291	0.271	0.244	0.218	0.291	0.280	0.145
13	0.549	0.295	0.185	0.324	0.226	0.205	0.273	0.143
14	0.418	0.559	0.219	0.298	0.292	0.163	0.163	0.140
15	0.421	0.556	0.220	0.300	0.292	0.161	0.163	0.139
F 2-10	0.463	0.486	0.460	0.500	0.567	0.476	0.487	0.343

Fishing mortality - Species Saithe

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
0	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.002	0.018	0.007	0.002	0.002	0.019
2	0.017	0.064	0.001	0.099	0.081	0.012	0.006	0.007	0.065	0.130	0.196	0.084	0.165	0.247	0.137
3	0.035	0.249	0.129	0.134	0.163	0.288	0.118	0.156	0.283	0.365	0.504	0.710	0.420	0.938	0.281
4	0.365	0.195	0.668	0.402	0.226	0.310	0.293	0.508	0.382	0.448	0.576	0.738	0.663	1.005	0.688
5	0.526	0.692	0.460	0.475	0.354	0.322	0.250	0.538	0.403	0.279	0.320	0.427	0.486	0.684	0.800
6	0.174	0.344	0.411	0.388	0.420	0.228	0.319	0.536	0.273	0.519	0.297	0.465	0.449	0.578	0.837
7	0.148	0.192	0.165	0.437	0.202	0.091	0.352	0.266	0.330	0.429	0.381	0.487	0.588	0.420	0.870
8	0.017	0.367	0.043	0.129	0.205	0.028	0.337	0.174	0.293	0.438	0.401	0.373	0.638	0.486	0.851
9	0.060	0.070	0.080	0.090	0.100	0.140	0.180	0.220	0.260	0.300	0.327	0.444	0.536	0.487	0.769
10	0.060	0.070	0.080	0.090	0.100	0.140	0.180	0.220	0.260	0.300	0.323	0.444	0.527	0.483	0.763
F 3-6	0.275	0.370	0.417	0.350	0.291	0.287	0.245	0.434	0.335	0.403	0.425	0.585	0.505	0.801	0.652

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
1	0.014	0.004	0.009	0.029	0.007	0.001	0.000	0.002	0.001	0.009	0.000	0.020	0.002	0.002	0.002
2	0.200	0.252	0.127	0.168	0.237	0.148	0.107	0.025	0.059	0.238	0.076	0.078	0.031	0.123	0.037
3	0.550	0.266	0.351	0.173	0.415	0.304	0.620	0.689	0.239	0.402	0.377	0.320	0.467	0.480	0.254
4	0.567	0.459	0.349	0.261	0.514	0.525	0.811	1.279	1.519	0.901	0.645	0.726	0.668	0.777	0.734
5	0.476	0.460	0.596	0.322	0.585	0.740	0.810	0.896	1.154	0.980	1.025	0.749	0.731	0.601	0.968
6	0.341	0.440	0.550	0.498	0.498	0.910	1.048	0.584	0.906	0.531	0.614	1.013	0.648	0.477	0.597
7	0.320	0.637	0.553	0.594	0.537	1.037	0.709	0.566	0.532	0.627	0.646	0.578	0.696	0.450	0.464
8	0.518	0.391	0.534	0.833	0.499	1.122	0.851	0.609	0.477	0.608	0.532	0.750	0.536	0.486	0.444
9	0.379	0.475	0.538	0.630	0.537	0.974	0.765	0.558	0.744	0.721	0.828	0.835	0.556	0.614	0.730
10	0.381	0.471	0.530	0.602	0.536	0.956	0.754	0.555	0.741	0.715	0.813	0.836	0.561	0.607	0.721
F 3-6	0.484	0.406	0.462	0.314	0.503	0.620	0.822	0.862	0.955	0.704	0.665	0.702	0.629	0.584	0.638

Table 4.1.1 (Cont'd)

Age	1993	1994	1995	1996	1997	1998	1999	2000
0	_	_	_	_	_	_	_	0.000
1	0.000	0.001	0.000	0.003	0.000	0.000	0.000	0.000
2	0.072	0.028	0.026	0.041	0.138	0.024	0.043	0.012
3	0.329	0.217	0.139	0.113	0.081	0.145	0.120	0.060
4	0.474	0.681	0.583	0.317	0.292	0.300	0.316	0.358
5	0.607	0.665	0.584	0.557	0.415	0.466	0.447	0.346
6	0.639	0.474	0.384	0.684	0.332	0.396	0.442	0.381
7	0.687	0.397	0.954	0.692	0.569	0.336	0.452	0.297
8	1.170	0.282	0.537	0.561	0.545	0.505	0.701	0.250
9	1.475	1.345	1.100	0.279	0.432	0.629	0.932	0.396
10	1.504	1.365	1.106	0.278	0.427	0.631	0.935	0.397
F 3-6	0.512	0.509	0.423	0.418	0.280	0.327	0.331	0.286

Fishing mortality - Species Sandeel

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
0	0.021	0.016	0.022	0.032	0.020	0.035	0.034	0.023	0.089	0.011	0.001	0.022	0.030	0.016	0.033
1	0.111	0.090	0.091	0.119	0.198	0.117	0.165	0.400	0.082	0.149	0.181	0.445	0.153	0.407	0.418
2	0.204	0.132	0.146	0.145	0.203	0.271	0.097	0.514	0.586	0.379	0.231	0.137	0.466	0.462	0.579
3	0.135	0.138	0.113	0.124	0.125	0.124	0.102	0.094	0.280	0.178	0.235	0.250	0.250	0.528	0.504
4	0.135	0.138	0.113	0.124	0.125	0.124	0.102	0.094	0.280	0.178	0.235	0.250	0.250	0.505	0.515
F 1-2	0.158	0.111	0.118	0.132	0.200	0.194	0.131	0.457	0.334	0.264	0.206	0.291	0.309	0.435	0.499

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.138	0.108	0.041	0.072	0.073	0.031	_	0.015	0.017	0.003	0.027	0.010	0.024	0.046	0.025
1	0.470	0.278	0.457	0.425	0.301	0.204	0.578	0.257	0.291	0.384	0.288	0.887	0.651	0.668	0.531
2	0.624	0.691	0.776	0.620	0.833	0.539	0.234	1.598	0.649	0.395	1.520	0.467	0.979	0.971	0.408
3	0.500	0.496	0.476	0.477	0.493	0.612	0.584	1.387	0.379	0.299	0.625	1.665	0.728	0.447	0.542
4	0.511	0.505	0.467	0.487	0.500	0.571	0.606	1.317	0.400	0.306	0.629	1.735	0.749	0.455	0.552
F 1-2	0.547	0.484	0.616	0.522	0.567	0.371	0.406	0.928	0.470	0.389	0.904	0.677	0.815	0.820	0.469

Age	1993	1994	1995	1996	1997	1998	1999	2000
0	0.052	0.001	0.013	0.030	0.008	0.097	0.048	0.026
1	0.375	0.450	0.591	0.423	0.434	0.488	0.572	0.393
2	0.403	0.599	0.276	0.734	0.380	0.689	0.581	1.115
3	0.388	0.567	0.455	0.387	0.726	0.697	0.602	0.668
4	0.397	0.581	0.464	0.412	0.755	0.722	0.619	0.681
F 1-2	0.389	0.524	0.433	0.578	0.407	0.589	0.576	0.754

Fishing mortality - Species Sole

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
0	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
1	_	0.000	_	_	_	0.011	0.008	0.010	0.011	0.005	0.007	0.001	0.007	0.010	0.013
2	0.062	0.018	0.104	0.125	0.110	0.307	0.330	0.153	0.324	0.239	0.205	0.185	0.276	0.104	0.260
3	0.218	0.251	0.148	0.421	0.368	0.661	0.687	0.632	0.563	0.627	0.698	0.586	0.540	0.557	0.533
4	0.520	0.204	0.273	0.175	0.459	0.649	0.505	0.544	0.651	0.527	0.552	0.652	0.652	0.492	0.600
5	0.443	0.408	0.247	0.296	0.539	0.458	0.694	0.279	0.570	0.502	0.573	0.438	0.488	0.541	0.466
6	0.509	0.263	0.451	0.259	0.190	0.207	0.404	0.341	0.339	0.352	0.411	0.524	0.400	0.389	0.346
7	0.352	0.314	0.274	0.209	0.186	0.112	0.200	0.304	0.391	0.176	0.351	0.483	0.376	0.316	0.190
8	0.452	0.135	0.227	0.194	0.305	0.215	0.139	0.201	0.270	0.328	0.373	0.367	0.499	0.432	0.274
9	0.368	0.240	0.145	0.136	0.209	0.184	0.213	0.099	0.214	0.253	0.553	0.304	0.476	0.408	0.326
10	0.336	0.135	0.154	0.091	0.132	0.255	0.222	0.164	0.212	0.180	0.255	0.524	0.260	0.316	0.324
11	0.449	0.150	0.122	0.145	0.087	0.076	0.242	0.175	0.271	0.120	0.512	0.258	0.378	0.320	0.207
12	0.324	0.146	0.189	0.114	0.320	0.145	0.106	0.284	0.453	0.229	0.540	0.427	0.305	0.309	0.302
13	0.615	0.305	0.298	0.060	0.104	0.078	0.120	0.106	0.239	0.300	0.341	0.089	0.153	0.319	0.397
14	0.420	0.195	0.182	0.109	0.171	0.148	0.181	0.166	0.278	0.216	0.442	0.321	0.315	0.335	0.311
15	0.420	0.195	0.182	0.109	0.171	0.148	0.181	0.166	0.278	0.216	0.442	0.321	0.315	0.335	0.311
F 2-8	0.365	0.228	0.246	0.240	0.308	0.373	0.423	0.351	0.444	0.393	0.452	0.462	0.462	0.404	0.381

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_
1	0.001	0.001	0.004	0.003	0.018	0.003	0.003	0.002	0.002	0.001	0.000	0.001	0.005	0.002	0.003
2	0.235	0.226	0.126	0.248	0.230	0.308	0.285	0.313	0.142	0.235	0.237	0.128	0.140	0.091	0.116
3	0.564	0.657	0.558	0.513	0.668	0.595	0.713	0.716	0.602	0.506	0.646	0.523	0.417	0.421	0.424
4	0.502	0.615	0.586	0.604	0.543	0.667	0.673	0.756	0.642	0.580	0.701	0.655	0.523	0.550	0.458
5	0.501	0.434	0.556	0.524	0.639	0.315	0.570	0.584	0.647	0.457	0.560	0.424	0.550	0.725	0.510
6	0.470	0.429	0.344	0.531	0.585	0.487	0.664	0.421	0.722	0.520	0.481	0.385	0.569	0.401	0.576
7	0.592	0.319	0.516	0.352	0.439	0.443	0.562	0.348	0.461	0.405	0.471	0.295	0.436	0.585	0.581
8	0.587	0.543	0.407	0.358	0.360	0.438	0.399	0.461	0.278	0.299	0.379	0.328	0.400	0.507	0.478
9	0.226	0.428	0.444	0.359	0.393	0.357	0.394	0.402	0.658	0.302	0.253	0.307	0.499	0.381	0.538
10	0.382	0.187	0.142	0.403	0.399	0.308	0.353	0.228	0.760	0.471	0.201	0.157	0.257	0.489	0.411
11	0.636	0.535	0.274	0.406	0.536	0.570	0.324	0.464	0.698	0.410	0.248	0.345	0.289	0.509	0.475
12	0.410	0.672	0.306	0.144	0.482	0.178	0.347	0.482	0.888	0.608	0.343	0.399	0.897	0.589	0.732
13	0.413	0.632	0.636	1.206	0.243	0.139	0.234	0.350	0.610	0.857	0.312	0.298	0.541	0.658	0.371
14	0.414	0.492	0.361	0.505	0.411	0.311	0.331	0.385	0.727	0.532	0.272	0.301	0.676	0.617	0.533
15	0.414	0.492	0.361	0.505	0.412	0.311	0.331	0.386	0.727	0.532	0.272	0.301	0.672	0.609	0.531
F 2-8	0.493	0.460	0.442	0.447	0.495	0.465	0.552	0.514	0.499	0.429	0.496	0.391	0.434	0.469	0.449

Table 4.1.1 (Cont'd)

Age	1993	1994	1995	1996	1997	1998	1999	2000
0	_	_	_	_	_	_	_	0.000
1	0.001	0.012	0.053	0.003	0.006	0.002	0.003	0.036
2	0.185	0.139	0.303	0.263	0.146	0.273	0.142	0.261
3	0.403	0.482	0.438	0.663	0.535	0.568	0.571	0.561
4	0.535	0.589	0.762	0.909	0.631	0.693	0.621	0.462
5	0.798	0.626	0.552	0.697	0.688	0.643	0.600	0.540
6	0.621	0.808	0.528	0.656	0.737	0.565	0.442	0.438
7	0.731	0.588	0.675	0.618	0.397	0.607	0.357	0.472
8	0.426	0.461	0.642	0.708	0.611	0.470	0.499	0.461
9	0.545	0.578	0.531	0.791	0.525	0.558	0.345	0.386
10	0.431	0.608	0.397	0.992	0.859	0.773	0.499	0.775
11	0.439	0.308	0.244	0.612	0.300	0.580	0.308	0.352
12	0.538	0.565	0.438	1.265	0.465	0.728	0.484	0.572
13	0.579	0.942	0.209	0.556	0.501	0.417	0.294	0.350
14	0.564	0.606	0.546	0.799	0.507	0.600	0.413	0.716
15	0.561	0.606	0.542	0.803	0.509	0.600	0.418	0.725
F 2-8	0.528	0.528	0.557	0.645	0.535	0.546	0.462	0.456

Fishing mortality - Species Sprat

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
0	0.001	0.001	0.001	0.001	0.001	0.004	0.053	0.036	0.018	0.018	0.041	0.007	0.002	0.015	0.006
1	0.047	0.042	0.075	0.075	0.042	0.035	0.066	0.061	0.057	0.068	0.121	0.084	0.256	0.206	0.152
2	0.086	0.092	0.080	0.187	0.075	0.081	0.048	0.050	0.100	0.077	0.144	0.174	0.301	0.440	0.279
3	0.050	0.055	0.060	0.065	0.070	0.075	0.080	0.085	0.090	0.095	0.100	0.089	0.163	0.219	0.149
4	0.050	0.055	0.060	0.065	0.070	0.075	0.080	0.085	0.090	0.095	0.100	0.085	0.164	0.208	0.127
F 1-2	0.067	0.067	0.077	0.131	0.058	0.058	0.057	0.055	0.079	0.073	0.132	0.129	0.278	0.323	0.215

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.003	0.003	0.005	0.007	0.003	0.002	0.005	_	_	_	0.000	0.001	_	0.005	0.003
1	0.545	0.496	0.491	0.506	0.707	0.986	0.246	0.266	0.031	0.002	0.057	0.117	0.110	0.197	0.344
2	0.314	0.606	0.951	1.073	0.994	0.794	1.001	0.252	0.201	1.753	1.352	1.502	0.235	0.445	0.328
3	0.222	0.313	0.437	0.486	0.535	0.470	0.417	0.141	0.099	0.605	0.495	0.569	0.080	0.202	0.361
4	0.233	0.331	0.432	0.485	0.513	0.427	0.390	0.140	0.100	0.618	0.446	0.711	0.074	0.203	0.375
F 1-2	0.430	0.551	0.721	0.790	0.851	0.890	0.624	0.259	0.116	0.877	0.704	0.810	0.172	0.321	0.336

Age	1993	1994	1995	1996	1997	1998	1999	2000
0	0.001	0.014	0.014	_	0.003	0.010	0.002	0.000
1	0.351	0.509	0.744	0.210	0.296	0.461	0.587	0.435
2	0.553	0.361	0.691	0.948	0.344	0.565	0.280	0.440
3	0.319	0.279	0.411	0.407	0.215	0.334	0.207	0.294
4	0.334	0.271	0.351	0.382	0.226	0.345	0.201	0.262
F 1-2	0.452	0.435	0.717	0.579	0.320	0.513	0.433	0.438

Fishing mortality - Species Whiting

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
0	0.025	0.027	0.008	0.008	0.010	0.022	0.218	0.210	0.126	0.037	0.018	0.019	0.026	0.033	0.066
1	0.179	0.186	0.233	0.416	0.461	0.169	0.814	0.807	0.440	0.353	0.323	0.446	0.276	0.197	0.473
2	0.899	0.233	0.489	0.665	0.528	0.764	0.517	0.788	0.502	0.681	0.786	0.866	0.806	0.929	0.499
3	0.831	0.573	0.420	0.907	0.729	0.764	0.729	0.901	0.528	0.536	0.995	1.003	0.962	1.186	0.820
4	0.989	0.537	0.667	0.857	0.786	0.947	0.552	0.736	0.637	0.532	0.549	0.939	0.878	0.951	0.901
5	0.868	0.791	0.440	1.180	0.714	0.741	0.900	0.555	0.526	0.865	1.324	0.324	0.956	0.733	0.848
6	0.953	0.811	0.815	1.686	1.045	1.049	0.438	0.881	0.236	0.913	0.922	1.921	2.140	1.199	0.829
7	0.946	0.728	0.630	1.230	0.843	0.915	0.627	0.718	0.458	0.766	0.911	1.049	1.369	1.017	0.852
8	0.943	0.726	0.628	1.227	0.841	0.912	0.625	0.716	0.457	0.764	0.908	1.049	1.306	0.986	0.849
F 2-6	0.908	0.589	0.566	1.059	0.761	0.853	0.627	0.772	0.486	0.705	0.915	1.011	1.148	1.000	0.779

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.032	0.036	0.026	0.032	0.017	0.093	0.019	0.023	0.032	0.015	0.045	0.013	0.048	0.119	0.028
1	0.161	0.266	0.105	0.158	0.160	0.290	0.289	0.257	0.363	0.167	0.429	0.159	0.300	0.157	0.284
2	0.426	0.461	0.438	0.299	0.276	0.471	0.558	0.276	0.453	0.521	0.461	0.462	0.550	0.486	0.391
3	0.597	0.694	0.777	0.672	0.476	0.717	0.817	0.592	0.711	0.854	0.625	0.677	0.884	0.448	0.503
4	0.772	0.633	0.882	0.861	0.653	0.683	1.001	0.800	1.083	1.171	0.891	0.766	0.904	0.738	0.519
5	0.687	0.780	1.142	0.931	0.797	0.822	0.981	1.030	0.973	1.281	1.044	1.371	1.060	0.937	0.748
6	1.025	0.848	0.994	1.172	0.939	0.869	1.165	1.128	1.130	1.683	1.190	1.421	0.931	0.619	0.985
7	0.843	0.750	0.967	1.064	0.800	0.796	1.021	1.002	1.077	1.375	1.045	1.225	0.973	0.790	0.871
8	0.842	0.733	0.954	1.038	0.815	0.794	1.031	1.004	1.092	1.392	1.028	1.256	0.974	0.789	0.881
F 2-6	0.702	0.683	0.847	0.787	0.628	0.713	0.905	0.765	0.870	1.102	0.842	0.939	0.866	0.646	0.629

Age	1993	1994	1995	1996	1997	1998	1999	2000
0	0.071	0.019	0.093	0.025	0.002	0.002	0.004	0.000
1	0.219	0.191	0.168	0.132	0.127	0.079	0.160	0.061
2	0.476	0.330	0.315	0.277	0.267	0.195	0.256	0.227
3	0.652	0.597	0.509	0.429	0.394	0.308	0.411	0.337
4	0.674	0.705	0.607	0.553	0.427	0.416	0.559	0.449
5	0.688	0.775	0.713	0.745	0.585	0.471	0.517	0.754
6	0.940	0.926	0.902	0.770	0.593	0.651	0.533	0.686
7	0.754	0.758	0.804	0.727	0.473	0.701	0.533	0.735
8	0.769	0.751	0.802	0.715	0.476	0.692	0.526	0.742
F 2-6	0.686	0.667	0.609	0.555	0.453	0.408	0.455	0.491

Table 4.1.1 (Cont'd)

Predation mortality (M2) - Species Cod

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	1.9071	1.9042	1.8398	1.5868	0.9609	2.3651	2.0537	0.8888	0.8913	0.9360	2.6962	1.2425	1.5640	2.5654	0.9796	2.0362	0.9481	1.2624
1	0.4567	0.5447	0.6734	0.7364	0.8516	0.6939	0.7796	0.8762	0.7429	0.6610	0.7959	0.7075	0.5410	0.5402	0.6239	0.6890	0.7087	0.7557
2	0.1600	0.1808	0.2446	0.2850	0.3101	0.2432	0.3054	0.3838	0.2947	0.2291	0.2927	0.3160	0.2282	0.1969	0.2145	0.2138	0.2220	0.2155
3	0.0793	0.0912	0.1039	0.1118	0.1225	0.1053	0.1291	0.1475	0.1223	0.0985	0.1253	0.1358	0.1061	0.1013	0.1032	0.1069	0.1105	0.1125
4	0.0166	0.0173	0.0177	0.0177	0.0191	0.0175	0.0208	0.0231	0.0217	0.0178	0.0207	0.0242	0.0202	0.0216	0.0205	0.0220	0.0215	0.0231
5	0.0128	0.0122	0.0112	0.0105	0.0096	0.0109	0.0119	0.0118	0.0122	0.0112	0.0130	0.0148	0.0140	0.0156	0.0152	0.0166	0.0167	0.0182
6	0.0259	0.0249	0.0232	0.0219	0.0197	0.0223	0.0244	0.0243	0.0249	0.0229	0.0266	0.0303	0.0286	0.0321	0.0311	0.0344	0.0348	0.0379
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
0	3.4198	2.3088	1.5666	3.2632	1.2161	1.8687	1.8851	1.2684	2.0755	2.2870	1.7709	2.5850	2.3245	2.9840	3.7125	2.6966	3.9428	3.7345
1	0.9486	0.7046	0.6879	0.5710	0.6141	0.5755	0.5305	0.5724	0.5399	0.5539	0.4623	0.4524	0.4683	0.4938	0.4776	0.5472	0.4938	0.5073
2	0.2634	0.2550	0.2276	0.1767	0.1699	0.1673	0.1399	0.1477	0.1434	0.1411	0.1342	0.1292	0.1220	0.1348	0.1336	0.1632	0.1656	0.1530
3	0.1350	0.1279	0.1273	0.1056	0.1206	0.1196	0.1215	0.1137	0.1309	0.1409	0.1537	0.1688	0.1750	0.1855	0.1981	0.2142	0.2176	0.2308
4	0.0267	0.0258	0.0274	0.0239	0.0300	0.0294	0.0331	0.0286	0.0349	0.0385	0.0443	0.0500	0.0527	0.0558	0.0607	0.0630	0.0650	0.0705
5	0.0206	0.0204	0.0214	0.0202	0.0260	0.0266	0.0307	0.0264	0.0327	0.0362	0.0429	0.0491	0.0524	0.0551	0.0597	0.0613	0.0633	0.0696
6	0.0430	0.0424	0.0448	0.0417	0.0532	0.0544	0.0632	0.0544	0.0679	0.0754	0.0887	0.1025	0.1092	0.1135	0.1230	0.1267	0.1308	0.1440
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Age	1999	2000
0	4.3206	3.8597
1	0.5590	0.4857
2	0.1553	0.1450
3	0.2348	0.2616
4	0.0708	0.0825
5	0.0698	0.0823
6	0.1438	0.1693
7	0.0000	0.0000
8	0.0000	0.0000
9	0.0000	0.0000
10	0.0000	0.0000
11	0.0000	0.0000

Predation mortality (M2) - Species Haddock

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	1.7333	2.0366	2.1092	1.9141	1.4701	2.1089	2.5949	1.7956	1.8798	2.2425	2.0576	1.6550	1.9151	2.4328	2.0830	2.2147	1.8793	2.3723
1	0.6652	0.9485	1.0585	1.0784	1.0472	1.0018	1.7974	1.7251	1.5185	1.8298	2.2000	1.8335	1.3567	1.6011	1.1968	1.2106	1.2967	1.2303
2	0.0834	0.1018	0.1361	0.1509	0.1576	0.1243	0.1607	0.1973	0.1478	0.1230	0.1572	0.1628	0.1210	0.1098	0.1165	0.1178	0.1224	0.1206
3	0.0414	0.0474	0.0581	0.0696	0.0757	0.0609	0.0724	0.0935	0.0861	0.0661	0.0713	0.0792	0.0636	0.0613	0.0583	0.0541	0.0534	0.0515
4	0.0364	0.0380	0.0482	0.0582	0.0655	0.0526	0.0555	0.0783	0.0784	0.0570	0.0562	0.0631	0.0547	0.0486	0.0474	0.0441	0.0448	0.0400
5	0.0437	0.0445	0.0444	0.0471	0.0461	0.0446	0.0506	0.0559	0.0570	0.0481	0.0527	0.0594	0.0536	0.0571	0.0548	0.0580	0.0585	0.0617
6	0.0241	0.0238	0.0287	0.0320	0.0336	0.0292	0.0315	0.0442	0.0423	0.0287	0.0299	0.0366	0.0333	0.0289	0.0281	0.0288	0.0295	0.0276
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
0	2.3783	2.0706	1.6580	2.0707	2.0559	2.0885	2.3950	2.0822	2.1211	2.1374	1.8362	1.9064	2.0269	1.6675	2.3748	1.7795	2.3082	2.5334
1	1.6872	1.1923	1.2548	0.8731	1.0618	0.8554	0.9095	1.1717	0.9697	1.0661	0.8765	0.8043	0.7947	0.8705	0.7777	1.1293	1.0233	1.6127
2	0.1548	0.1392	0.1233	0.0913	0.0933	0.0893	0.0747	0.0898	0.0836	0.0838	0.0744	0.0661	0.0600	0.0647	0.0607	0.0788	0.0733	0.0709
3	0.0603	0.0577	0.0554	0.0432	0.0427	0.0380	0.0339	0.0332	0.0347	0.0368	0.0352	0.0354	0.0339	0.0346	0.0361	0.0411	0.0421	0.0417
4	0.0482	0.0488	0.0468	0.0385	0.0340	0.0325	0.0272	0.0271	0.0266	0.0297	0.0282	0.0273	0.0267	0.0260	0.0266	0.0310	0.0321	0.0321
5	0.0705	0.0701	0.0731	0.0656	0.0801	0.0799	0.0897	0.0789	0.0949	0.1053	0.1212	0.1379	0.1459	0.1533	0.1647	0.1731	0.1776	0.1946
6	0.0348	0.0346	0.0343	0.0301	0.0308	0.0313	0.0312	0.0286	0.0320	0.0364	0.0393	0.0423	0.0444	0.0454	0.0486	0.0524	0.0537	0.0580
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Age	1999	2000
0	1.8750	2.5713
1	1.7170	1.3150
2	0.0777	0.0652
3	0.0403	0.0421
4	0.0294	0.0297
5	0.1949	0.2229
6	0.0566	0.0643
7	0.0000	0.0000
8	0.0000	0.0000
9	0.0000	0.0000
10	0.0000	0.0000

Table 4.1.1 (Cont'd)

Predation mortality (M2) - Species Herring

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0.7801	0.7205	0.7371	0.6392	0.4842	0.6618	0.7154	0.4582	0.4577	0.5996	0.6885	0.6149	0.8874	0.6838	0.6040	0.6056	0.5782	0.7630
1	0.5676	0.5509	0.5994	0.5627	0.4740	0.7084	0.6072	0.4917	0.4808	0.4904	0.5333	0.4025	0.5136	0.4867	0.5434	0.6050	0.6532	0.7929
2	0.2304	0.2949	0.3091	0.3396	0.3535	0.3371	0.4265	0.3938	0.3790	0.4196	0.4244	0.3264	0.2778	0.3214	0.3374	0.3553	0.3753	0.3882
3	0.1144	0.1419	0.1813	0.2275	0.2498	0.2162	0.2849	0.3146	0.2854	0.3127	0.3629	0.2826	0.1982	0.2065	0.2213	0.2151	0.2154	0.1875
4	0.0589	0.0691	0.0788	0.0964	0.0977	0.0932	0.1122	0.1270	0.1295	0.1411	0.1382	0.1104	0.0938	0.0987	0.0978	0.0928	0.0882	0.0845
5	0.0861	0.0932	0.0982	0.1100	0.0987	0.1109	0.1218	0.1229	0.1296	0.1403	0.1290	0.1097	0.1094	0.1126	0.1115	0.1095	0.1047	0.1122
6	0.0547	0.1064	0.1171	0.1090	0.0932	0.0809	0.2150	0.1861	0.1052	0.1072	0.1905	0.1930	0.1253	0.1292	0.1027	0.0954	0.0839	0.1108
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
0	0.5241	0.5633	0.4443	0.5387	0.4280	0.4701	0.7266	0.7013	0.8089	1.7987	1.5971	1.6583	1.5127	1.3325	1.3299	0.5081	0.8664	0.7429
1	0.7183	0.5875	0.5025	0.4803	0.4228	0.5010	0.5611	0.5540	0.6618	0.6042	0.4703	0.4542	0.4110	0.3652	0.3605	0.3643	0.3233	0.3728
2	0.5008	0.3620	0.3412	0.2781	0.3156	0.3082	0.3484	0.3797	0.3108	0.3618	0.2709	0.2458	0.2591	0.2517	0.2282	0.3083	0.2526	0.3076
3	0.2358	0.2275	0.2057	0.1548	0.1751	0.1824	0.1817	0.1845	0.1395	0.1286	0.1309	0.1234	0.1294	0.1633	0.1338	0.2059	0.1892	0.2227
4	0.0992	0.1010	0.0892	0.0789	0.0877	0.0853	0.0926	0.0841	0.0729	0.0686	0.0674	0.0669	0.0725	0.0763	0.0755	0.0983	0.0950	0.1118
5	0.1187	0.1260	0.1090	0.1145	0.1160	0.1112	0.1181	0.1091	0.1103	0.1042	0.0998	0.1025	0.1061	0.1027	0.1105	0.1133	0.1169	0.1264
6	0.1266	0.0969	0.0946	0.0612	0.0923	0.0644	0.0640	0.0658	0.0737	0.0655	0.0513	0.0532	0.0436	0.0538	0.0574	0.0779	0.0907	0.0957
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Age	1999	2000
0	0.7357	0.7124
1	0.3710	0.4191
2	0.3132	0.2584
3	0.2269	0.1527
4	0.1011	0.0871
5	0.1092	0.1175
6	0.1319	0.0886
7	0.0000	0.0000
8	0.0000	0.0000
9	0.0000	0.0000

Predation mortality (M2) - Species Norway pout

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	1.0578	1.1153	1.0912	0.9394	0.8795	1.0365	1.0688	0.7592	0.8009	1.0736	0.9950	0.8201	0.9336	0.9823	0.9241	0.9020	0.8378	1.2031
1	0.9210	1.3115	1.5068	1.5397	1.2525	1.4648	2.2417	2.2617	2.1231	1.9893	1.9340	1.3892	1.5650	1.9838	1.5592	1.4912	1.1868	1.1949
2	0.5642	0.8388	0.9638	1.0730	0.9773	0.9749	1.3885	1.5486	1.5612	1.5162	1.5371	1.0979	1.0540	1.3533	1.1800	1.1361	0.9376	0.8464
3	0.4809	0.6575	0.8911	1.0449	1.1718	1.1149	1.4559	1.6239	1.8322	1.8565	1.7979	1.1720	0.9851	1.3456	1.1515	1.1797	1.0387	0.7829

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
0	0.8904	0.9392	0.8679	1.1588	1.1771	1.3050	2.0674	1.5795	1.5610	1.5563	1.2368	1.4495	1.5687	0.8936	1.4193	0.9706	1.5250	1.6659
1	1.8357	1.5565	1.2489	1.3978	1.7786	1.9205	1.8112	1.5394	1.3031	1.3954	1.3811	1.2260	1.4904	1.3999	1.5645	1.9493	1.7169	1.9902
2	1.3004	1.1374	0.9478	0.9407	1.2687	1.3795	1.3389	1.1693	0.9331	1.0076	0.9903	0.8769	1.0188	1.0634	1.0547	1.4295	1.2104	1.4542
3	1.2858	1.1349	1.0866	1.0121	1.3992	1.5023	1.3815	1.2691	0.9350	0.9661	1.0129	0.8775	1.0913	1.1799	1.1333	1.5451	1.3201	1.6318

Age	1999	2000
0	1.1453	2.4301
1	1.6473	1.5621
2	1.3280	1.0827
3	1.5335	1.0791

Predation mortality (M2) - Species Sandeel

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0.9321	0.9107	0.8787	0.7868	0.7778	1.1438	1.0643	0.6217	0.6674	0.9566	1.5394	1.0005	1.4340	0.9476	0.6231	0.8022	0.8047	1.0401
1	0.9682	1.0161	1.0040	0.8193	0.7618	1.1440	1.3503	1.0175	0.8114	1.0466	1.1136	0.8407	0.9227	0.9105	0.7484	0.8125	0.8126	0.8824
2	0.7606	0.7773	0.8095	0.6636	0.5096	0.5621	0.6223	0.4815	0.3546	0.4051	0.5084	0.3951	0.4878	0.4351	0.4137	0.4440	0.4608	0.5297
3	1.1309	1.1343	1.1573	0.9404	0.7185	0.6721	0.6682	0.4885	0.4214	0.4874	0.5351	0.4658	0.5536	0.4971	0.4564	0.4791	0.4869	0.5659
4	1.0159	0.9575	1.0052	0.7658	0.6056	0.6654	0.5408	0.3401	0.3033	0.3958	0.3740	0.3121	0.3866	0.3151	0.3167	0.3155	0.3238	0.4151

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
0	0.9333	1.0907	0.8854	1.2941	0.8672	1.1040	1.4311	1.1080	1.3925	1.2434	1.1107	1.3908	1.1155	1.1171	1.3774	0.8831	1.3645	1.4149
1	1.0819	0.6562	0.7167	0.6567	0.7584	0.6592	0.7619	0.8252	0.8125	0.8402	0.6080	0.6088	0.6566	0.5948	0.5969	0.6764	0.5236	0.7118
2	0.5911	0.4352	0.4089	0.4233	0.4062	0.4073	0.4407	0.4648	0.5270	0.5428	0.4216	0.4256	0.3973	0.3609	0.3804	0.3737	0.3480	0.3864
3	0.5847	0.4973	0.4691	0.4852	0.4661	0.4424	0.5092	0.4785	0.5848	0.5808	0.4828	0.5073	0.4538	0.4112	0.4566	0.4028	0.4177	0.4593
4	0.3484	0.3127	0.2650	0.2934	0.2567	0.2661	0.3326	0.2900	0.3653	0.3305	0.2726	0.2729	0.2503	0.2121	0.2513	0.2192	0.2208	0.2269

Age	1999	2000
0	1.2633	1.5770
1	0.8217	0.7453
2	0.4452	0.4571
3	0.4599	0.5456
4	0.2364	0.3113

Table 4.1.1 (Cont'd)

Predation mortality (M2) - Species Sprat

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0.6445	0.6411	0.5933	0.5833	0.5388	0.7679	0.7183	0.4862	0.5213	0.4865	0.5322	0.5098	0.4995	0.6020	0.5861	0.6124	0.6240	0.7928
1	1.2756	1.0625	1.1286	0.9681	0.8784	1.3119	0.9748	0.6922	0.5666	0.7874	0.8975	0.5911	0.8189	0.7540	0.8228	0.9260	0.9844	1.2277
2	1.0418	1.0676	1.0170	0.9391	0.7854	0.9868	0.9019	0.5920	0.5723	0.7521	0.7602	0.6233	0.6935	0.7563	0.7958	0.9125	0.9540	1.1599
3	0.5605	0.6015	0.5243	0.4978	0.3524	0.3960	0.4619	0.2344	0.2206	0.2755	0.3249	0.2650	0.2343	0.2764	0.2820	0.3327	0.3948	0.4359
4	0.7457	0.9514	0.7052	0.7402	0.4761	0.5922	0.7716	0.3978	0.3753	0.3928	0.4883	0.4122	0.3781	0.5007	0.5823	0.6259	0.7360	0.9160

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
0	0.6784	0.7960	0.6068	0.8062	0.6118	0.7843	1.5804	1.1291	1.3389	0.8297	0.7451	0.9711	0.6809	0.7589	0.9313	0.5392	0.7554	0.7293
1	1.1360	0.7951	0.7482	0.7141	0.7314	0.8024	0.8825	0.9884	1.1318	1.0908	0.7606	0.6812	0.6695	0.5374	0.5470	0.5613	0.4147	0.5381
2	1.0748	0.7866	0.7345	0.6705	0.6906	0.7180	0.8707	0.9609	1.0233	0.9950	0.6957	0.6850	0.6206	0.5221	0.5432	0.5113	0.4802	0.6722
3	0.5778	0.3271	0.3502	0.2642	0.3213	0.2755	0.3564	0.4480	0.3954	0.5198	0.3251	0.2992	0.2778	0.2480	0.2042	0.2613	0.1790	0.2444
4	1.0122	0.6533	0.6469	0.4942	0.5825	0.5419	0.7723	0.8401	0.7880	0.9944	0.6061	0.6312	0.5267	0.4605	0.4157	0.4756	0.3679	0.4072

Age	1999	2000
0	0.6613	0.8922
1	0.6870	0.6757
2	0.6223	0.7407
3	0.2644	0.2462
4	0.4444	0.5244

Predation mortality (M2) - Species Whiting

Age	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	2.0008	1.6834	1.6349	1.3005	0.9251	2.5235	1.8366	0.8793	0.8451	1.0784	2.1044	1.1409	1.6114	2.3448	1.3288	1.8625	1.3602	1.9407
1	0.6330	0.8246	0.9452	0.9710	0.8206	0.8117	1.0416	0.8414	0.7155	0.7702	0.9198	0.7049	0.6665	0.9763	0.7315	1.0111	0.9371	0.9653
2	0.1559	0.2157	0.2644	0.3213	0.3361	0.2602	0.3198	0.3295	0.2910	0.3066	0.3336	0.2722	0.2080	0.2243	0.2382	0.2466	0.2815	0.2524
3	0.0996	0.1307	0.1547	0.1825	0.1947	0.1494	0.1916	0.2188	0.1833	0.1693	0.2026	0.1838	0.1416	0.1465	0.1488	0.1414	0.1547	0.1479
4	0.1024	0.1350	0.1549	0.1719	0.1912	0.1471	0.1913	0.2102	0.1712	0.1653	0.2087	0.1923	0.1425	0.1530	0.1550	0.1528	0.1598	0.1663
5	0.1155	0.1334	0.1425	0.1549	0.1612	0.1353	0.1685	0.1851	0.1686	0.1599	0.1831	0.1851	0.1509	0.1668	0.1580	0.1619	0.1669	0.1746
6	0.0962	0.1221	0.1320	0.1505	0.1478	0.1256	0.1524	0.1650	0.1580	0.1552	0.1675	0.1503	0.1328	0.1437	0.1406	0.1364	0.1459	0.1489
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
0	2.5782	1.9708	1.3075	2.5068	1.2558	1.8108	2.0069	1.4048	2.2210	2.2589	1.7398	2.1444	1.9178	2.2561	3.0074	2.1665	2.6853	2.4573
1	1.7818	1.0197	0.9900	0.9618	0.8790	0.8050	0.8326	0.9906	0.9512	1.1967	0.8933	0.8887	0.9263	0.9853	0.9584	1.1285	0.9403	1.2344
2	0.3359	0.2878	0.2503	0.2016	0.2197	0.1950	0.1740	0.2016	0.1663	0.1576	0.1545	0.1396	0.1494	0.1690	0.1521	0.1936	0.1719	0.1845
3	0.1791	0.1773	0.1538	0.1255	0.1345	0.1303	0.1127	0.1245	0.1203	0.1164	0.1245	0.1223	0.1223	0.1408	0.1370	0.1616	0.1595	0.1620
4	0.1915	0.1842	0.1667	0.1350	0.1554	0.1522	0.1440	0.1431	0.1515	0.1467	0.1628	0.1708	0.1725	0.1965	0.1999	0.2229	0.2251	0.2318
5	0.2065	0.1979	0.1935	0.1669	0.2046	0.1990	0.2125	0.1969	0.2174	0.2345	0.2675	0.2963	0.3093	0.3385	0.3579	0.3867	0.3922	0.4227
6	0.1748	0.1645	0.1477	0.1317	0.1504	0.1475	0.1488	0.1445	0.1460	0.1532	0.1710	0.1838	0.1919	0.2137	0.2200	0.2446	0.2441	0.2614
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

(Continued)

Age	1999	2000
0	2.9805	2.8672
1	1.4940	1.0051
2	0.1928	0.1390
3	0.1757	0.1629
4	0.2487	0.2552
5	0.4372	0.4738
6	0.2730	0.2799
7	0.0000	0.0000
8	0.0000	0.0000

Table 4.1.2 Partial predation mortality (M2) summary

Prey Cod

Quarter	Age	Sea birds %	Cod %	Grey Gurnards %	Haddock %	NS. Mackerel %	Saithe %	Raja radiata %	Grey Seals %	Whiting %	West Mackerel %	All %	Average M2
1	1	37.1	29.0	3.1	_	_	_	_	4.4	26.4	_	100.0	0.248
	2	_	93.8	_	_	_	_	_	6.2	_	_	100.0	0.076
	3	_	22.3	_	_	_	_	_	77.7	_	_	100.0	0.035
	4	_	_	_	_	_	_	_	100.0	_	_	100.0	0.013
	5	_	_	_	_	_	_	_	100.0	_	_	100.0	0.012
	6	_	_	_	_	_	_	_	100.0	_	_	100.0	0.013
2	1	3.1	93.8	_	_	_	_	_	3.1	_	_	100.0	0.320
	2	_	92.5	_	_	_	_	_	7.5	_	_	100.0	0.052
	3	_	65.8	_	_	_	_	_	34.2	_	_	100.0	0.062
	4	_	43.4	_	_	_	_	_	56.6	_	_	100.0	0.011
	5	_	_	_	_	_	_	_	100.0	_	_	100.0	0.012
	6	_	_	_	_	_	_	_	100.0	_	_	100.0	0.035
3	0	5.3	2.3	60.9	0.0	5.4	3.3	3.3	0.4	13.7	5.4	100.0	1.270
	1	_	81.9	_	_	_	_	_	18.1	_	_	100.0	0.030
	2	_	93.7	_	_	_	_	_	6.3	_	_	100.0	0.047
	3	_	16.4	_	_	_	_	_	83.6	_	_	100.0	0.013
	4	_	68.9	_	_	_	_	_	31.1	_	_	100.0	0.001
	5	_	_	_	_	_	_	_	100.0	_	_	100.0	0.000
4	0	17.1	2.4	62.2	_	_	_	_	0.2	18.2	_	100.0	0.880
	1	_	34.9	_	_	_	_	_	65.1	_	_	100.0	0.024
	2	_	70.5	_	_	_	_	_	29.5	_	_	100.0	0.030
	3	_	16.1	_	_	_	_	_	83.9	_	_	100.0	0.030
	4	_	_	_	_	_	_	_	100.0	_	_	100.0	0.009
	5	_	_	_	_	_	_	_	100.0	_	_	100.0	0.005
	6	_	_	_	_	_	_	_	100.0	_	_	100.0	0.012
All	0	10.1	2.3	61.4	0.0	3.2	1.9	1.9	0.3	15.6	3.2	100.0	2.150
	1	16.4	65.1	1.2	_	_	_	_	6.7	10.5	_	100.0	0.622
	2	_	90.0	_	_	_	_	_	10.0	_	_	100.0	0.205
	3	_	39.6	_	_	_	_	_	60.4	_	_	100.0	0.139
	4	_	15.6	_	_	_	_	_	84.4	_	_	100.0	0.034
	5	_	_	_	_	_	_	_	100.0	_	_	100.0	0.029
	6	_	_	_	_	_	_	_	100.0	_	_	100.0	0.060

Partial predation mortality (M2) summary, Prey Haddock

Quarter	Age	Sea birds %	Cod %	Grey Gurnards %	Haddock %	Horse Mackerel %	Saithe %	Grey Seals %	Whiting %	All %	Average M2
1	1	1.8	22.4	_	_	_	50.2	0.0	25.6	100.0	0.578
	2	_	89.8	_	_	_	2.3	0.3	7.6	100.0	0.047
	3	_	85.5	_	_	_	0.1	14.4	_	100.0	0.008
	4	_	92.0	_	_	_	0.3	7.7	_	100.0	0.013
	5	_	14.0	_	_	_	_	86.0	_	100.0	0.020
	6	_	46.8	_	_	_	_	53.2	_	100.0	0.017
2	1	1.1	49.0	0.4	_	_	6.8	0.1	42.6	100.0	0.173
	2	_	60.9	_	_	_	10.5	0.5	28.2	100.0	0.034
	3	_	88.8	_	_	_	3.3	7.9	_	100.0	0.018
	4	_	84.1	_	_	_	_	15.9	_	100.0	0.015
	5	_	17.4	_	_	_	_	82.6	_	100.0	0.023
	6	_	60.5	_	_	_	_	39.5	_	100.0	0.013
3	0	0.6	4.4	5.1	0.7	8.1	40.5	0.0	40.6	100.0	1.142
	1	_	11.9	_	0.5	_	86.7	0.2	0.7	100.0	0.408
	2	_	93.9	_	_	_	0.7	5.4	_	100.0	0.017
	3	_	74.0	_	_	_	_	26.0	_	100.0	0.016
	4	_	92.5	_	_	_	_	7.5	_	100.0	0.011
	5	_	12.0	_	_	_	_	88.0	_	100.0	0.023
	6	_	_	_	_	_	_	100.0	_	100.0	0.002
4	0	1.3	20.8	8.2	1.2	_	17.9	0.0	50.7	100.0	0.922
	1	_	78.8	_	_	_	0.5	2.9	17.8	100.0	0.066
	2	_	97.5	_	_	_	0.1	2.4	_	100.0	0.012
	3	_	79.6	_	_	_	_	20.4	_	100.0	0.009
	4	_	50.9	_	_	_	_	49.1	_	100.0	0.003
	5	_	6.5	_	_	_	_	93.5	_	100.0	0.024
	6	_	_	_	_	_	_	100.0	_	100.0	0.004
All	0	0.9	11.7	6.5	1.0	4.5	30.4	0.0	45.1	100.0	2.064
	1	1.0	25.7	0.1	0.2	_	53.5	0.3	19.3	100.0	1.225
	2	_	82.3	_	_	_	4.4	1.4	12.0	100.0	0.109
	3	_	82.0	_	_	_	1.2	16.8	_	100.0	0.052
	4	_	86.3	_	_	_	0.1	13.6	_	100.0	0.043
	5	_	12.4	_	_	_	_	87.6	_	100.0	0.090
	6	_	43.7	_	_	_	_	56.3	_	100.0	0.037

Table 4.1.2 (Cont'd)

Partial predation mortality (M2) summary, Prey Herring

		Predator											
Quarter	Age	Sea birds %	Cod %	Haddock %	Horse Mackerel %	NS. Mackerel %	Saithe %	Raja radiata %	Grey Seals %	Whiting %	West Mackerel %	All %	Average M2
1	1	_	18.2	0.3	_	_	8.7	_	_	72.8	_	100.0	0.134
	2	0.1	27.0	1.7	_	_	20.5	_	0.0	50.8	_	100.0	0.187
	3	1.0	42.1	_	_	_	55.0	_	0.0	1.9	_	100.0	0.089
	4	12.8	50.6	_	_	_	36.1	_	0.5	_	_	100.0	0.032
	5	49.2	39.3	_	_	_	9.6	_	1.9	_	_	100.0	0.013
	6	_	100.0	_	_	_	_	_	_	_	_	100.0	0.006
2	1	_	44.5	_	_	10.6	0.2	_	_	44.6	_	100.0	0.086
	2	1.4	62.2	_	_	_	36.2	0.1	_	0.1	_	100.0	0.050
	3	9.8	51.5	_	_	_	38.5	0.2	_	_	_	100.0	0.022
	4	29.7	32.0	_	_	_	38.1	0.3	_	_	_	100.0	0.007
	5	48.7	24.0	_	_	_	27.1	0.1	_	_	_	100.0	0.015
3	0	_	0.2	_	52.4	4.6	3.9	0.7	_	31.9	6.3	100.0	0.363
	1	_	7.6	_	_	_	1.2	_	0.0	91.2	_	100.0	0.254
	2	0.9	27.0	_	_	_	22.4	_	0.1	49.6	_	100.0	0.065
	3	1.2	69.8	_	_	_	28.8	_	0.1	_	_	100.0	0.079
	4	21.9	39.1	_	_	_	38.1	_	1.0	_	_	100.0	0.027
	5	59.4	20.7	_	_	_	16.6	_	3.3	_	_	100.0	0.024
	6	_	8.2	_	_	_	91.8	_	_	_	_	100.0	0.041
4	0	_	2.9	0.2	46.5	5.9	15.0	_	_	29.0	0.4	100.0	0.418
	1	_	37.2	_	_	_	26.8	19.3	0.0	16.7	_	100.0	0.041
	2	2.6	26.4	_	_	_	60.7	9.8	0.2	0.2	_	100.0	0.026
	3	11.8	16.7	_	_	_	64.6	6.5	0.4	_	_	100.0	0.012
	4	27.5	13.6	_	_	_	57.6	0.8	0.5	_	_	100.0	0.027
	5	56.6	16.2	_	_	_	26.4	_	0.8	_	_	100.0	0.059
	6	_	100.0	_	_	_	_	_	_	_	_	100.0	0.052
All	0	_	1.7	0.1	49.2	5.3	9.9	0.3	_	30.4	3.1	100.0	0.781
	1	_	18.9	0.1	_	1.8	5.0	1.5	0.0	72.7	_	100.0	0.515
	2	0.6	32.3	0.9	_	_	26.5	0.8	0.0	38.8	_	100.0	0.329
	3	2.7	52.4	_	_	_	43.6	0.4	0.1	0.8	_	100.0	0.203
	4	21.0	35.1	_	_	_	43.1	0.2	0.6	_	_	100.0	0.093
	5	55.3	21.0	_	_	_	22.4	0.0	1.3	_	_	100.0	0.112
	6	_	62.0	_	_	_	38.0	_	_	_	_	100.0	0.099

Partial predation mortality (M2) summary
Prey Norway pout

		Predator										
Quarter	Age	Cod %	Grey Gurnards %	Haddock %	Horse Mackerel %	NS. Mackerel %	Saithe %	Raja radiata %	Whiting %	West Mackerel %	All %	Average M2
1	1	6.4	9.8	15.2	_	_	32.8	3.0	32.8	_	100.0	0.350
	2	9.5	1.7	3.4	_	_	70.2	1.9	13.3	_	100.0	0.430
	3	4.9	0.7	_	_	_	87.3	3.4	3.7	_	100.0	0.646
2	1	3.9	1.5	0.3	_	0.3	81.7	0.1	12.2	_	100.0	0.557
	2	8.3	4.3	0.1	_	_	76.2	0.2	11.0	_	100.0	0.368
	3	25.8	3.6	_	_	_	68.5	_	2.2	_	100.0	0.413
3	0	1.6	2.3	11.1	2.2	15.2	22.9	0.2	25.1	19.4	100.0	0.307
	1	8.4	2.5	0.4	_	0.6	70.4	1.6	14.4	1.8	100.0	0.369
	2	20.9	1.8	0.6	_	_	69.9	0.1	6.6	_	100.0	0.211
	3	18.3	1.6	_	_	_	40.0	_	40.0	_	100.0	0.133
4	0	1.1	0.1	4.8	0.3	2.6	13.2	0.2	43.5	34.1	100.0	0.873
	1	16.9	_	13.5	_	_	43.0	5.0	21.5	_	100.0	0.320
	2	9.4	_	0.3	_	_	28.2	5.2	57.0	_	100.0	0.135
	3	14.2	_	_	_	_	85.8	_	_	_	100.0	0.018
All	0	1.2	0.6	6.5	0.8	5.9	15.8	0.2	38.7	30.3	100.0	1.180
	1	8.1	3.3	6.2	_	0.3	60.6	2.1	19.1	0.4	100.0	1.596
	2	11.2	2.4	1.5	_	_	67.1	1.4	16.5	_	100.0	1.144
	3	13.6	1.8	_	_	_	75.6	1.8	7.1	_	100.0	1.209

Table 4.1.2 (Cont'd)

Partial predation mortality (M2)

Prey Sandeel

Quarter	Age	Sea birds %	Cod %	Grey Gurnards %	Haddock %	Horse Mackerel %	NS. Mackerel %	Saithe %	Raja radiata %	Whiting %	West Mackerel %	All %	Average M2
1	1	2.4	2.9	1.3	15.0	_	1.7	24.9	6.9	44.2	0.8	100.0	0.217
	2	29.3	10.6	2.0	3.6	_	_	10.8	2.5	41.3	_	100.0	0.036
	3	_	26.3	14.6	6.3	_	_	0.0	12.4	40.4	_	100.0	0.005
	4	_	44.1	4.5	16.4	_	_	_	4.9	30.1	_	100.0	0.006
2	1	7.1	9.4	4.3	15.7	_	8.2	15.1	0.7	38.0	1.6	100.0	0.491
	2	6.4	8.0	7.0	7.7	_	18.4	3.6	5.5	41.8	1.6	100.0	0.302
	3	23.0	8.6	4.5	4.4	_	32.3	3.6	4.6	18.5	0.6	100.0	0.309
	4	_	11.6	3.4	5.5	_	48.3	4.1	3.8	22.9	0.4	100.0	0.189
3	0	3.3	0.7	7.5	8.9	14.8	5.7	2.5	0.9	17.8	37.7	100.0	0.917
	1	11.2	4.3	4.8	1.2	0.4	2.2	1.5	1.6	44.8	27.9	100.0	0.076
	2	14.2	3.5	0.4	3.0	_	4.9	0.1	0.4	38.3	35.3	100.0	0.109
	3	33.6	1.3	4.3	3.1	_	11.2	_	0.3	18.8	27.4	100.0	0.178
	4	_	1.1	2.6	15.6	_	35.6	_	_	21.5	23.6	100.0	0.096
4	0	5.8	2.2	21.9	19.0	0.1	5.6	0.2	2.0	42.5	0.5	100.0	0.159
	1	_	5.6	7.5	5.5	_	8.9	_	1.5	71.0	0.1	100.0	0.040
	2	13.8	10.7	1.9	_	_	_	_	1.4	72.1	_	100.0	0.033
	3	_	8.8	2.7	0.1	_	_	_	0.7	87.7	_	100.0	0.075
	4	_	8.9	0.8	_	_	_	_	0.3	89.9	_	100.0	0.100
All	0	3.7	0.9	9.7	10.4	12.6	5.7	2.2	1.1	21.5	32.2	100.0	1.076
	1	5.9	7.1	3.7	13.7	0.0	5.9	15.7	2.4	41.8	3.7	100.0	0.824
	2	10.4	7.4	4.7	5.8	_	12.7	3.1	3.8	43.1	9.0	100.0	0.481
	3	23.1	6.5	4.3	3.5	_	21.1	2.0	2.8	28.0	8.9	100.0	0.567
	4	_	8.9	2.5	6.7	_	32.1	2.0	2.0	39.8	6.0	100.0	0.392

Partial predation mortality (M2) summary

Prey Sprat

Quarter	Age	Cod %	Grey Gurnards %	Haddock %	Horse Mackerel %	NS. Mackerel %	Saithe %	Whiting %	West Mackerel %	All %	Average M2
1	1	6.5	_	0.6	_	_	0.0	92.9	_	100.0	0.236
	2	12.6	_	0.9	_	_	6.1	80.5	_	100.0	0.238
	3	13.4	_	0.0	_	_	5.6	81.0	_	100.0	0.212
	4	16.4	_	_	_	_	_	83.6	_	100.0	0.345
2	1	0.9	0.7	0.0	0.7	8.3	0.1	84.4	4.9	100.0	0.309
	2	10.3	0.3	0.1	_	22.8	_	66.5	0.0	100.0	0.122
	3	7.2	_	_	_	48.5	_	44.3	_	100.0	0.069
	4	0.1	_	_	_	79.1	_	20.8	_	100.0	0.032
3	0	0.0	5.9	0.0	82.1	_	0.0	11.9	0.1	100.0	0.547
	1	0.3	0.4	0.3	_	8.0	_	90.9	0.0	100.0	0.167
	2	0.6	_	_	_	_	_	99.4	_	100.0	0.208
	3	1.3	_	_	_	_	_	98.7	_	100.0	0.042
	4	_	_	_	_	_	_	100.0	_	100.0	0.001
4	0	0.2	1.8	_	5.0	1.7	_	74.7	16.7	100.0	0.178
	1	3.6	_	_	_	15.6	0.0	80.2	0.6	100.0	0.123
	2	4.9	_	_	_	5.4	0.1	89.5	0.1	100.0	0.220
	3	3.4	_	_	_	28.4	0.1	67.8	0.3	100.0	0.021
	4	5.1	_	_	_	_	_	94.9	_	100.0	0.227
All	0	0.0	4.9	0.0	63.1	0.4	0.0	27.3	4.1	100.0	0.725
	1	2.7	0.4	0.2	0.3	7.0	0.0	87.5	1.9	100.0	0.836
	2	6.9	0.1	0.3	_	5.0	1.9	85.8	0.0	100.0	0.788
	3	10.1	_	0.0	_	11.4	3.4	75.0	0.0	100.0	0.344
	4	11.3	_	_	_	4.2	_	84.5	_	100.0	0.605

Table 4.1.2 (Cont'd)

Partial predation mortality (M2), Prey Whiting

Quarter	Age	Sea birds %	Cod %	Grey Gurnards %	Haddock %	Horse Mackerel %	NS. Mackerel %	Saithe %	Raja radiata %	Grey Seals %	Whiting %	West Mackerel %	All %	Average M2
1	1	2.0	27.2	24.2	_	_	_	0.1	_	0.1	46.4	_	100.0	0.425
	2	_	92.1	_	_	_	_	0.5	_	2.8	4.7	_	100.0	0.085
	3	_	82.6	_	_	_	_	0.3	_	17.0	0.1	_	100.0	0.054
	4	_	51.6	_	_	_	_	0.0	_	48.4	_	_	100.0	0.063
	5	_	34.7	_	_	_	_	_	_	65.3	_	_	100.0	0.063
	6	_	57.9	_	_	_	_	_	_	42.1	_	_	100.0	0.035
2	1	0.5	22.5	23.0	_	_	_	0.1	1.1	0.2	52.7	_	100.0	0.342
	2	_	94.0	_	_	_	_	5.3	0.1	0.6	_	_	100.0	0.081
	3	_	88.9	_	_	_	_	8.4	_	2.7	_	_	100.0	0.046
	4	_	83.0	_	_	_	_	12.0	_	5.1	_	_	100.0	0.056
	5	_	68.2	_	_	_	_	16.3	_	15.6	_	_	100.0	0.040
	6	_	73.5	_	_	_	_	19.4	_	7.1	_	_	100.0	0.040
3	0	0.5	2.0	18.6	0.0	10.3	0.4	6.8	0.2	0.0	59.7	1.5	100.0	0.911
	1	_	45.3	29.4	_	_	_	21.5	_	0.8	3.1	_	100.0	0.076
	2	_	95.2	_	_	_	_	0.1	_	4.7	_	_	100.0	0.017
	3	_	60.3	_	_	_	_	2.7	_	37.0	_	_	100.0	0.012
	4	_	43.9	_	_	_	_	6.9	_	49.2	_	_	100.0	0.011
	5	_	28.7	_	_	_	_	2.2	_	69.1	_	_	100.0	0.013
	6	_	16.4	_	_	_	_	8.9	_	74.6	_	_	100.0	0.004
4	0	1.1	1.6	61.9	0.4	_	_	2.8	_	0.2	32.1	_	100.0	0.982
	1	_	65.2	0.7	_	_	_	0.1	18.1	15.9	_	_	100.0	0.108
	2	_	72.8	_	_	_	_	0.0	8.7	18.4	_	_	100.0	0.047
	3	_	39.2	_	_	_	_	_	_	60.8	_	_	100.0	0.040
	4	_	29.2	_	_	_	_	_	_	70.8	_	_	100.0	0.044
	5	_	8.9	_	_	_	_	_	_	91.1	_	_	100.0	0.110
	6	_	27.1	_	_	_	_	_	_	72.9	_	_	100.0	0.088
All	0	0.8	1.8	41.1	0.2	4.9	0.2	4.8	0.1	0.1	45.4	0.7	100.0	1.893
	1	1.1	31.2	21.5	_	_	_	1.8	2.4	2.0	39.9	_	100.0	0.951
	2	_	89.0	_	_	_	_	2.1	1.8	5.3	1.7	_	100.0	0.229
	3	_	71.5	_	_	_	_	2.9	_	25.6	0.0	_	100.0	0.152
	4	_	55.6	_	_	_	_	4.3	_	40.1	_	_	100.0	0.174
	5	_	27.7	_	_	_	_	3.0	_	69.3	_	_	100.0	0.226
	6	_	44.3	_	_	_	_	4.8	_	50.9	_	_	100.0	0.167

Table 4.1.3 Summary

Species Cod

Year	Mean F Ages 2 to 8	Recruits Age 0 1.July (millions)	Recruits Age 1 1.January (millions)	Yield ('000' t)	Stock Biomass 1.January ('000' t)	Spawning Stock Biomass 1.January ('000' t)	Eaten by model predators ('000' t)	Dead by other causes ('000' t)
1963	0.461	2797	168	99	285	137	43	52
1964	0.470	3671	375	110	335	152	62	62
1965	0.533	4562	494	162	426	190	88	76
1966	0.501	3636	655	196	523	214	103	93
1967	0.597	709	673	232	573	232	94	96
1968	0.601	3498	245	279	585	242	83	94
1969	0.561	9778	297	204	500	244	125	86
1970	0.538	2963	1134	226	503	259	113	89
1971	0.656	541	1102	320	592	253	109	97
1972	0.821	1195	200	371	603	213	69	89
1973	0.684	4656	423	251	463	195	89	73
1974	0.671	1713	284	202	405	210	54	67
1975	0.700	1101	447	186	360	185	45	60
1976	0.682	11946	208	196	358	157	120	58
1977	0.700	1532	830	192	339	138	65	63
1978	0.779	4793	520	265	405	137	92	63
1979	0.671	3036	566	239	443	145	79	73
1980	0.770	1725	1064	265	447	157	92	75
1981	0.749	23783	441	311	518	172	258	81
1982	0.863	3640	704	281	424	167	88	64
1983	0.878	3114	327	247	349	134	65	52
1984	0.823	3741	588	208	304	113	67	50
1985	0.805	2416	129	203	301	106	45	45
1986	0.853	1792	648	192	247	95	52	43
1987	0.871	1209	250	192	260	85	36	40
1988	0.873	977	166	176	245	81	30	36
1989	0.928	1034	248	122	176	73	27	28
1990	0.708	1463	117	107	167	64	27	26
1991	0.871	1614	134	88	148	61	28	23
1992	0.789	1696	248	88	149	59	31	25
1993	0.837	3053	115	104	169	57	41	27
1994	0.808	4082	270	94	173	58	56	30
1995	0.670	6278	186	121	195	63	69	33
1996	0.860	5809	138	106	200	69	74	34
1997	0.843	2868	354	102	193	71	53	34
1998	0.907	5612	50	122	203	63	62	31
1999	0.982	15868	121	78	151	55	133	25
2000	0.803	6541	190	59	117	47	63	21
Avg.	0.740	4222	398	184	338	136	75	56

Table 4.1.3 (Cont'd)

Species Haddock

Year	Mean F Ages 2 to 6	Recruits Age 0 1.July (millions)	Recruits Age 1 1.January (millions)	Yield ('000' t)	Stock Biomass 1.January ('000' t)	Spawning Stock Biomass 1.January ('000' t)	Eaten by model predators ('000' t)	Dead by other causes ('000' t)
1963	0.725	1139	11759	274	830	92	414	145
1964	0.899	9055	181	420	889	331	195	159
1965	0.832	28517	1016	368	784	522	430	136
1966	0.889	50081	2899	458	658	430	730	115
1967	0.833	155652	6023	291	582	220	2128	201
1968	0.614	28898	32235	311	2103	191	1691	327
1969	1.130	32057	3169	1115	2122	733	787	338
1970	1.104	88270	2139	965	1411	905	1193	226
1971	0.766	107442	12837	526	1194	410	1861	198
1972	1.058	59914	14696	409	1247	270	1508	163
1973	0.901	108355	5660	346	816	262	1597	158
1974	0.868	87742	12509	371	1035	244	1739	177
1975	1.037	12484	15075	520	1191	199	947	163
1976	1.063	20684	1643	430	665	262	377	105
1977	1.063	27582	1597	250	398	217	420	65
1978	1.075	43155	3053	201	330	114	673	64
1979	1.065	54966	4167	171	376	88	851	81
1980	0.982	29020	7260	228	623	114	710	97
1981	0.724	38504	2293	221	533	197	630	96
1982	0.693	18554	3020	215	564	276	374	89
1983	0.961	29148	2037	230	440	219	445	77
1984	1.007	14276	4720	194	506	166	356	80
1985	0.945	14898	1593	245	467	186	274	82
1986	1.053	32470	1677	232	397	205	456	70
1987	1.002	4762	3608	170	407	132	203	60
1988	1.012	5762	389	193	306	139	103	46
1989	0.855	7140	644	106	198	117	115	29
1990	0.953	19166	768	85	141	69	261	28
1991	0.808	12865	2019	78	185	48	226	34
1992	0.932	21266	1782	123	243	70	315	48
1993	0.875	7743	2717	169	346	106	190	55
1994	0.895	20428	886	149	298	129	273	60
1995	0.737	13511	3447	140	384	131	290	65
1996	0.944	11279	1066	153	364	149	193	65
1997	0.762	20288	1666	137	357	179	324	64
1998	0.773	19356	1817	127	324	149	335	53
1999	1.013	57797	1387	110	238	111	769	65
2000	0.927	25115	7985	103	538	73	734	84
Avg.	0.915	35246	4827	285	645	223	661	110

Table 4.1.3 (Cont'd)

Species Herring

Year	Mean F Ages 2 to 6	Recruits Age 0 1.July (millions)	Recruits Age 1 1.January (millions)	Yield ('000' t)	Stock Biomass 1.January ('000' t)	Spawning Stock Biomass 1.January ('000' t)	Eaten by model predators ('000' t)	Dead by other causes ('000' t)
1963	0.201	36291	15136	596	2061	1879	776	263
1964	0.306	48519	15570	883	2215	2028	783	265
1965	0.628	26383	22157	1285	2103	1837	729	234
1966	0.560	17549	11915	907	1704	1561	556	183
1967	0.739	28694	8572	778	1286	1183	456	139
1968	1.240	29206	16370	857	1021	825	602	115
1969	0.995	15614	13793	515	797	631	481	94
1970	0.999	23715	7192	517	724	637	368	81
1971	1.281	18399	13625	550	614	450	347	77
1972	0.610	13349	10590	450	606	422	347	72
1973	1.026	6136	6485	449	540	418	259	53
1974	0.972	13030	2756	266	305	250	153	34
1975	1.364	2746	6016	254	243	158	116	26
1976	1.314	2219	928	159	180	146	65	17
1977	0.605	3399	917	39	87	70	43	9
1978	0.040	3645	1583	11	91	67	60	13
1979	0.053	9956	1799	24	137	106	100	21
1980	0.229	13256	4873	59	214	145	205	33
1981	0.312	23176	5350	167	316	226	230	44
1982	0.227	34512	7825	231	406	285	314	63
1983	0.312	30072	12172	313	615	426	351	91
1984	0.394	21190	11107	314	892	682	403	119
1985	0.578	34381	10229	548	1110	857	429	135
1986	0.502	45126	20485	519	1199	862	647	167
1987	0.494	33936	26445	729	1636	1049	888	212
1988	0.491	25147	14226	750	1840	1336	723	209
1989	0.495	21969	11047	752	1642	1382	546	186
1990	0.396	51237	8169	600	1364	1181	716	161
1991	0.446	31916	7810	573	1129	951	467	132
1992	0.524	60547	5603	577	955	764	586	116
1993	0.658	46119	8843	521	830	552	510	106
1994	0.716	28230	7467	467	799	598	391	99
1995	0.761	35614	5805	532	776	608	407	98
1996	0.404	24051	6631	264	691	512	289	90
1997	0.331	15983	12345	208	822	567	365	120
1998	0.426	12150	6179	327	1164	866	408	140
1999	0.355	9135	5355	330	1126	931	343	129
2000	0.343	19735	3629	325	997	860	294	120
Avg.	0.588	24114	9395	464	927	745	415	112

Table 4.1.3 (Cont'd)

Species Norway pout

Year	Mean F Ages 1 to 2	Recruits Age 0 1.July (millions)	Recruits Age 1 1.January (millions)	Yield ('000' t)	Stock Biomass 1.January ('000' t)	Spawning Stock Biomass 1.January ('000' t)	Eaten by model predators ('000' t)	Dead by other causes ('000' t)
1963	0.451	102035	21403	137	386	239	611	102
1964	0.177	167791	30667	61	386	177	999	124
1965	0.094	215455	49130	43	556	220	1357	158
1966	0.088	135659	64988	52	753	309	1233	158
1967	0.337	195774	47386	182	695	371	1215	169
1968	1.074	431619	71481	451	819	330	2270	259
1969	0.245	577504	133768	113	1177	262	3496	328
1970	0.411	393321	178184	237	1628	410	2966	310
1971	0.488	403614	163631	305	1559	440	2999	322
1972	0.732	227878	160340	444	1532	435	2582	259
1973	0.867	369678	65872	345	804	354	2023	209
1974	2.053	225295	119755	721	1018	199	1560	213
1975	1.018	424625	85245	494	817	234	2159	255
1976	0.965	285423	143651	429	1275	292	2350	243
1977	0.693	121760	92961	363	939	303	1309	164
1978	0.786	182720	42639	231	572	281	1122	140
1979	1.086	224517	66201	330	647	194	1287	184
1980	1.149	140613	86897	521	896	302	1332	185
1981	0.856	357413	37806	426	585	326	1626	190
1982	1.162	234950	107617	355	917	181	1748	207
1983	1.000	180889	82376	445	884	321	1358	193
1984	1.279	177601	66804	340	795	338	1361	160
1985	1.147	153686	49206	217	552	216	1132	113
1986	1.315	239199	42476	176	409	118	1421	125
1987	1.004	114008	55648	146	492	111	1126	94
1988	0.781	163188	12978	101	203	115	933	79
1989	0.942	178455	28924	161	271	73	1062	98
1990	0.881	156860	31618	127	325	108	1009	94
1991	0.867	207282	29502	152	327	125	1140	117
1992	0.882	151635	52699	257	510	149	1124	126
1993	0.843	108836	31609	173	432	216	874	89
1994	1.129	281265	19973	176	265	128	1164	139
1995	0.471	191314	101081	183	821	130	1769	184
1996	0.388	266455	41033	122	627	346	1573	169
1997	0.524	184031	89829	129	833	219	1821	175
1998	0.262	192240	36095	61	539	292	1464	121
1999	0.691	296660	32738	84	388	165	1558	153
2000	0.525	83019	84773	175	746	167	1326	140
Avg.	0.781	230112	69973	249	721	242	1565	172

Table 4.1.3 (Cont'd)

Species Plaice

Year	Mean F Ages 2 to 10	Recruits Age 0 1.July (millions)	Recruits Age 1 1.January (millions)	Yield ('000' t)	Stock Biomass 1.January ('000' t)	Spawning Stock Biomass 1.January ('000' t)	Eaten by model predators ('000' t)	Dead by other causes ('000' t)
1963	0.264	1068	313	109	547	437	0	46
1964	0.273	323	1016	117	630	420	0	54
1965	0.276	319	307	106	580	412	0	50
1966	0.259	289	303	106	587	414	0	51
1967	0.243	256	275	112	589	490	0	50
1968	0.221	342	244	120	547	453	0	46
1969	0.254	387	325	130	514	415	0	43
1970	0.333	288	368	146	499	390	0	41
1971	0.316	245	274	111	475	362	0	39
1972	0.341	566	233	113	468	364	0	38
1973	0.381	472	539	117	458	326	0	37
1974	0.391	351	449	101	439	298	0	36
1975	0.366	339	333	93	455	303	0	38
1976	0.315	493	322	103	436	310	0	36
1977	0.335	450	469	112	456	320	0	38
1978	0.329	465	428	108	453	312	0	37
1979	0.458	691	442	138	453	299	0	36
1980	0.399	446	658	125	471	288	0	38
1981	0.401	1079	424	126	454	289	0	37
1982	0.442	623	1027	141	540	289	0	44
1983	0.420	642	593	138	535	316	0	44
1984	0.389	563	611	156	555	322	0	45
1985	0.380	1322	536	163	541	354	0	44
1986	0.441	567	1258	165	652	360	0	54
1987	0.435	592	539	158	638	394	0	53
1988	0.402	434	563	160	617	371	0	51
1989	0.371	423	413	177	578	412	0	47
1990	0.353	414	402	173	537	383	0	44
1991	0.428	416	394	168	468	332	0	37
1992	0.450	286	395	143	421	287	0	33
1993	0.463	244	272	119	370	256	0	29
1994	0.486	325	232	112	314	221	0	24
1995	0.460	250	309	98	292	201	0	23
1996	0.500	836	238	82	259	173	0	21
1997	0.567	258	796	84	321	154	0	26
1998	0.476	244	246	72	331	200	0	28
1999	0.487	377	232	81	328	192	0	27
2000	0.343	375	359	84	314	217	0	26
Avg.	0.380	475	451	123	477	325	0	39

Table 4.1.3 (Cont'd)

Species Saithe

Year	Mean F Ages 3 to 6	Recruits Age 0 1.July (millions)	Recruits Age 1 1.January (millions)	Yield ('000' t)	Stock Biomass 1.January ('000' t)	Spawning Stock Biomass 1.January ('000' t)	Eaten by model predators ('000' t)	Dead by other causes ('000' t)
1963	0.275	168	201	24	183	97	0	39
1964	0.370	206	152	43	231	105	0	49
1965	0.417	165	186	56	285	93	0	60
1966	0.350	473	149	84	355	117	0	72
1967	0.291	440	428	81	408	157	0	85
1968	0.287	513	398	94	556	208	0	119
1969	0.245	258	464	114	725	257	0	155
1970	0.434	251	233	230	903	291	0	178
1971	0.335	265	227	264	989	398	0	186
1972	0.403	301	240	298	849	437	0	154
1973	0.425	715	273	269	778	464	0	141
1974	0.585	218	647	283	775	470	0	139
1975	0.505	155	197	281	761	410	0	139
1976	0.801	139	140	378	683	278	0	114
1977	0.652	114	126	224	467	220	0	77
1978	0.484	295	103	144	394	203	0	68
1979	0.406	178	266	110	371	194	0	67
1980	0.462	212	161	115	370	190	0	68
1981	0.314	350	192	108	453	203	0	86
1982	0.503	527	317	155	466	166	0	86
1983	0.620	436	477	168	439	171	0	84
1984	0.822	169	394	211	465	134	0	91
1985	0.862	198	153	248	457	103	0	84
1986	0.955	108	179	227	407	93	0	74
1987	0.704	187	97	217	323	95	0	54
1988	0.665	218	169	150	255	99	0	44
1989	0.702	154	198	119	229	83	0	43
1990	0.629	240	139	104	247	75	0	48
1991	0.584	167	217	117	262	73	0	49
1992	0.638	371	151	108	273	80	0	53
1993	0.512	175	336	103	315	87	0	60
1994	0.509	290	159	100	332	95	0	66
1995	0.423	145	262	114	459	120	0	92
1996	0.418	142	131	110	459	141	0	90
1997	0.280	206	128	103	472	185	0	93
1998	0.327	216	186	100	409	186	0	78
1999	0.331	215	195	107	394	206	0	74
2000	0.286	225	195	82	444	204	0	88
Avg.	0.495	258	233	154	464	189	0	88

Table 4.1.3 (Cont'd)

Species Sandeel

Year	Mean F Ages 1 to 2	Recruits Age 0 1.July (millions)	Recruits Age 1 1.January (millions)	Yield ('000' t)	Stock Biomass 1.January ('000' t)	Spawning Stock Biomass 1.January ('000' t)	Eaten by model predators ('000' t)	Dead by other causes ('000' t)
1963	0.158	483158	172033	162	1439	768	1480	303
1964	0.111	477661	168572	128	1417	760	1482	304
1965	0.118	358859	171004	130	1479	812	1397	296
1966	0.132	269860	131880	143	1306	792	1048	281
1967	0.200	561049	107706	188	1231	811	1118	306
1968	0.194	387653	228535	193	1618	727	1521	317
1969	0.131	227335	107909	113	1223	802	1009	239
1970	0.457	475281	68600	191	948	680	770	233
1971	0.334	254327	225760	188	1151	270	903	266
1972	0.264	668882	107957	259	1313	892	1240	314
1973	0.206	638068	230005	224	1645	748	1764	335
1974	0.291	702636	123715	340	1434	952	1272	350
1975	0.309	565063	228553	359	1746	855	1632	368
1976	0.435	621001	118224	426	1338	877	1180	296
1977	0.499	648585	214390	588	1540	704	1193	353
1978	0.547	542587	304351	800	1936	749	1425	379
1979	0.484	690170	191699	684	1790	1042	1393	385
1980	0.616	351960	250593	724	1851	873	1322	328
1981	0.522	1154235	107996	528	1220	799	1620	299
1982	0.567	265401	382106	595	2003	513	1314	415
1983	0.371	835418	75038	530	1571	1278	1266	374
1984	0.406	381733	302242	750	2018	839	1339	390
1985	0.928	1343226	94692	707	1272	903	1540	317
1986	0.470	732605	503146	685	2363	400	2017	546
1987	0.389	428038	216013	791	2571	1729	1659	525
1988	0.904	1014294	92289	1007	1912	1552	1608	368
1989	0.677	578123	294902	826	1580	430	1365	255
1990	0.815	917985	128614	584	1096	595	1380	226
1991	0.820	934128	233917	898	1314	402	1422	300
1992	0.469	496244	265760	820	1690	654	1270	349
1993	0.389	868689	108965	576	1524	1099	1394	366
1994	0.524	926067	244470	770	1811	857	1605	415
1995	0.433	540303	273977	915	2011	942	1429	429
1996	0.578	1675624	121696	776	1785	1310	2026	492
1997	0.407	547625	608386	1114	3067	694	1971	671
1998	0.589	694170	125539	1000	2701	2212	1616	501
1999	0.576	1257306	138469	718	1756	1216	1951	381
2000	0.754	497464	306687	692	1863	666	1490	348
Avg.	0.449	658232	204642	556	1672	874	1432	358

Table 4.1.3 (Cont'd)

Species Sole

Year	Mean F Ages 2 to 8	Recruits Age 0 1.July (millions)	Recruits Age 1 1.January (millions)	Yield ('000' t)	Stock Biomass 1.January ('000' t)	Spawning Stock Biomass 1.January ('000' t)	Eaten by model predators ('000' t)	Dead by other causes ('000' t)
1963	0.365	579	10	35	77	75	0	6
1964	0.228	127	551	15	82	53	0	7
1965	0.246	43	120	21	124	48	0	11
1966	0.240	78	40	38	121	104	0	10
1967	0.308	104	74	36	109	100	0	8
1968	0.373	52	99	35	102	88	0	8
1969	0.423	147	50	29	85	70	0	6
1970	0.351	43	140	20	76	62	0	6
1971	0.444	80	41	22	71	52	0	5
1972	0.393	111	76	18	64	55	0	5
1973	0.452	115	105	16	56	41	0	4
1974	0.462	43	110	16	60	42	0	4
1975	0.462	119	41	19	58	42	0	4
1976	0.404	147	113	15	54	43	0	4
1977	0.381	49	139	16	57	35	0	4
1978	0.493	12	46	19	58	38	0	4
1979	0.460	162	11	19	52	45	0	4
1980	0.442	156	154	13	45	35	0	3
1981	0.447	160	148	14	51	24	0	4
1982	0.495	151	152	20	61	34	0	4
1983	0.465	75	143	24	68	42	0	5
1984	0.552	86	71	26	67	45	0	5
1985	0.514	168	81	23	55	42	0	4
1986	0.499	76	160	17	54	35	0	4
1987	0.429	467	72	17	55	31	0	4
1988	0.496	114	444	21	72	41	0	5
1989	0.391	189	109	22	97	36	0	8
1990	0.434	77	180	33	113	90	0	9
1991	0.469	371	74	35	103	77	0	8
1992	0.449	74	353	32	104	77	0	8
1993	0.528	61	70	31	103	55	0	8
1994	0.528	105	58	33	86	74	0	6
1995	0.557	55	100	30	72	59	0	5
1996	0.645	294	52	22	52	37	0	4
1997	0.535	144	280	15	50	30	0	4
1998	0.546	92	137	21	65	23	0	5
1999	0.462	100	88	23	67	45	0	5
2000	0.456	85	96	22	62	46	0	4
Avg.	0.443	135	126	23	74	52	0	6

Table 4.1.3 (Cont'd)

Species Sprat

Year	Mean F Ages 1 to 2	Recruits Age 0 1.July (millions)	Recruits Age 1 1.January (millions)	Yield ('000' t)	Stock Biomass 1.January ('000' t)	Spawning Stock Biomass 1.January ('000' t)	Eaten by model predators ('000' t)	Dead by other causes ('000' t)
1963	0.067	480981	231244	67	1276	963	1533	281
1964	0.067	318901	228334	70	1260	952	1364	273
1965	0.077	378782	151828	76	1137	932	1178	244
1966	0.131	430898	189188	107	1109	853	1128	259
1967	0.058	355173	217363	71	1200	907	1124	288
1968	0.058	253236	187345	71	1407	1155	1315	262
1969	0.057	160642	105890	69	1034	891	775	192
1970	0.055	236864	67200	62	742	651	443	174
1971	0.079	293650	127109	86	903	732	579	232
1972	0.073	605584	154906	108	1143	934	1078	309
1973	0.132	740129	330986	261	1752	1305	1598	427
1974	0.129	360691	377570	278	2181	1671	1466	525
1975	0.278	649285	194556	568	2412	2150	1666	519
1976	0.323	341964	355845	527	2200	1719	1440	454
1977	0.215	304880	166947	283	1590	1365	1211	324
1978	0.430	460991	152524	400	1397	1191	1104	286
1979	0.551	250277	225546	412	1050	746	900	198
1980	0.721	205336	120969	305	754	591	706	120
1981	0.790	76799	83631	180	436	323	348	64
1982	0.851	41442	34993	139	236	189	150	37
1983	0.890	122391	16869	82	128	105	132	34
1984	0.624	37805	60234	78	203	122	169	48
1985	0.259	32694	15191	49	202	181	147	42
1986	0.116	105517	16042	15	176	154	154	43
1987	0.877	130391	43570	44	187	129	251	45
1988	0.704	193556	24285	82	190	157	270	44
1989	0.810	123799	56612	63	227	151	292	46
1990	0.172	86967	29331	41	194	155	216	40
1991	0.321	132889	34315	69	217	171	211	55
1992	0.336	192208	56795	103	275	198	303	73
1993	0.452	337975	65638	180	367	278	405	108
1994	0.435	132984	154539	323	645	437	423	150
1995	0.717	55509	55524	357	615	540	311	116
1996	0.579	68820	19519	135	346	319	141	59
1997	0.320	99671	36313	100	213	163	160	60
1998	0.513	162156	42254	162	278	221	263	77
1999	0.433	127874	70031	188	359	265	273	80
2000	0.438	64512	59624	195	392	311	265	77
Avg.	0.372	240901	120017	169	801	639	671	175

Table 4.1.3 (Cont'd)

Species Whiting

Year	Mean F Ages 2 to 6	Recruits Age 0 1.July (millions)	Recruits Age 1 1.January (millions)	Yield ('000' t)	Stock Biomass 1.January ('000' t)	Spawning Stock Biomass 1.January ('000' t)	Eaten by model predators ('000' t)	Dead by other causes ('000' t)
1963	0.908	13710	5965	233	509	287	278	89
1964	0.589	22565	1637	141	484	405	295	92
1965	0.566	19587	3689	176	552	419	327	94
1966	1.059	22191	3428	242	476	348	316	76
1967	0.761	30314	5426	207	451	255	363	86
1968	0.853	22029	10763	237	711	325	517	119
1969	0.627	19183	1565	319	618	531	305	97
1970	0.772	10683	2225	286	455	376	172	66
1971	0.486	17780	3251	174	311	194	199	59
1972	0.705	30636	6090	208	448	228	378	87
1973	0.915	32348	9085	286	669	338	601	109
1974	1.011	24287	3507	323	556	412	320	93
1975	1.148	33475	6887	276	591	343	461	109
1976	1.000	55265	5887	326	655	428	738	109
1977	0.779	26780	4636	289	598	422	357	103
1978	0.702	44929	6006	205	586	366	602	107
1979	0.683	27020	6117	249	650	423	428	109
1980	0.847	36834	6050	235	668	443	531	114
1981	0.787	35358	4664	202	635	456	590	94
1982	0.628	17299	2350	140	443	356	277	73
1983	0.713	14404	2143	167	369	288	211	61
1984	0.905	30509	3213	147	334	218	405	59
1985	0.765	17095	2207	100	280	195	219	54
1986	0.870	24620	4308	168	374	219	347	70
1987	1.102	24489	3527	161	385	252	332	70
1988	0.842	25236	2933	181	381	269	308	71
1989	0.939	32069	5358	153	438	246	458	80
1990	0.866	22572	3109	204	413	291	331	68
1991	0.646	14480	2033	145	316	240	198	55
1992	0.629	23219	2043	121	301	225	288	56
1993	0.686	19080	2393	109	302	214	262	54
1994	0.667	21673	2363	86	286	198	306	53
1995	0.609	36249	2015	97	283	207	432	57
1996	0.555	9333	1476	68	255	198	175	43
1997	0.453	33991	944	53	209	173	409	47
1998	0.408	58728	2093	39	218	142	681	57
1999	0.455	52454	4542	54	316	153	740	61
2000	0.491	58905	2399	57	276	186	677	67
Avg.	0.748	27931	3903	181	442	297	390	78

Table 4.1.4 Average estimated predation mortality (M2) by species and age group and residual natural mortality (M1); average for the whole period assessed, 1963-2000 (Note that the predation mortality for the 0-group refers exclusively to the second half of the year).

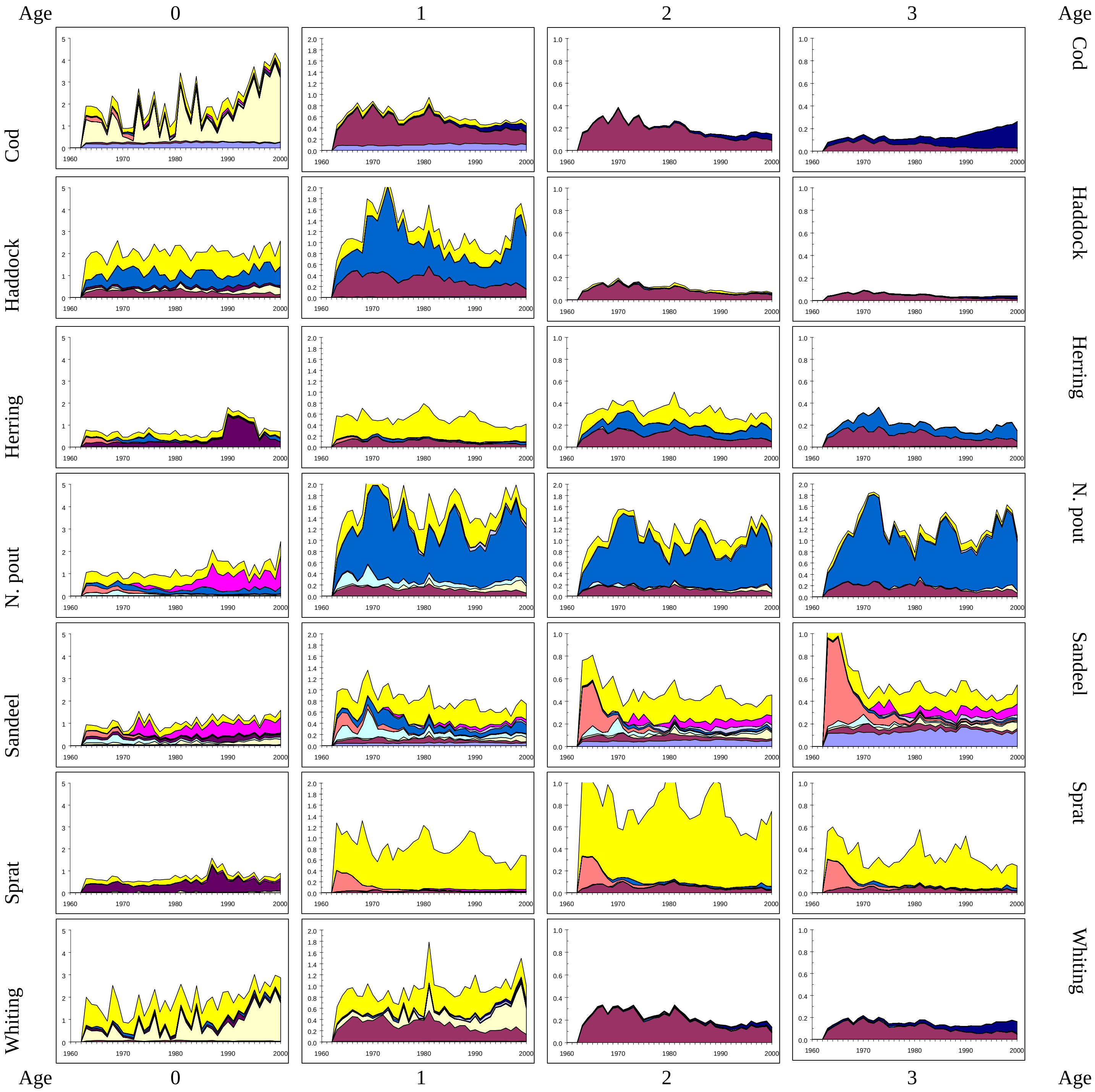
	Predation Mortality M2							M1
Age	0	1	2	3	4	5	6	all
Species								ages
Cod	2.151	0.622	0.205	0.139	0.033	0.029	(0.058)	0.2
Haddock	2.064	1.226	0.108	0.052	0.043	0.090	0.036	0.2
Herring	0.781	0.514	0.329	0.203	0.093	0.112	0.099	0.1
N.Pout	1.181	1.595	1.144	1.209				0.2
Sandeel	1.076	0.824	0.481	0.568	0.393			0.2
Sprat	0.726	0.836	0.787	0.343	0.605			0.2
Whiting	1.894	0.952	0.229	0.151	0.174	0.226	0.167	0.2

Table 4.1.5 Average estimated predation mortality (M2) by species and age group and residual natural mortality (M1); average for recent years, 1995-2000 (Note that the predation mortality for the 0-group refers exclusively to the second half of the year).

	Predation Mortality M2							M1
Age	0	1	2	3	4	5	6	all
Species								ages
Cod	3.710	0.513	0.152	0.225	0.068	0.067	(0.138)	0.2
Haddock	2.240	1.263	0.072	0.040	0.030	0.185	0.055	0.2
Herring	0.817	0.367	0.278	0.188	0.095	0.117	0.092	0.1
N.Pout	1.528	1.738	1.258	1.373				0.2
Sandeel	1.312	0.680	0.400	0.458	0.245			0.2
Sprat	0.752	0.572	0.593	0.232	0.440			0.2
Whiting	2.697	1.127	0.170	0.160	0.232	0.412	0.252	0.2

Table 4.1.6 System summary

Year	VPA species Stock Biomass 1.Jan ('000' t)	VPA species Spawning Stock Biomass 1.jan ('000' t)	VPA species Yield ('000' t)	Average stock biomass of other predators ('000' t)	VPA species Eaten by model predators ('000' t)	Other food eaten by model predators ('000' t)	Total consumption by model predators ('000' t)	VPA species Dead by other causes ('000' t)
1963	7596	4981	1740	3264	5138	7824	12962	1331
1964	7932	5387	1992	3043	5182	7627	12810	1393
1965	8031	5490	2428	2793	5509	7134	12643	1363
1966	7598	5146	2337	2470	5118	6918	12037	1302
1967	7129	4731	2182	2128	6502	8114	14616	1432
1968	9476	4549	2654	1664	8002	8186	16189	1671
1969	8798	4839	2726	1596	6981	8158	15139	1584
1970	7894	4665	2884	1062	6028	5875	11903	1408
1971	7864	3566	2550	980	7000	5399	12400	1485
1972	8278	4255	2682	1026	7206	5381	12587	1495
1973	7986	4455	2569	1598	7934	6924	14859	1551
1974	8212	4751	2905	1091	6567	5739	12306	1643
1975	8639	4882	3055	1286	7030	5647	12677	1686
1976	7847	4518	2993	984	6273	5096	11369	1440
1977	6475	3799	2360	593	4601	3857	8459	1204
1978	6227	3461	2388	729	5081	4507	9588	1166
1979	5974	3287	2381	698	5042	4319	9361	1161
1980	6342	3142	2595	686	4900	4713	9614	1067
1981	5206	3020	2287	1213	5305	5513	10819	998
1982	6063	2459	2277	936	4268	4196	8465	1085
1983	5402	3303	2348	1020	3831	4107	7938	1019
1984	6143	2982	2426	1259	4103	4809	8913	1052
1985	5241	3149	2508	1130	3791	4431	8223	924
1986	6282	2546	2401	1335	5097	4259	9357	1202
1987	6959	4009	2629	1645	4498	4976	9474	1161
1988	6026	4163	2825	1510	3978	4513	8492	958
1989	5440	3007	2505	1663	3868	4810	8678	825
1990	4603	3014	2063	1554	3942	4798	8741	748
1991	4473	2484	2328	1626	3696	4409	8105	817
1992	4925	2568	2377	1870	3920	5103	9024	892
1993	4763	2925	2091	1788	3679	4949	8628	906
1994	5015	2800	2315	1732	4222	4848	9071	1047
1995	5912	3005	2592	1796	4710	5251	9961	1107
1996	5042	3260	1843	1577	4475	4320	8795	1071
1997	6541	2439	2050	1785	5106	4950	10057	1299
1998	6235	4358	2035	1712	4832	5784	10617	1095
1999	5127	3342	1778	2065	5769	6217	11986	1006
2000	5754	2781	1800	1781	4853	6425	11278	980
Mean	6565	3724	2392	1544	5211	5529	10741	1199



Legend for predators: Sea Birds, Cod, Gurnard, Haddock, Horse Mackerel, NS Mackerel, Saithe, Rays, Seals, W.Mackerel, Whiting

Figure 4.1.1. Partial predation mortality per species-age group as a function of year and predator species. Note the varying vertical scales.

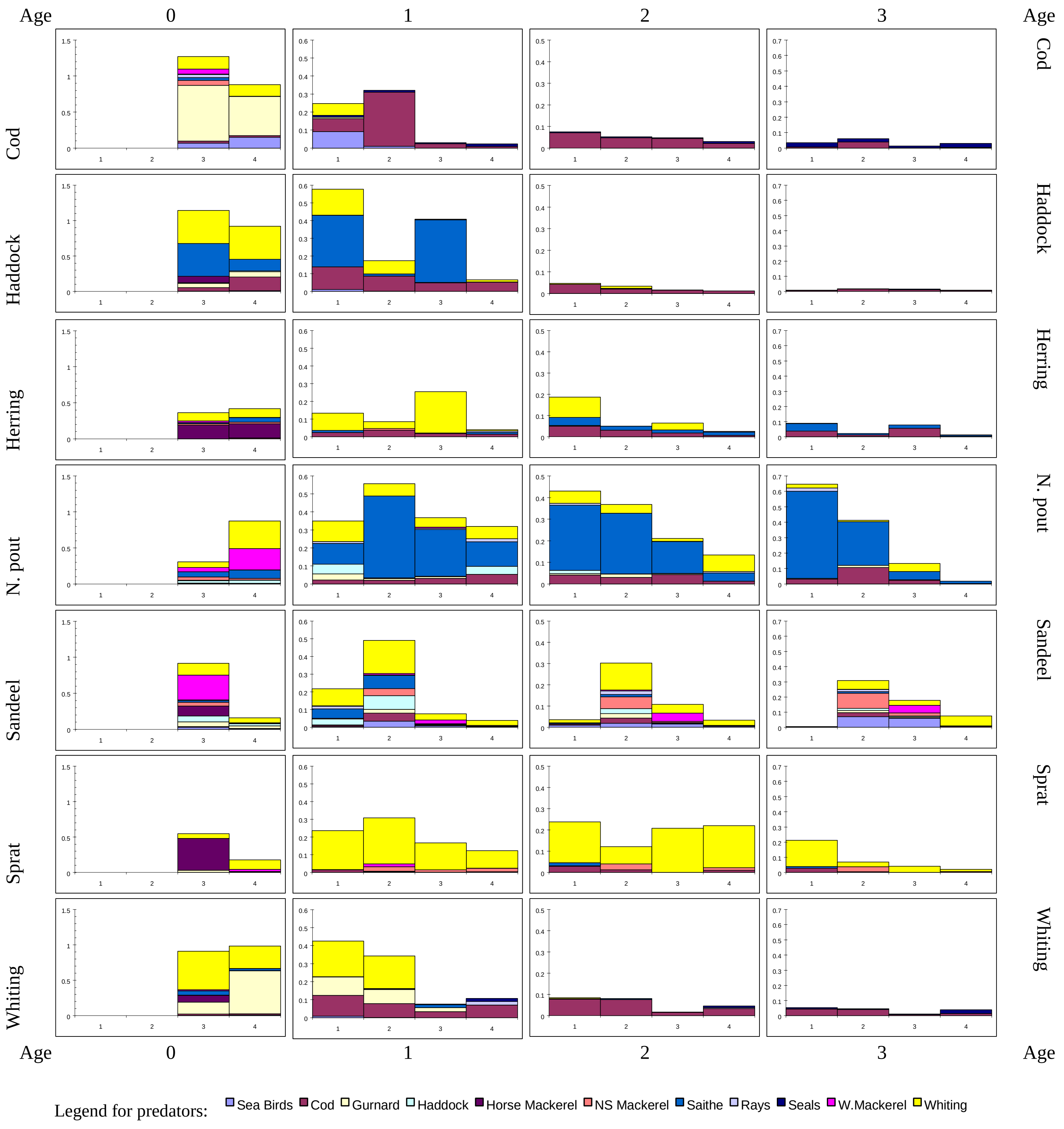


Figure 4.1.2. Partial predation mortality per species-age group as a function of quarter and predator species. Horizontal axis of each sub-plot: quarter; vertical scale: partial predation mortality on a quarterly basis. Note the varying vertical scales per age-group.

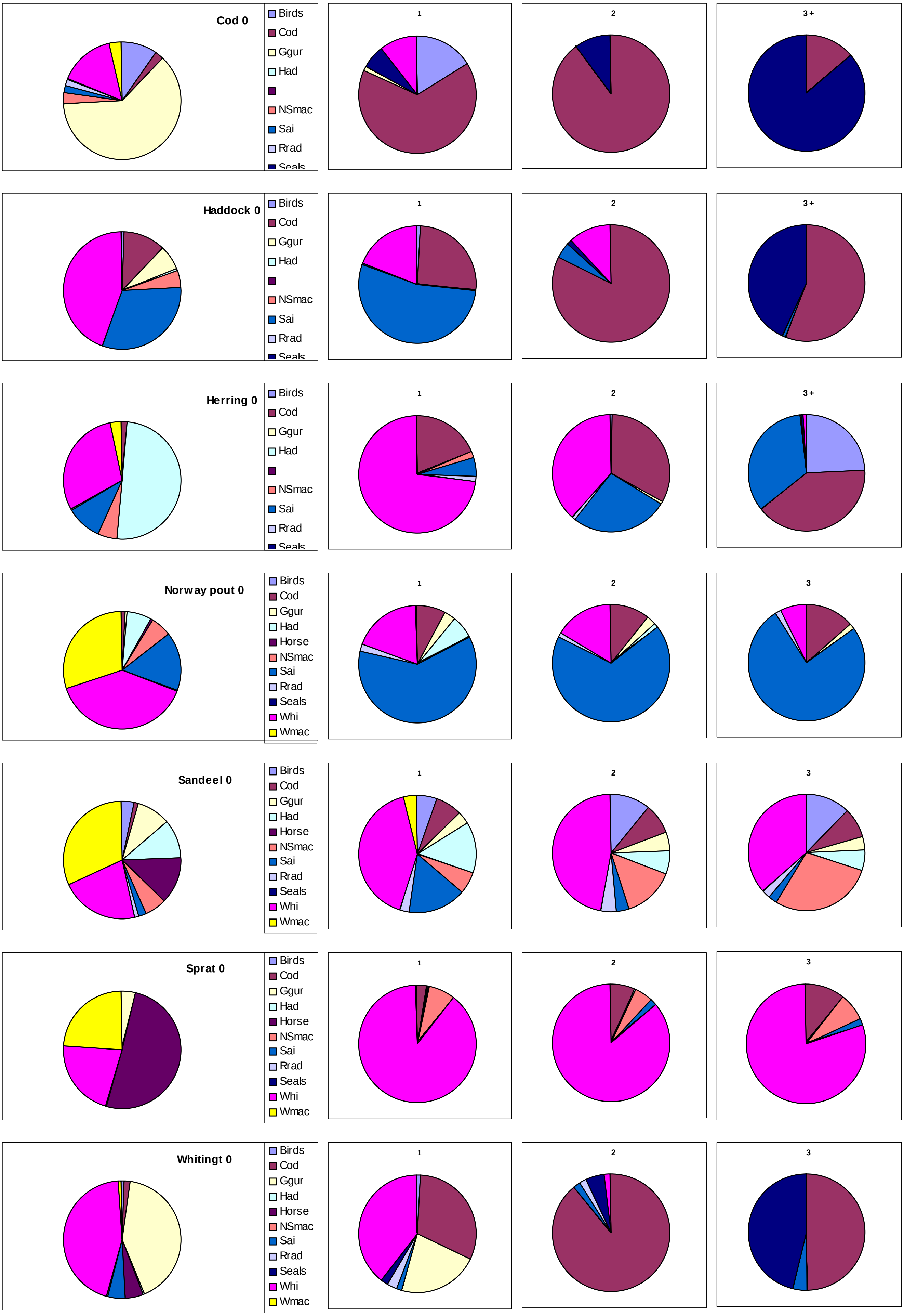


Figure 4.1.3 Percentage of the predation mortality on prey age groups caused by different predators.

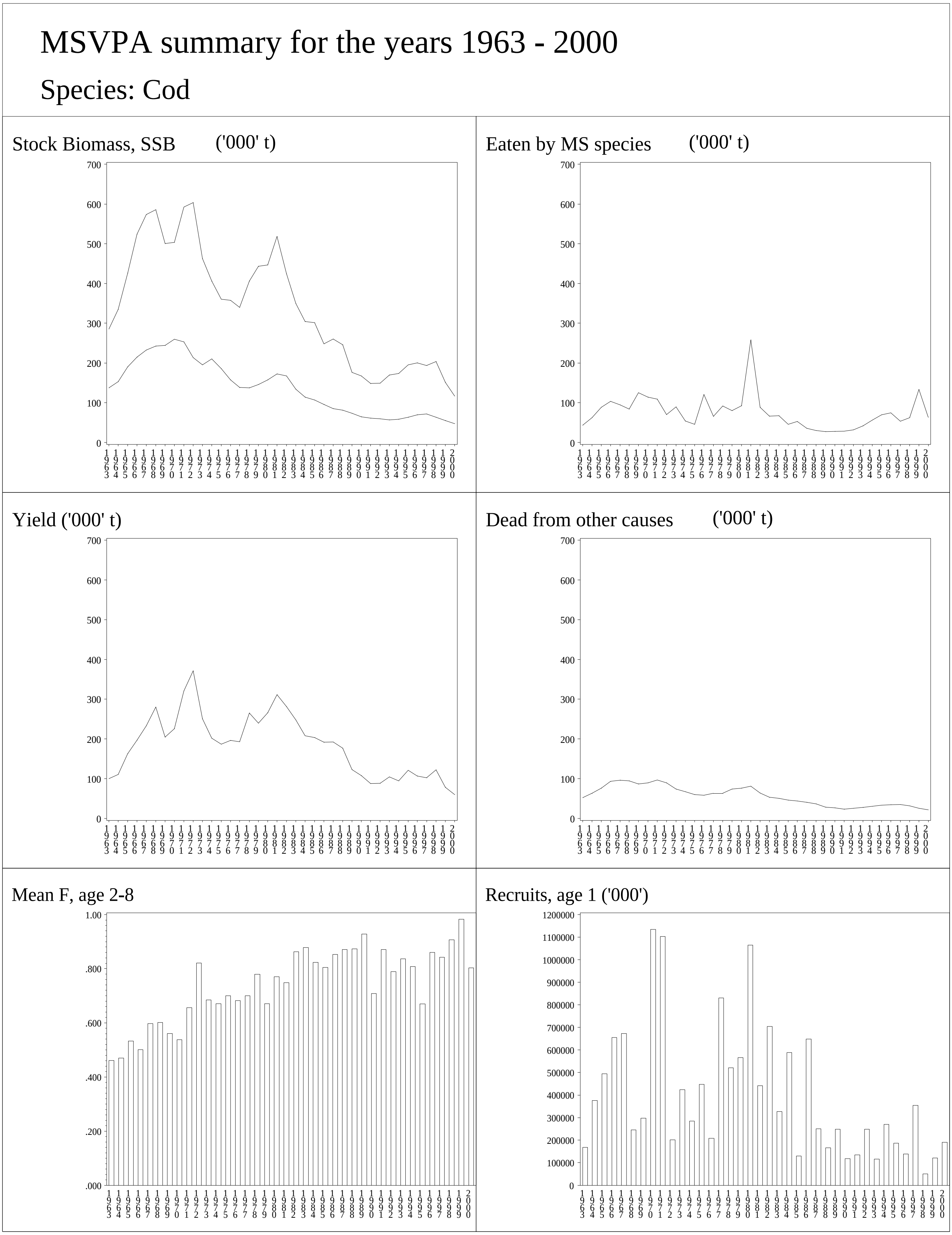


Figure 4.1.4. MSVPA summary

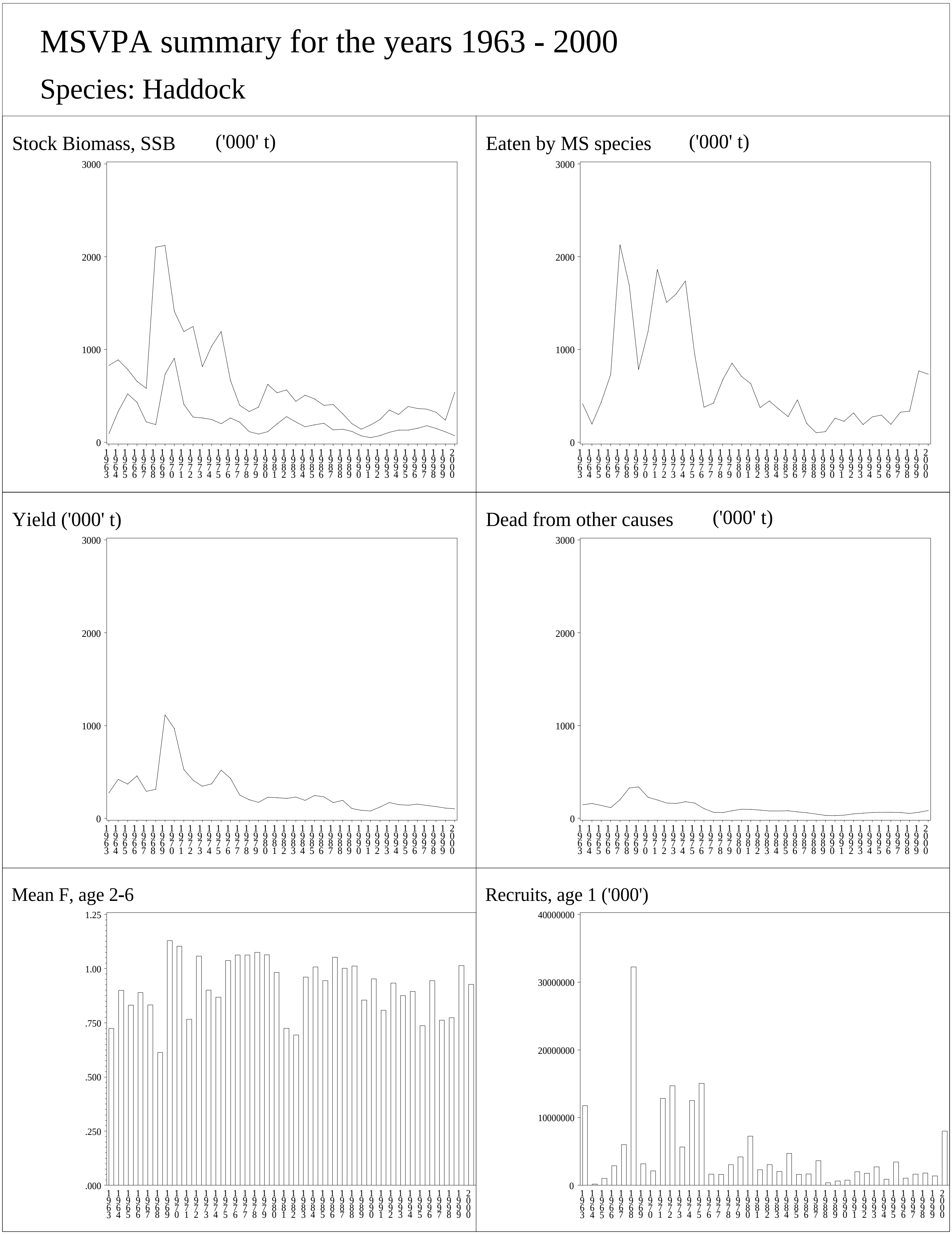


Figure 4.1.4 (continued). MSVPA summary

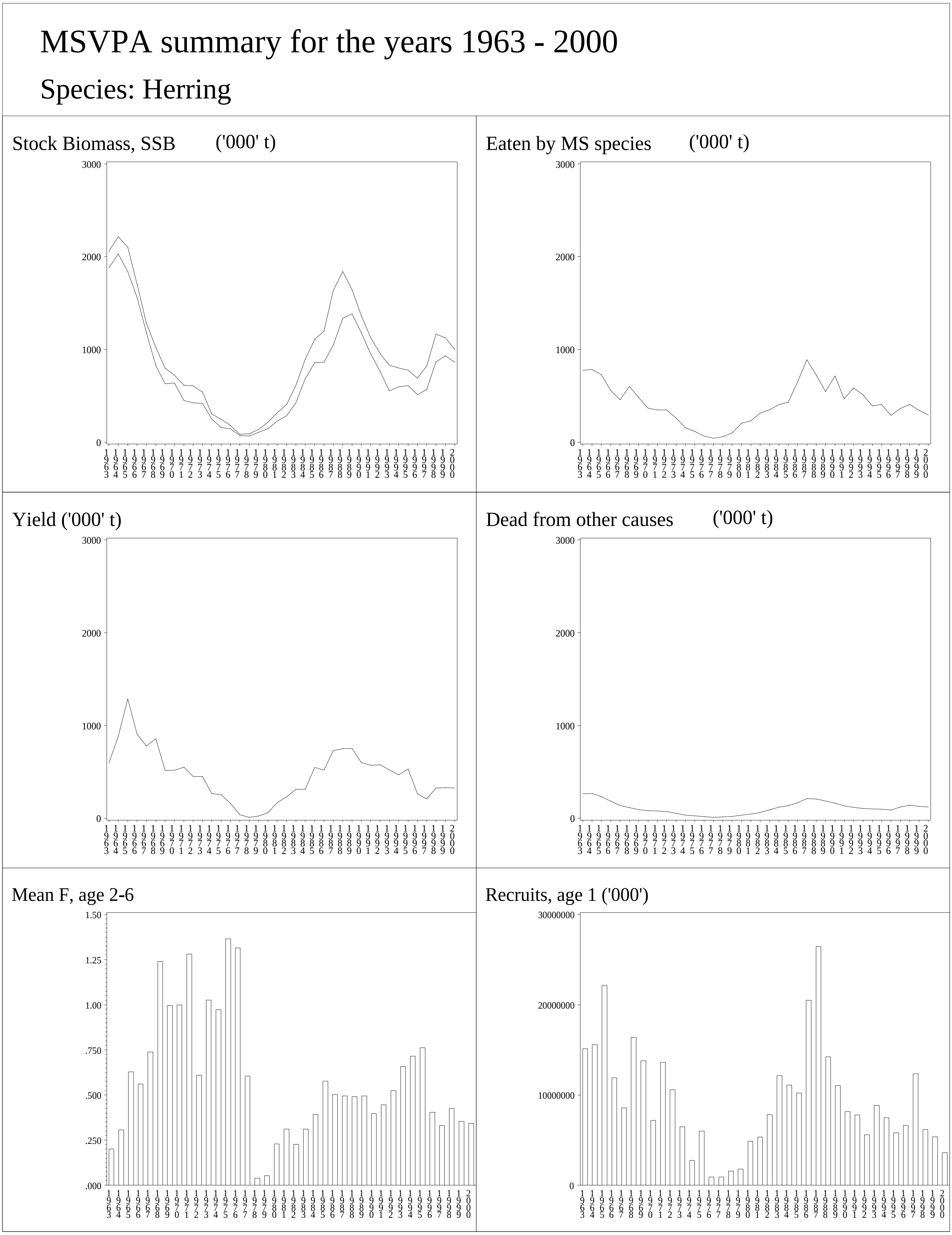


Figure 4.1.4 (continued). MSVPA summary

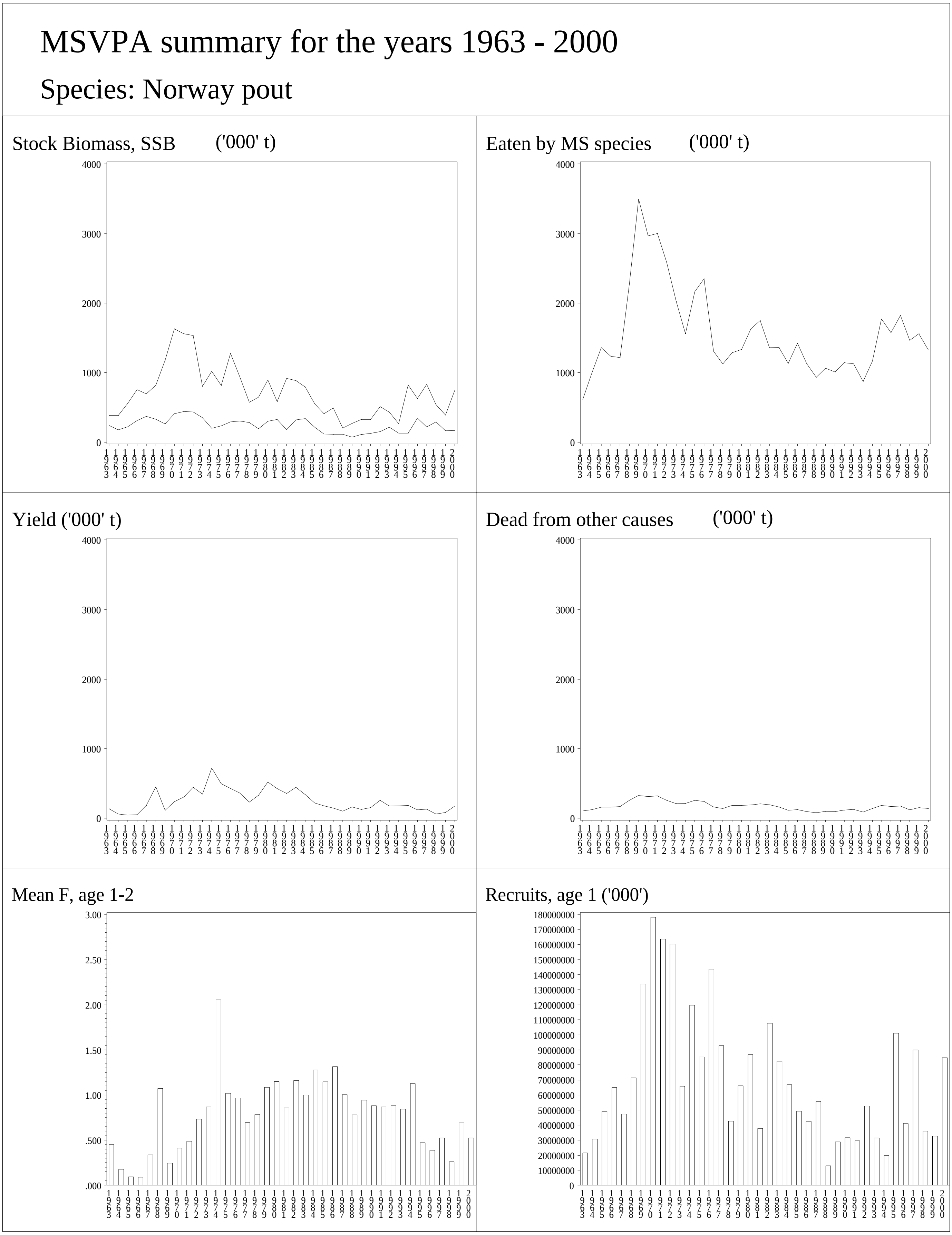


Figure 4.1.4 (continued). MSVPA summary

MSVPA summary for the years 1963 - 2000

Species: Plaice

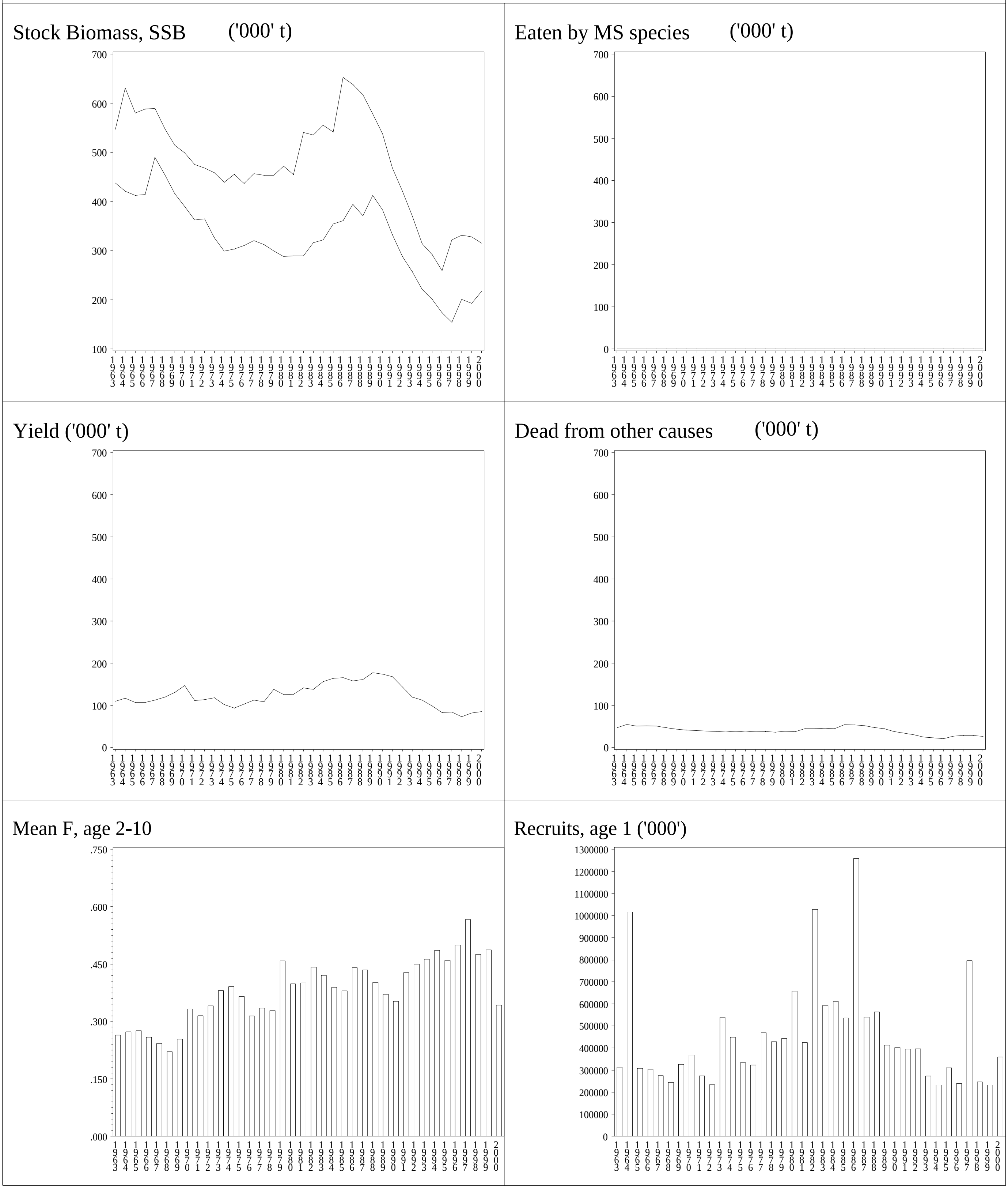


Figure 4.1.4 (continued). MSVPA summary

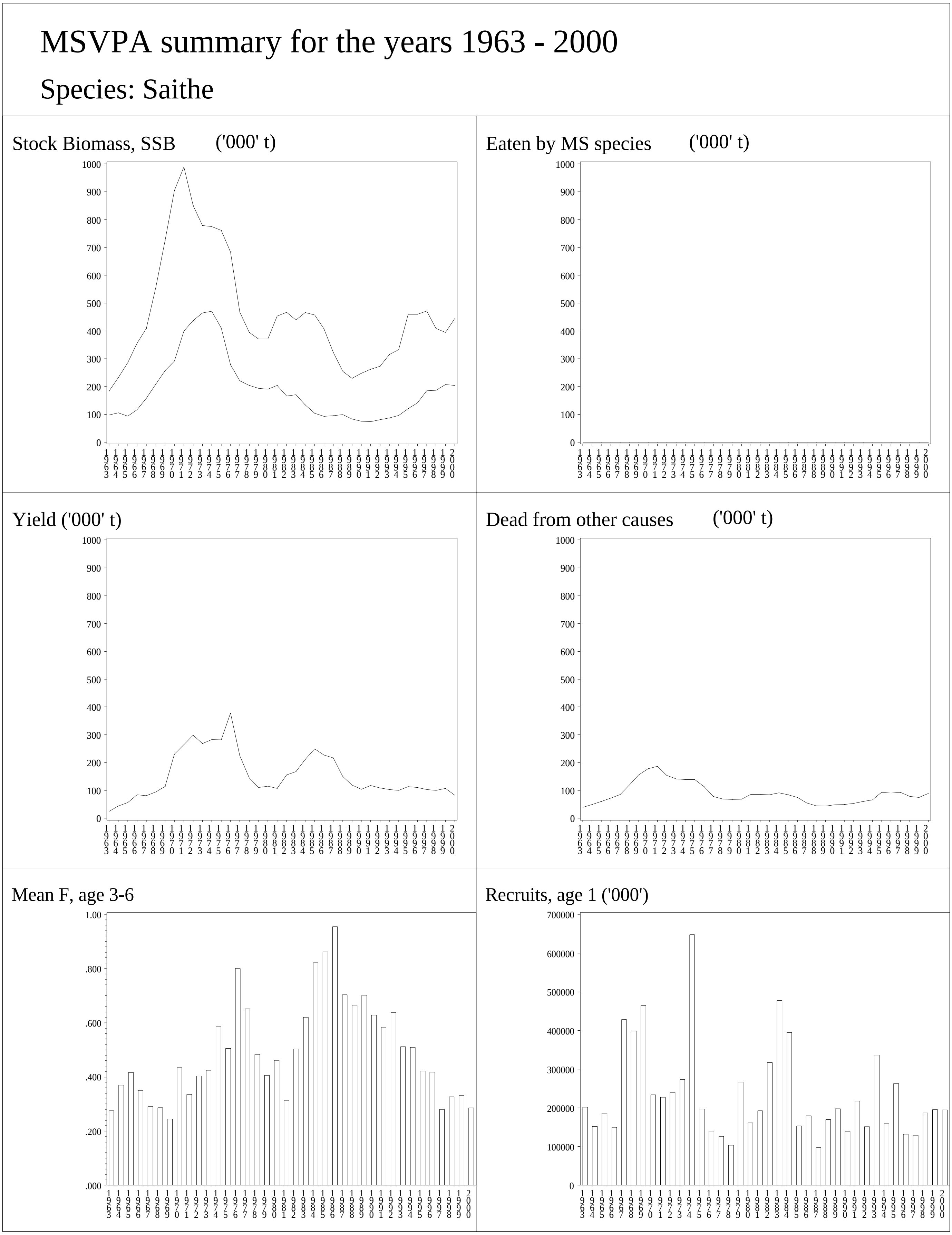


Figure 4.1.4 (continued). MSVPA summary

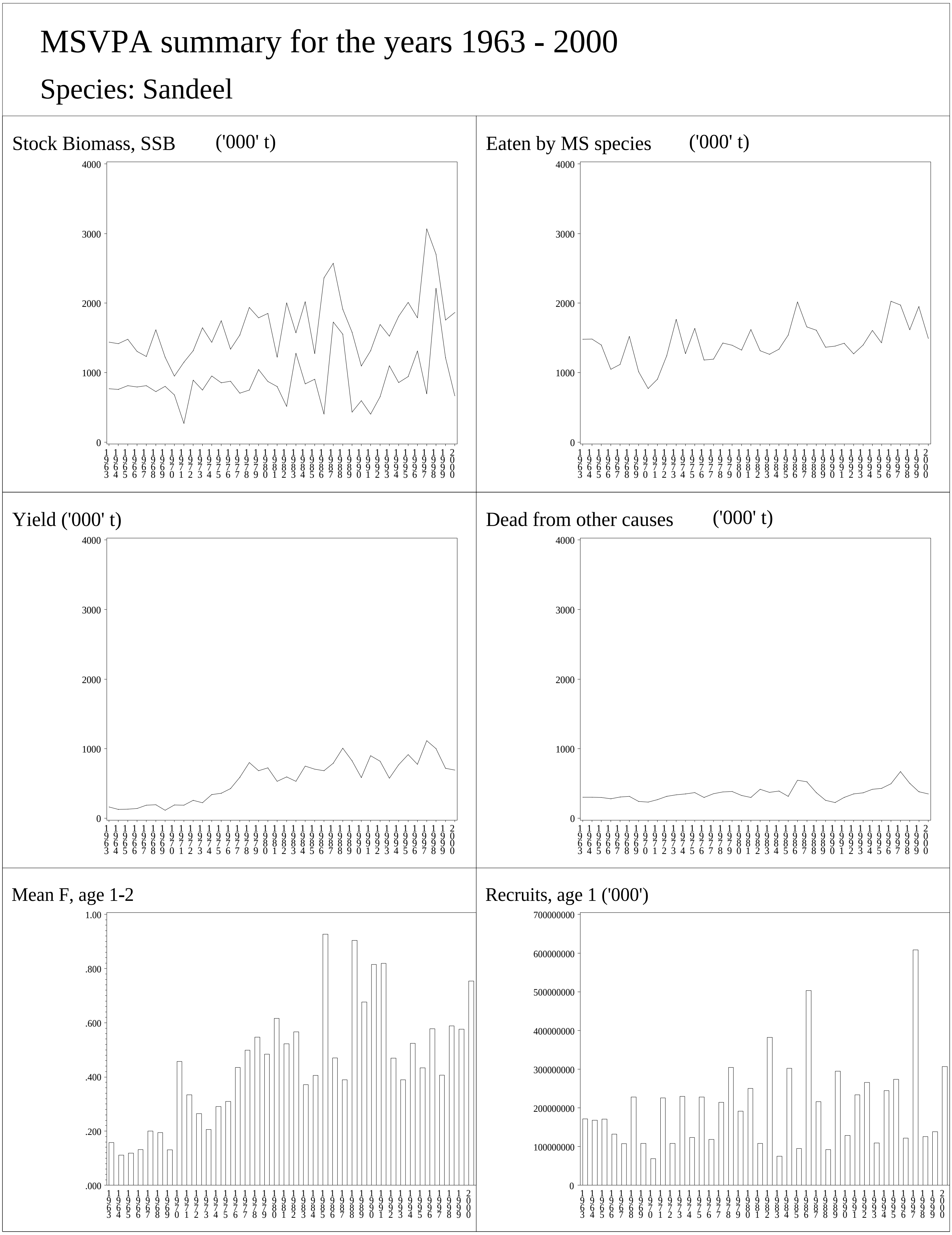


Figure 4.1.4 (continued)   MSVPA summary

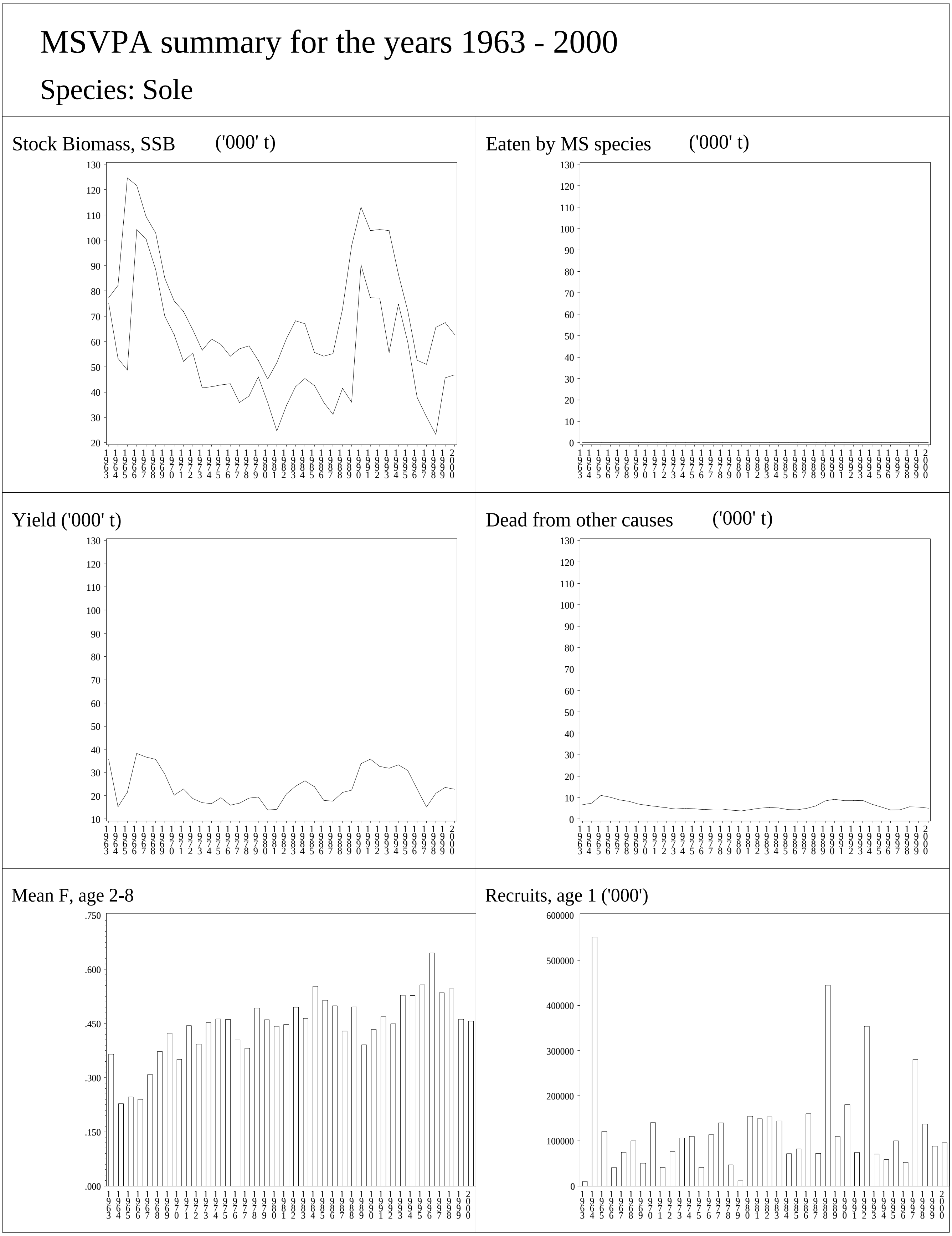


Figure 4.1.4 (continued). MSVPA summary

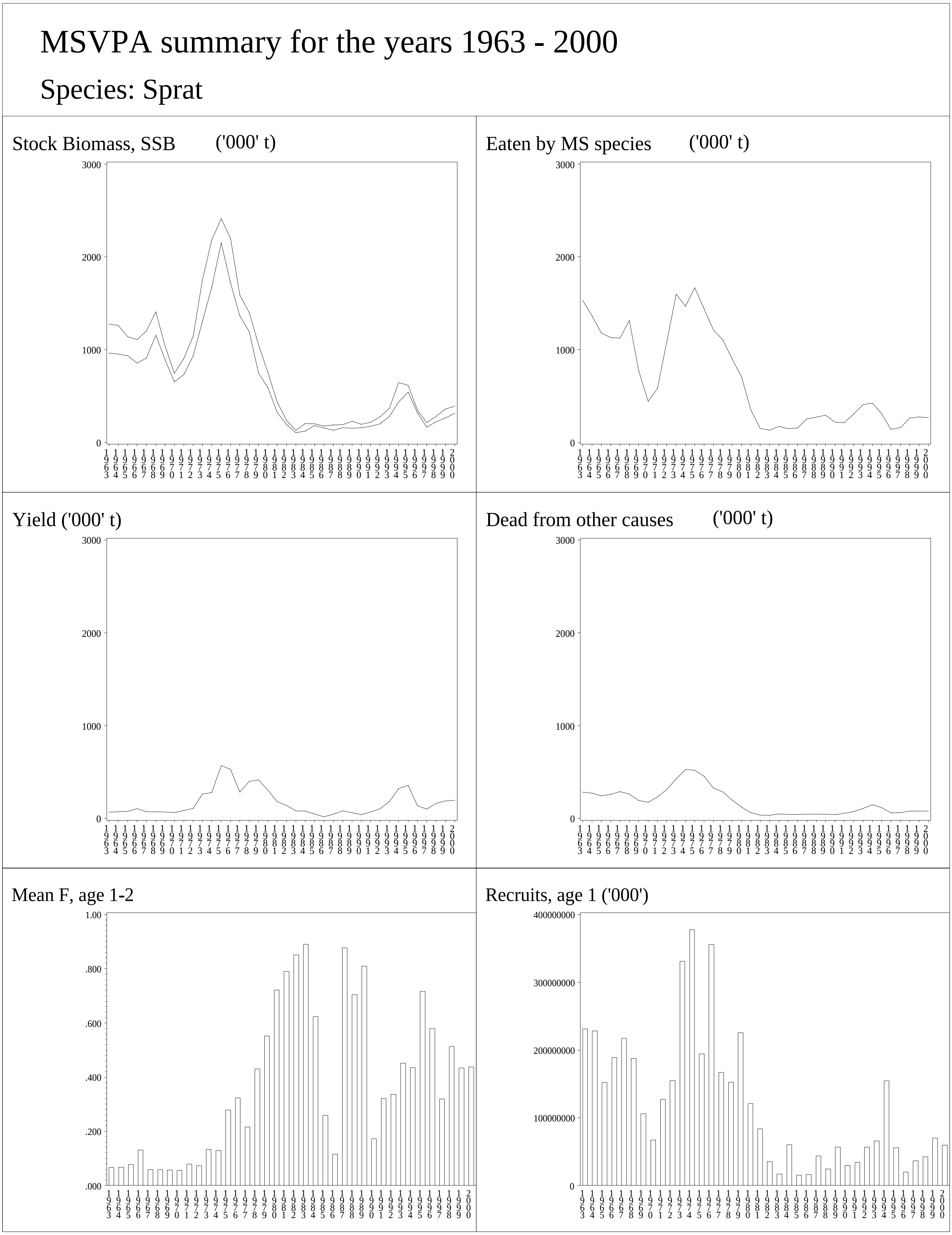


Figure 4.1.4 (continued). MSVPA summary

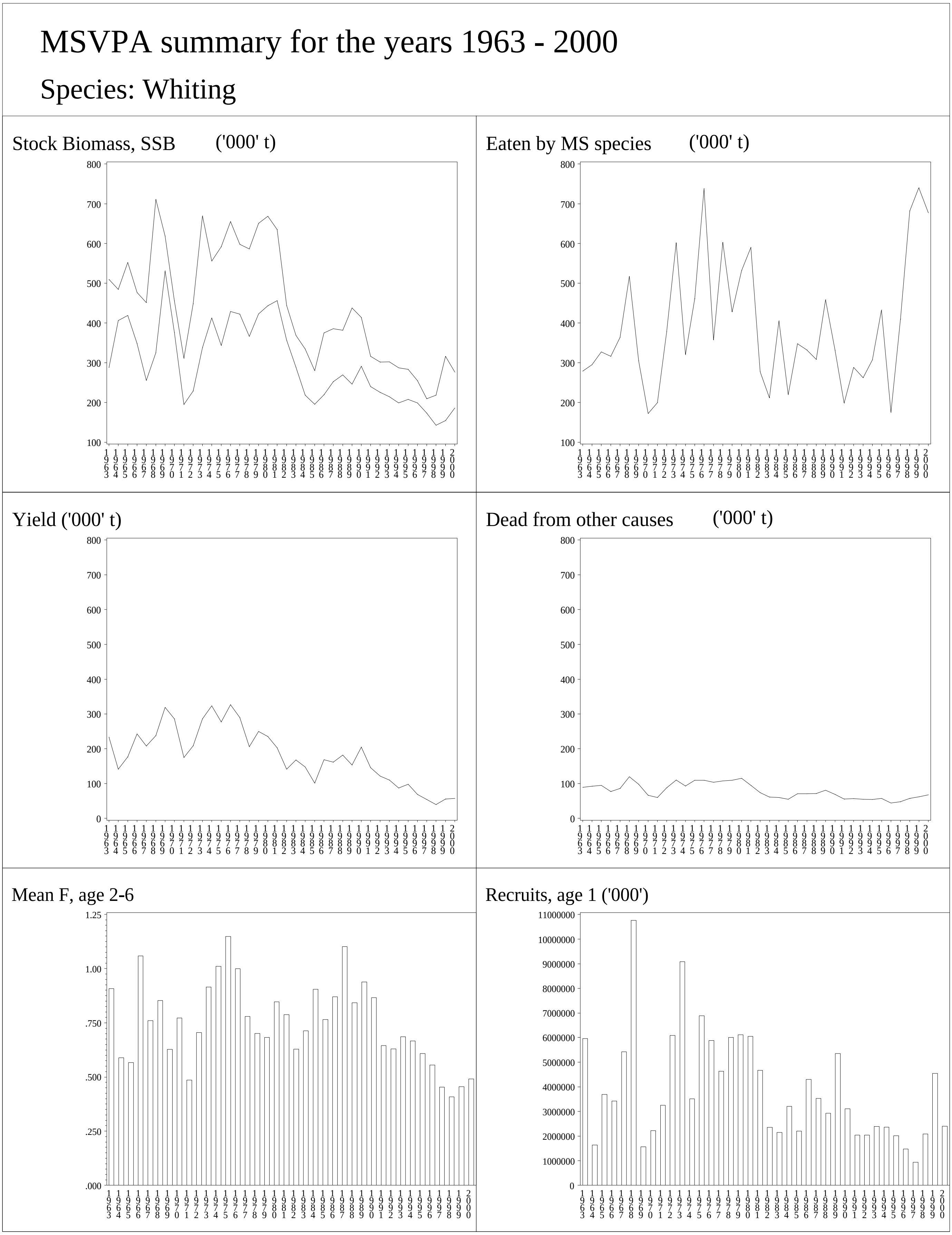


Figure 4.1.4 (continued). MSVPA summary

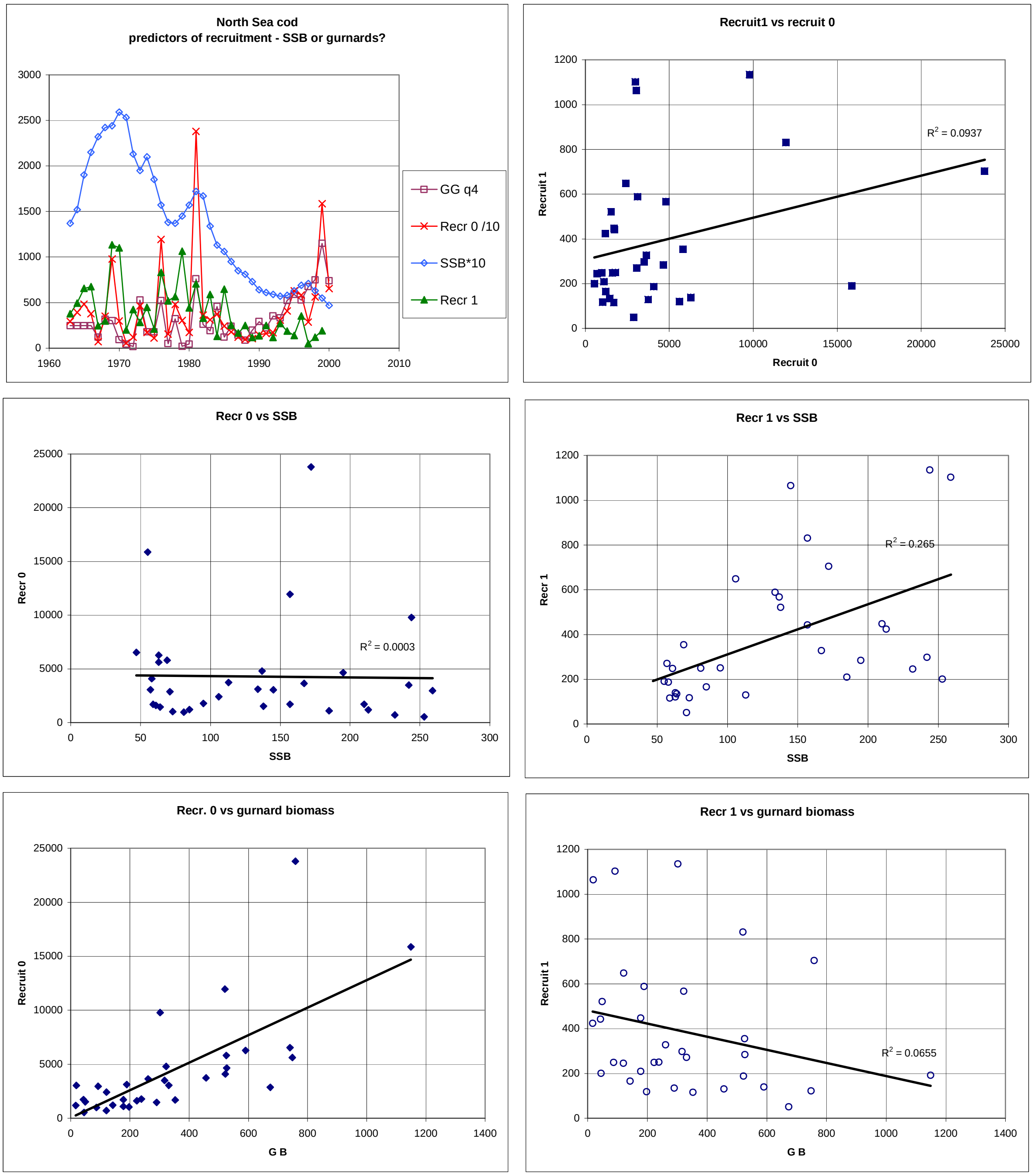


Figure 4.1.5. Relationship between recruitment of cod at ages 0 and 1, as estimated by MSVPA, the amount of gurnards and the SSB of cod. The apparent correlation of the 0-group cod recruitment to the gurnard biomass is the consequence of the estimation procedure of the MSVPA and not a characteristic of (mutually independent) data.

5 RECOMMENDATIONS AND FURTHER WORK

WKMSNS has addressed its terms of reference at this first meeting of a multi-species assessment working group since August 1997, and the workshop felt it has been both a useful and stimulating forum for discussion. The group recommends that two further meetings be held – the suggested terms of reference for which are given in Section 5.2.

The workshop had focused primarily on the task of updating the MSVPA quarterly database and producing a key run of the North Sea.

5.1 Possible directions for multi-species work in the North Sea

The North Sea is a relatively small and heavily exploited area. For several stocks, like the cod, the fishing mortality has increased steadily over many years and may have reached a level that is not sustainable. Other stocks, like herring and mackerel, have experienced collapse. The impact of this intensive fishery on the fish community as a whole is not well understood. Likewise, there is limited knowledge regarding the actual state of the North Sea system, ecosystem effects of other human activities in the North Sea and surrounding land areas, the effectiveness of recovery plans and other protective measures.

Although the MSVPA and its successor 4M have provided a major breakthrough in the understanding of the interaction between fish species in the North Sea, they have several shortcomings.

Being basically a VPA, relying on the catch statistics for estimates of the stock abundance in absolute terms, it is not fully adequate for estimating the dynamics of stocks before they enter the fishery, and inferences from it can be very dependent on the quality of the catch data. In particular, for stocks where discards of undersized fish are not included, the basis for estimates of predation mortality at the youngest age may be unreliable.

It also concentrates on biological interactions which is an important aspect, but not the only one.

Finally, it does not incorporate migration, which *i.a.* limits its usefulness for evaluating the effect of area-wise management measures.

Thus, one reason for considering alternative approaches would be to overcome shortcomings such as these.

Another reason for exploring alternative approaches is the wide range of purposes of multi-species modelling. One aspect is to improve the general understanding of the system and its dynamics. Another aspect is to obtain realistic estimates of stock abundance and mortalities. A third aspect is management advice, which includes estimation of yield and biomass per recruit, reference points for management and realistic targets and strategies for the rebuilding of depleted stocks, taking multi-species interactions into account, but also includes addressing questions about tradeoffs between management priorities (e.g. is it worth building up a stock if that leads to reduced catch opportunities for other stocks?).

The variety of conceptual approaches should not be limited in developing multi-species/ecosystem assessment and forecast tools. It is prudent to examine approaches that provide alternative views of the nature of species interactions and ecosystem structure/functioning. Better understanding of the spatio-temporal behavioural dynamics of predators and prey will be a key element in guiding model development. Also essential for a pragmatic basis is awareness of policy objectives and likely questions. General approaches might include, but not be limited to:

- age structured models
- length structured model
- biomass dynamic models
- individual based models
- evolutionary models
- heuristic models

Very large process oriented models, like BORMICON (see Section 5.1.2.1) accounts for many more of the processes believed to have an impact on the system dynamics than MSVPA does. DIFRES is going to develop a statistical model for the North Sea stock including biological interactions. This model will use the same data as are available for the MSVPA. Such models can be useful to investigate the importance of processes that are suspected to have an impact on the system, but may be too complex for routine assessment use and as a tool for management advice. For such purposes, it may be useful to explore simpler ways of representing the dynamics as they emerge from more complex models (Collie *et al*. 2001 BD1). A third aspect is to improve the understanding of the dynamical properties of a complex system, where exploratory tools like Ecopath (Section 5.1.2.3) can be a possible approach.

One question that could be worth addressing in the near future concerns how misleading advice based on single species assessments, predictions and reference points will be. This is relevant both for the ongoing development of recovery plans, e.g. for cod in the North Sea, and for considerations of alternative reference points for management (ICES 2002d).

Various approaches are intended to be discussed at a forthcoming ICES Workshop on Comparison of Ecosystem Models (c.f. ICES 2001g).

5.1.1 Within the 4M package

Whilst a key run of the North Sea 4M package has been produced at this workshop there are still a number of further modest extensions to the assumptions that could be made in the short-term. Specifically, consumption rates might be re-evaluated (see Section 5.1.1.1) and improved data on seabirds and marine mammals might be incorporated into the analyses (see Section 5.1.1.2). Brief details of these activities are presented below.

5.1.1.1 Consumption rates

Suggested work to be done:

1) before the multi-species meeting in the summer of 2003:

- to analyse ICES data on individual stomach contents as well as other relevant stomach data to obtain estimates of the correction factor *k*.

- to estimate food rations of whiting and saithe (feeding primarily on fish) using a prey energy density dependent evacuation model (Andersen 2001) to quarterly mean stomach data.

- to analyse the ICES stomach data to acquire possible information about prey composition of individual stomachs. The focus will be on major prey types that deviate significantly in energy density.

2) before the multi-species meeting in 2004:

- to estimate food rations of cod and haddock (preying to a large extent on invertebrates with a robust exoskeleton also) using a gastric evacuation model which accounts for the effects of a robust exoskeleton on evacuation of total stomach content as well as of individual prey types. Such a model is expected to be in operation around medio 2003.

5.1.1.2 Seabirds and marine mammals

The workshop welcomed the information given by the ICES Secretariat, working groups and individuals to be used in creating input data for estimating the predation on various fish prey. However, the information was far from complete and simple assumptions had to be made in order to have input data match the model requirements of the 4M package.

Suggested work to be undertaken before the next multi-species meeting in the summer of 2003 is as follows.

Seabirds

The implications of using an aggregate *fish-eating* seabird when the relative abundance of the contributing species change through time are unclear. The dietary preferences, energetics and hence per-capita consumption of the aggregate bird will change, but given the relatively low partial M2 which seabirds appear to inflict these differences may be negligible.

In order for predation by seabirds on fish to be usefully incorporated into 4M, the Workshop therefore recommends that the Working Group on Seabird Ecology [WGSE] construct a time series by year and quarter of numbers of fish eating seabirds (e.g. Fulmar, Gannet, European Shag, Great Black Backed Gull, Herring Gull, Black Legged Kittiwake, Common Guillemot, Razorbill and Atlantic Puffin) feeding within the North Sea since 1963. WKMSNS currently uses dietary information from Hunt & Furness (1996) and would welcome updated information on dietary composition.

Marine mammals

In order for predation by sea mammals on fish to be usefully incorporated into 4M, the Workshop recommends that the Working Group on Marine Mammal Population Dynamics and Habitats [WGMMPH] construct time series by year and quarter of the major stocks of fish eating marine mammals (e.g. grey seals, harbour porpoise, harbour seals and minke whales) feeding within the North Sea since 1963. Consumption rates and dietary composition for selected periods (by prey species and size class) by quarter and year are also requested.

5.1.2 Other modelling approaches

5.1.2.1 BORMICON

BORMICON (BOReal MIgration and CONsumption model - Stefánsson & Pálsson, 1997) is an extensive model for multiple interacting stocks, which includes area-disaggregation and migration, models for growth as function of available prey, as well as mortality by predation and fishing. The fishery is disaggregated on multiple fleets. It is essentially a simulation model, running forwards in time, but also has the option to estimate parameters through minimising an objective function of the likelihood type. A variant of BORMICON named Fleksibest (Frøysa *et al*. 2002) is specifically designed to be an assessment tool. The main difference is that Fleksibest estimates parameters in separable models for fishing mortalities while Bormicon in principle treats the fishing fleet as another predator. The model framework is at present being further developed under the EU project dst^2, under the name *gadget*.

The population in these models is disaggregated both by age and length, and most biological processes like growth, maturation and mortalities are primarily related to length, and are specified separately for immature and mature fish. Growth is modelled as a function of food availability. This is done to account for the variations in growth and in food abundance that can be considerable in boreal waters. Migration is also dependent on length and maturity. The model is quite flexible with respect to time scales, to incorporate both rapid and slow processes.

Since the model in principle is a simulation model specified through parameters, the observed data are used to fit the model to data, and not for calculations within the model itself. Accordingly, it can use a variety of data, and can work even when data are not complete. However, lack of essential data limits which parameters can be estimated. Therefore, BORMICON allows the user to specify the formulation of parametric process models in many cases, and allows the user to choose which parameters to estimate and which to consider known.

The model is statistically based and therefore allows for variance estimates and for formal testing of whether or not certain interactions exist.

BORMICON was primarily designed for Icelandic waters, but work is in progress to implement it for other areas. Fleksibest is primarily being designed to assess the North East Arctic cod stock, but may also be applied to other stocks or stock complexes.

5.1.2.2 MSFIV

A length-based multi-species projection program was presented to the Workshop. This had previously been presented to the Study Group to Evaluate the Effects of Multispecies Interactions (ICES 2001c). In addition to the incorporation of length-based feeding relationships, other differences between this model and MSFOR included the incorporation of spatial properties of stocks and the potential for multi-species stock-recruitment functions. Although the model does not yet perform satisfactorily, initial results indicate that the spatial component of the model is highly influential in the production of different stock dynamics. The workshop considered the work on spatial processes and length-based feeding to be important and that it should be continued. In particular it would be desirable to refine the modelling and forecasting of spatial overlap, and to develop a methodology for calculating overlaps from alternative data sources so that additional species such as sandeels might be incorporated into the program.

5.1.2.3 Ecosystem approaches

Ecopath with Ecosim

Ecopath with Ecosim (EwE) software is a widely used tool for the quantification of food webs and analysis of ecosystem dynamics (e.g. Pauly *et al*. 2000). The approach is founded on a static description of the ecosystem represented by biomasses aggregated into ecologically functional groups. All components of the defined ecosystem are represented by these user-defined functional groups. The essential parameters required for each group are generally the same as those other multi-species models, namely biomass, consumption rates, diet composition, production rate, fisheries catch. Predators and prey are linked through consumption defined by the diet composition matrix and consumption rate parameters. The static description differs from traditional multi-species type models in that it does not require (i) representation of individual species, (ii) age structure of species. The big difference between MSVPA and Ecopath is the use of direct data on total mortality rate by Ecopath, in the form of the Production/Biomass ratio that users must provide (Christensen & Walters 2000).

Biomass dynamic simulations are performed in Ecosim by changing fishing mortality (applied either by fishing gear type to a variety of groups, or to individual groups). The purpose of Ecosim is to enable users, through alternative parameterisations, to represent a variety of assumptions on the nature of predator-prey interactions and examine influences on ecosystem dynamics resulting from a given harvest policy (Walters *et al*. 1997, Pauly 1998). Ecosim is not designed to re-construct historical stock sizes as is the case for MSVPA, rather, the output of MSVPA offers useful data for construction and validation of EwE models and simulations. Indeed, Christensen & Walters (2000) advocate an iterative process where information is passed between single-species analysis and EwE to check and improve estimates.

Ecopath models of the North Sea

At present, three published Ecopath models exist for the North Sea. Based on the 1981 year of the stomach data, Christensen (1995) constructed two models representing the 1981 period; a 24 box model and 29 box model including more detailed, size-based plankton groups. Neither model includes fisheries catches. Mackinson (2001) constructed a detailed historical representation of the North Sea in the 1880s which includes 49 boxes, with catch data for five different fishing fleets. It has been used in an examination of the utility of Ecosim's harvest policy analysis routine; with specific consideration given to evaluating sensitivity to Ecosim input parameters (Mackinson 2002).

More recent work by a DIFRES and Fisheries Centre collaboration (Christensen, Vinther, Gislasson and others) has sought to compare the Ecosim with MSVPA. Biomass values output from the MSVPA are used as input to a detailed (40+ box) Ecopath model of the North Sea in 1974. For fish groups, this model is structured to be similar to MSVPA. One specific objective of the project is to construct MSVPA and Ecosim models using the 1981 year of the stomach diet data, simulate forward to 1991 and compare the models' predicted the 1991 diet compositions with observed 1991 year of the stomach data. A second objective is to compare predictions of MSFOR and Ecosim for different management scenarios (see SGEEMI 2001 for details).

Key issues and recommendations for future Ecopath modelling of the North Sea

Work to date on North Sea Ecopath models has highlighted a number of key issues that deserve a more directed research effort. They include modelling structure/ specification and ecological issues (also noted at the 2001 meeting of SGEEMI), specifically:

- model structure in relation to representing ecological linkages and management objectives;
- spatial representation of functional groups and their interactions; and
- sensitivity testing and derivation of predator-prey interaction parameters.

With consideration of these issues, a positive step in future Ecopath modelling of the North Sea is to review the present available models and use them as an aid in constructing a detailed model for 1991. Primary data sources for parameterisation include 1991 year of the stomach data, MSVPA and single species VPA. Reviews of parameter estimates should be undertaken through consultation with relevant experts. The revised model should include fisheries landings, discards, economic and social data for the purpose of testing alternative harvest policy scenarios.

5.1.3 Ideas for the future direction of multi-species field work

Essential data requirements of all multi-species/ecosystem models are basic data on who's eating who, how much, when and where.

In identifying areas for future field investigations relevant to multi-species/ecosystem modelling, we explicitly consider a temporal perspective. The following section reflects a medium- to long-term requirement for investigations supporting the advancement of present models and development of any future, as-yet-unexplored multi-species/ecosystem models. The specific objective is to identify the general type of field studies (rather than specific methods) that will support the data requirements of modelling exercises. With regard to this, we have been cognisant of the need to avoid underestimating likely advances in future technical development in computing and fisheries data collection and monitoring that will considerably change the nature (volume and detail) of data available to modellers.

We consider that the most pressing data needs requiring field investigations to support development of multi-species/ecosystem modelling are:

1. *Spatial resolution*

Focus on spatio-temporal scales of species distribution, habitat associations and movements.

2. *Behavioural dynamics of predator-prey interactions*

The mechanisms of predator-prey interactions, including qualitative and quantitative investigations leading to hypotheses on predator-prey dynamics. Such investigations are wedded to the issue of spatial resolution and include quantifying spatial association/overlap potentials of predators and prey.

3. *Focus on lower end of food web*

There is a particular requirement for size based sampling of non-target species for which little information is presently available (right down to micro-plankton and meiofauna etc). Also included are investigations on critical transition stages of fishes. Estimation of gear and species specific catchabilities are required to provide area density estimates of biomass.

4. *Behavioural dynamics of fishing fleets*

Spatially resolved data on fishing fleet effort allocation, landings, by-catch composition and discarding rates.

5. *Specific studies providing independent data for validating models*

Investigations providing data suitable for independent validation of model predictions. E.g. isotope analyses used for validation of model estimates of trophic level.

It is imperative that planning such field investigations includes development of data storage systems that facilitate wide distribution of the data in an easily accessible format.

5.2 Future terms of reference

ToR c) charged the workshop with defining the terms of reference for two meetings of a study group on the future direction of multi-species work in the North Sea. The workshop agreed to a change of name from the Workshop on MSVPA in the North Sea [WKMSNS] to the Study Group on Multi-Species in the North Sea [SGMSNS] and a proposal for the ToRs of the first of these two meetings is provided below.

The proposed **Study Group on Multi-Species in the North Sea [SGMSNS]** (Co-Chairs: M. Vinther, Denmark and C.M. O'Brien, UK) should meet in Bergen, Norway for 5 days during late August 2003 to:

a) update the MSVPA quarterly database to include data up to 2002; incorporating any revisions in consumption rates and additional information on predation by seabirds and marine mammals;

b) evaluate the effect of applying single species reference points in a multi-species framework, with particular reference to limit and precautionary reference points as presently proposed by ICES in the North Sea;

c) evaluate the single species recovery plan proposed for North Sea cod by taking into account biological interactions;

d) review the data sources collated by SGGROMAT for the construction, by quarter, of historical stock lengths and weights-at-age for North Sea MSVPA species;

e) review the developments in representing ecological linkages and management objectives within North Sea Ecopath-like models; and

f) propose the Terms of Reference for the second meeting of the study group.

SGMSNS should report for the attention of the Resource Management Committee, the Living Resources Committee and ACFM and ACE.

In addition, the workshop further endorsed the recent recommendation made by WGECO (ICES 2002e) that: a new Study Group be established and tasked with the development of the methodology to integrate information on the North Sea fish community derived from different surveys and to derive time series of absolute biomass, with associated estimates of uncertainty, from the integrated set for as many non-target species as possible.

It is now possible to model growth in the 4M package by linking changes in weight-at-age to available food. However, this requires that representative weight-at-age for the predators are available. It is therefore very promising that a **Study Group on Growth, Maturity and Condition Indices in Stock Projections** [SGGROMAT] co-chaired by C.L. Needle, UK and C.T. Marshall, Norway will be established and will meet at ICES Headquarters from 5–10 December 2002. Among the terms of reference for this group are to:

a. collate data on weights, maturity, condition, fecundity, and age-length and length-weight keys for stocks in the North Sea, Irish Sea, North-east Arctic and Baltic Sea;

b. develop the implementation of growth, maturity and condition models for use in projections for those stocks for which data are available.

The SGMSNS would like to study whether changes in stock weights-at-age of North Sea cod and whiting, for example, can be related to changes in available food. This requires that quarterly mean weight-at-age is made available for the two species for as long a time period as possible and we would therefore ask SGGROMAT to collate such data.

Using the growth model in the 4M package will change predation mortalities and estimates of prey stock biomass and available food. However, these changes may not be large and in order for SGGROMAT to include the current estimates of available amount of food at age in their model along with environmental data such as temperature the estimates of the average quarterly biomass of available food for each age groups of predator have been included in the database available at the ICES web site. It is important to realise that part of the available food consists of other food. Other food is assumed to remain constant over time in the 4M package and we therefore advise the SGGROMAT to use the data only for species and ages for which fish constitutes a significant part of the diet.

6 WORKING DOCUMENT AND BACKGROUND MATERIAL PRESENTED TO THE WORKSHOP

At the Workshop one working document (WD1) and one background document (BD1) were presented and discussed. These are listed below, together with the reference codes used in the text of this report.

Working document: WD1

Vinther, M. A suggestion for a new key run for the North Sea multispecies VPA, 1974-1999 and an attempt to extend the time series back to 1963.

Background document: BD1

Collie, J., Gislason, H. and Vinther, M. (2001). Using AMOEBAs to integrate multispecies, multifleet fisheries advice. ICES CM 2001/T:01.

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