Advisory Committee on
Fishery Management

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REPORT OF THE

MULTISPECIES ASSESSMENT WORKING GROUP

ICES Headquarters
11–19 August 1997

PART 1 OF 2

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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1 INTRODUCTION

1.1 Terms of Reference

At the 1996 Annual Science Conference (84th Statutory Meeting) in Reykjavík, Iceland, it was decided (C.Res.1996/2:14:16) that the Multispecies Assessment Working Group [MAWG] (Chairman: Dr J. Rice, Canada) will meet at ICES Headquarters from 11–19 August 1997 to:

a) review research on stomach evacuation rates, food rations, and related factors for fish predators in the North Sea, and integrate results with the North Sea MSVPA models and parameters;

b) integrate the results of the 1981, 1985–1987, and 1991 North Sea stomach sampling programmes, and produce an updated MSVPA for the North Sea, with particular attention to the estimates of M2 to be used in assessments of North Sea stocks;

c) update the multispecies assessment of the North Sea, taking into account as many groups of predators and prey as possible;

d) evaluate options and provide recommendations to ACFM which would ensure that:

   i. the databases necessary for the North Sea multispecies assessments continue to be updated and maintained,
   ii. ICES maintains the capability to conduct multispecies assessments of the North Sea, when required to contribute to ICES advisory functions;

e) review the progress on multispecies models of boreal systems, and provide recommendations which would ensure that ICES remains in a position to review and advise on multispecies models when progress warrants such action;

f) evaluate and report on the Comprehensive Fisheries Evaluation Working Group Report, with particular attention to the implications of multispecies interactions for rebuilding strategies and biological reference points.

The Working Group will report to the 1997 Annual Science Conference.

1.2 Participants

The Working Group met at ICES Headquarters with the following participants:

Jake Rice (Chairman)	Canada
Sara Adlerstein	Germany
Tatiana Bulgakova	Russia
Niels Daan	Netherlands
Padmini Dalpadado	Norway
Helen Dobby	Scotland
Jens Floeter	Germany
Henrik Gislason	Denmark
John Hislop	Scotland
George Lilly	Canada
Nils Mergardt	Germany
Bob Mohn	Canada
Stefan Neuenfeldt	Denmark
Éva Plagányi	South Africa
John Pope	United Kingdom
Dankert Skagen	Norway
Axel Temming	Germany
Dmitry Vasilyev	Russia

Roy Veitch	Scotland
Morten Vinther	Denmark
Henny Welleman	Netherlands

1.3 Report Summary

The nature of this Working Group report is influenced by the impending change in status of the Working Group. Following this meeting the Working Group will not meet on a regular basis, but only when ACFM sees a specific review or advisory need that the Working Group should fulfil. Therefore the Working Group tried to complete a few tasks as fully as possible, and simply took note of several promising lines of inquiry without pursuing them. At previous meetings such lines of inquiry would have been investigated, at least far enough to leave a clear Term of Reference for the next meeting, and for core questions, if problems with data were identified, analysis components may have been deferred for subsequent meetings when the uncertainties regarding inputs were addressed.

Section 2 details the input data to the North Sea MSVPA. This Section is extremely detailed. The objective was to document fully exactly where all input data to the MSVPA came from, and how they were processed. We hoped to be specific enough to allow others to reproduce our runs in future, and to allow experts in the various species to critique our treatment of their areas of specialization. This was a special challenge, because several new predators were added to the North Sea MSVPA run, including western and horse mackerel, grey gurnards, starry rays, seabirds and grey seals. Extensive tabular material helps archive our inputs for the future.

Section 2.1 details the sources and treatment of population data. For the traditional MSVPA predators and prey this was generally straightforward, drawing from the respective Working Groups. Despite new catch at data for sprat, however, uncertainties about data from earlier years led to the decision to delete sprat as a separate prey in the runs. Western and horse mackerel data were problematic, as the Assessment Working Groups have not provided the necessary catch or population data. Seabird and Marine Mammal Working Groups provided the necessary information, although in the case of seabirds, significant pre-processing of data was necessary to create the necessary MSVPA inputs. Population trends for gurnards and ray were developed from multispecies research surveys. The Working Group hopes that constructive commentary from other Working Groups and individual experts points ways to improve these data in future.

Section 2.2 documents the sources of stomach data. A history of how the treatment of stomach data has evolved over the past 15 years should help consolidate views on this and past reports. The ISR suite of programmes, developed and implemented at RIVO are the cornerstone of the data processing, ensuring data from all species are comparable. Only the seabird and grey seal consumption data did not go through the ISR programmes. The 1981 mackerel data continue to contain problematic entries, and had to be excluded from all analyses.

It was planned that all food consumption rates would be developed from first principles, incorporating a very large body of publications and data accumulated since the previous ration estimates were developed in the early 1980s. Section 2.3 documents the sequence of analyses planned, to include spatial, temperature, and size effects in each species' annual estimates. It also documents where problems arose at the meeting when the approach was implemented, and what was done accommodate the problems. Estimates were developed for all the new species of predators (except seabirds and marine mammals, which came directly from Study Group or Working Paper sources), and new estimates for all old predators. The revised mackerel estimates were not considered plausible, and were not used, but consumption rates for the other species were substantially higher than in past meetings.

Sections 2.4 and 2.5 explore potential problems with the weight at age data. It is concluded that weights at age have been stable enough over time to justify using the long-term average in MSVPA. For young ages of prey, their weights in stomachs show some undesirable trends with age. These trends may mean M2 is mis-estimated on the youngest ages of prey, but require much further investigation before firm conclusions are warranted. Section 2.6 itemizes the most serious data problems remaining with MSVPA. The biggest problems are with population data for some predators and prey, and not with the stomach data.

Section 3.1 presents the results of the North Sea MSVPA Keyrun in some detail, including the adjustments needed in M1 to account for the specification of many more predators in this year's MSVPA. Tabular material documents core output, so the Assessment Working Groups can check our results against theirs. Figures show the trends in biomass, mortality, and production over time, and the partial predation mortality of each predator on each prey. Inclusion of the new predators allows a much fuller accounting of biomass in the North Sea, and the

current population reconstructions make the North Sea as a whole appear much more stable than did results in past meetings. Candidate M2 and M1 values for Assessment Working Groups are summarized in tables at the end of this Section.

Sections 3.2 and 3.3 present the comparisons of several alternate runs to the key run. All suffer somewhat from the lack of time to investigate results fully. Because of the time required to get the input data right, the alternate runs were not available until late in the meeting.

The first contrast is a test of whether the noisy stomach weight data would benefit from some smoothing. The weight censoring had detectable effects on a very small number of suitabilities, and even less effect on the estimates of M2 and on forecasting performance with MSFOR.

The second contrast (3.2.2 and 3.3.2) returns to testing of the stability of suitabilities with different sets of stomach data; 1981 vs 1991. This meeting used the detailed investigations of past meetings as a framework, fitting only the best of past models to the suitabilities. Year effects are statistically significant but very small, and interaction terms including year were smaller yet. The overall fits of the size selectivity model derived from Ursin's theory are not quite as good as found in 1995. This year, time did not permit differentiating sampling zeros (uncommon prey which simply weren't encountered in the 1981 and/or 1991 sampling programmes) from biological zeros (predator - prey size and species combinations which would be highly unlikely, even if both predator and prey were common), and this was thought to cause the less informative model fits. The large majority of differences in suitabilities between the two data were small, although many suitabilities from saithe as predator did change substantially. The differences in M2 were much smaller, and showed very little relationship to the biomass covariates which would have indicated prey switching. Forecasting performance was also very stable for most species, although the projected response of haddock to changes in F continues to differ between the 1981 and 1991 data, despite several meetings of examination, and this year herring forecasts also showed some differences. The end of Section 3.2.2 summarizes the results of several years of investigation of the stability of suitabilities over time, and discusses the value of another "Year of the Stomach" in 2001 or later.

The rest of Section 3 evaluates the contrast of runs including and excusing horse mackerel as a predator, using old vs new consumption figures, and using only the 5 traditional MSVPA predators vs the larger suite of predators. The run with the 5 traditional predators was particularly informative, because it strongly suggests that in past analyses, the value of M1 chosen did not allow for enough mortality from other sources. In addition to shedding light on the consequences of some Working Group decisions (such as excluding horse mackerel in the key run because of questionable population data), some of the alternate runs serve as sensitivity tests of MSVPA. It performed well, and the Working Group concludes it has substantial confidence that the results of the Keyrun reflect the level of predation mortality in the North Sea realistically.

Section 4 investigates multispecies aspects of biological reference points. Section 4.2 begins with the Sissenwine and Shepherd algebraic/graphical approach endorsed by ComFIE.

Even a first cut at adding predation mortality to the stock - recruit and yield per recruit equations, and to the associated graphs, shows that M2 can have a great effect on at least some of the reference points explored by ComFIE. The timing of predation relative to the timing of fishing (cannibalism, sequential, or simultaneous) is an important consideration, as is the size of F. If F is "large", M2 has relatively little effect on yield or recruitment, and hence on the estimated reference points. When F is as low as 0.2, though, values of M2 as low as 0.1 can lead to major inaccuracies if single species approaches are used to estimate recruits per spawner, yield per recruit, or reference points derived using those population attributes.

Sections 4.2.2, 4.3 and 4.4 develop two species and three species simulations applying the relationships associated with Section 4.2.1. The simulations are consistent with the theoretical development. If the multispecies simulations are considered the true population trajectories, single species VPA reconstructions err in various systematic ways, depending on whether F is high (errors in recruits per spawner, depending on the size of the Ricker b parameter), or low (errors in yield per recruit, and in recruits per spawner associated with the a parameter). The three species model showed complicated behaviour, where zones of 0, 1, 2 and 3 species collapse can be mapped onto a space defined by magnitude of F on the predator and the prey. The simulations of rebuilding indicate that reference points determined using a single-species framework but applied to a multispecies system can be particularly unreliable when F is lowered quickly from a moderate level. Rebuilding may be much slower than planned, due to mis-estimations of expected yield per recruit and recruits per spawner.

All these simulations and the theoretical development relied on equilibrium approximations, so dynamic responses between species were not addressed. The Working Group examined an initial application of Lotka-Volterra predator-prey models to evaluating biological reference points, to see how a more dynamic system might respond. The parameters of interaction between the species were extremely influential on the sustainability of management strategies for either the predator or the prey. In these simple two species dynamic systems it is possible to identify region of allowable fishing in a space defined by fishing mortality on predator and prey. This region is likely to differ from the management strategies selected using single species reference points.

All results are summarized in Section 4.6. The Working Group stresses all the results in this Section are preliminary and require further investigation. However, they indicate that it may be risky and premature to formulate precautionary approaches to fisheries assessment and advice based on reference points derived solely from single species models and concepts.

Section 5 is our usual section on further developments in multispecies assessment modelling. It is particularly brief in this report, for reasons itemized above. However, the Section on the initiative at Strathclyde University to add length to MSVPA is important, because it may give MSVPA the ability to address predator - prey interactions of 0 group fish for the first time. This ability, in turn would allow MSVPA to investigate more aspects of recruitment dynamics of fish stocks; a field where new tools are always needed.

Section 6 addresses the Term of Reference to advise on how to ensure that ICES progress in multispecies assessments is not lost when the status of the Working Group changes. The Section specifies what needs to be done to care for the various types of data (population, stomach, consumption), and the modelling capability itself. It also notes that providing rigorous peer review of multispecies models has proven to be a difficult task. Given the widespread non-specialist interest in "ecosystem management" and similar concepts, the Working Group stresses that its unique competence in this complex area should not be undervalued.

This year's Food for Thought Section addresses two issues. One is the addition of additional trophic levels to multispecies assessment models. With the proliferation of marine ecosystem models, it may seem that MSVPA is old, simple, and unambitious. However, the Section notes that many alternate models containing more of the ecosystem are not appropriate as assessment models, and lack important properties required as a basis for scientific advice on the status of fish stocks and management issues. Multispecies assessment models may relate to models of lower trophic levels well by taking outputs of those models as inputs (usually of recruitment levels) to the assessment models. They are likely to work more poorly, or not at all, if they simply try to absorb more trophic levels in a single multispecies assessment model.

The other new development was application of geostatistical methods to problems in the stomach and feeding data bases. Several areas were seen where these methods might be of great use, including smoothing noisy stomach data over the traditional spatial domains, and filling in the sparser cells in spaces defined in predator and prey ages.

The final Section itemizes the recommendations and explicit conclusions of the other Sections. It provides as much of a wrap-up of the activities of this Working Group as is possible. It has been a source of intellectual challenge and excitement for its members over nearly two decades. We hope that ACFM and our other readers have found our results similarly challenging and, if not exciting, at least interesting.

1.4 Acknowledgements

The Working Group would like to thank the ICES Secretariat for the many forms of assistance they provided to the Working Group during its meeting. Thanks are particularly due to Mette Bertelsen for assistance during the meeting, to Karin Bundgaard for coordinating preparation of the report during and after the meeting, and above all, to Margaret Moody for arranging such a lovely way to spend a Sunday afternoon. The Working Group also thanks the Danish Institute for Fisheries Research, for access to the grounds and building during our excursion. The Working Group compliments ICES on the many improvements to the facilities. The cool Castle Room was essential to our plenary meetings, and the Beverton Rooms have become an excellent setting for conducting Working Group computations. As a Working Group which has been critical of ICES computing facilities at some past meetings, we conceed with pleasure that the facilities met most of our needs well, and offered many conveniences. More ease in exchanging data file with home labs would still be welcome, however.

Several Working Group members provided extra efforts prior to the meeting, in order to be ready for the ambitious agenda of the meeting, particularly John Hislop, Niels Daan, and Henny Welleman. The entire Working Group owes a huge debt of thanks to Henrik Gislason and Morten Vinther for the extraordinary efforts made to produce the much expanded KEYRUN, and diverse variants. Without their long nights in the Beverton room, much of this report could not have been completed. Not only did they provide our core analytical base, Henrik and Kirsten found a way to host a delicious meal in an ideal setting, earning even more gratitude from the Working Group.

Although the Multispecies Assessment Working Group will continue in some way within the ICES community, this meeting marked a major turning point for the Group. It is fitting to step back and offer special acknowledgement to those individuals of vision 20 years ago, who laid the foundations for the progress which has been made on this extremely complex task. Without meaning to slight the contributions of those who have retired in the interim, the Chair would like to note the wisdom and endurance of Niels Daan, Henrik Gislason, and John Pope, whose commitments and contributions have persisted from the very first meeting of the *ad hoc* Study Group. Looking to the past should always be paired with looking to the future, however, and it was particularly welcome to see a large number of new, young, enthusiastic and intelligent people at the table. Over the past 2 decades the Working Group has set firm foundations for multispecies assessments within ICES and the larger fisheries science community; they showed there are capable hands ready to build on those foundations.

2 MSVPA INPUT DATA

2.1 Population Data

2.1.1 Standard MSVPA species

Catch at age data for 1993–1995 were taken from single species Working Group reports, or supplied by Assessment Working group members. Stuart Reeves supplied data on cod, whiting, haddock and saithe and Frans van Beek supplied data on plaice and sole.

Terminal fishing mortality, F(4), was estimated assuming a quarterly M of 1/4 of the yearly single species M, in an iterative process starting with a guess on F(4) and adjusting it such that either the annual F equalled the single species assessment annual F by the Working Group, or the single species assessment stock number at 1 January was reproduced.

COD

Terminal F in 4th quarter for ages 1 to 11+ in 1995, and for age 11+ in 1993–1994 were calculated from single species annual F for area IV, IIIa and VIId (ICES 1997/Assess:6, Table 3.4.2). Terminal F for age 0, 1995 was calculated from the predicted stock number at age 1 in 1996 for area IV, IIIa and VIId, (ICES 1997/Assess:6, Table 3.7.1).

WHITING

Terminal F in 4th quarter for ages 0 to 10+ in 1995 and for age 10+ in 1993–1994 were calculated from single species annual F for areas IV, IIIa and VIId (ICES 1997/Assess:6, Table 5.1.11).

SAITHE

Terminal F in 4th quarter for ages 1 to 15+ in 1995 and for age 15+ in 1993–1994 were calculated from single species annual F for area IV and IIIa (ICES 1997/Assess:6, Table 6.8). Terminal F for age 0 in 1995 was calculated from predicted stock numbers at age 1 in 1996 for areas IV and IIIa (ICES 1997/Assess:6, Table 6.14).

MACKEREL

Data for 1993–1995 on total catch and age structure do not exist. The "Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy" guess on a total annual catch weight of 10,000 tonnes. The age structure is based on 1992 data with some additional information from 1993 (ICES 1997/Assess:3).

Catch numbers and mean weights were taken from Table 12.1–12.2 (ICES 1997/Assess:3). No correction was made for stock migration out of the North Sea.

Terminal Fs, age 0–5, were calculated from stock numbers at 1 January. Stock numbers were guessed to be 150 millions for the 0-group. The stock numbers for ages 1–5 were calculated using single species Ms and annual Fs (F-age 0=0, F-age 1=0.05, F-age 2=0.10, and F-age 3–5=0.15). Terminal Fs age 5–15 were calculated from annual F=0.15. The resulting spawning stock biomass in 1995 was around 40,000 tonnes. The data are in Table 3.1.2.1.

HADDOCK

Terminal F in 4th quarter for ages 0–11+ in 1995 and for age 11+ in 1993–1994 were calculated from single species annual F for area IV and IIIa (ICES 1997/Assess:6, Table 4.10).

HERRING

Data were supplied by the Herring Assessment Working Group for the Area South of 62°N. Catch numbers and mean weight for North Sea herring (caught in the North Sea) were taken from Table 2.10.1 (ICES 1994/Assess:13), Table 2.11.1 (ICES 1995/Assess:13) and Table 2.13.1 (ICES 1996/Assess:10). As in previous years, the catch data refer to catches taken within the North Sea, and do not include catches taken in Division IIIa. The single species stock numbers (North Sea component) for age 0–3 as estimated by the MSVPA differ significantly from total stock numbers as estimated by the Working Group, since MSVPA estimates indicate the stock abundance needed to account for the catches in the North Sea only.

Terminal Fs from annual F for total North Sea herring Stock were taken from Table 2.8.3 (ICES 1997/Assess:8).

It was discovered that the catch data for 1993 as reported by the Working Group, and used in the MSVPA were inconsistent with respect to distribution between the North Sea and the Skagerrak. It was not possible to amend this during the meeting, and it was decided to use data covering all areas for 1993.

SPRAT

The age composition data of the sprat catches have been problematic for a long time and in the past the Working Group has had great difficulties in reconstructing data which would give results, which might reflect some main patterns in stock development. However, there is very little information to judge from whether the results are realistic. Although catch at age data have been improved during the past few years (ICES 1997/Assess:8, Table 8.2.1, 8.2.2), the range is not nearly long enough to incorporate years for which F-values would have converged. No single species VPA has been run in recent years and a spreadsheet model aimed at estimating the recent history of the stock failed, because nonsensical terminal F-values were obtained (ICES 1997/Assess:8).

Because the responsible Working Group has not been able to provide a reliable set of catch input data, it was decided to delete for the time being sprat as possible prey from the MSVPA runs in order to avoid potential artefacts by having to make arbitrary assumptions. As a consequence, the amount of sprat eaten by the individual predators had to be added to the 'other food' component.

NORWAY POUT

Catch numbers and mean weights for area IV + IIIa are taken from Table 12.2.1 (ICES 1997/Assess:6). Danish IIIa catches are subtracted to get area IV catch numbers only. Terminal Fs are estimated from annual F for area IV+IIIa.

SANDEEL

Data were taken from ICES (1997/Assess:6). Catch numbers calculated as a sum of North, South and Shetland catch area. Mean weight calculated as a weighted mean. Data are given by half-year and it is assumed that first half-year catch is taken in second quarter and second half year in third Quarter.

Terminal Fs 1995 for ages 0 to 4 were estimated from stock numbers (ICES 1997/Assess:6, Table 13.1.4.1). SSVPA has a 5+ group and MSVPA has a 6+ group. It was assumed that 2/3 of the 5+ group was 5 year and the rest 6+ year. These stock numbers were used for terminal F estimation.

Terminal Fs in 1993–1994 for age 6+ were calculated from the mean of the annual Fs of 4 and 5+ ages.

PLAICE

Catch numbers supplied have been updated such that total catch numbers are similar to ICES (1997/Assess:6, Table 9.3) (12–16% increase). Terminal F in 4th quarter for ages 1–15+ in 1995 and for age 15+ in 1993–1994 were calculated from single species annual F for area IV (ICES 1997/Assess:6, Table 9.9). Terminal F for age 0 in 1995 was calculated from predicted stock numbers at age 1 in 1996 for area IV (ICES 1997/Assess:6, Table 9.15).

SOLE

Catch numbers supplied have been updated such that total catch numbers are similar to ICES (1997/Assess:6, Table 7.2.1) (1–4% increase). Terminal Fs for ages 1 to 15+ in 1995 and for age 15+ in 1993–1994 were calculated from single species annual F for area IV (ICES 1997/Assess:6, Table 7.4.4). Terminal F for age 0 in 1995 was calculated from predicted stock numbers at age 1 in 1996 for area IV (ICES 1997/Assess:6, Table 7.7.2).

2.1.2 Western mackerel

Stock numbers at age at 1 January from 1993 onwards were provided by the Working Group (ICES 1996/Assess:7) and it was assumed that the quarterly F for each group was simply one quarter of the annual F. The percentage of the western stock assumed present in the North Sea was taken from ICES (1997/Assess:7, Table 12.3). Numbers were reduced according to the yearly mortality to give the mean stock numbers by quarter. These were assembled into age classes 0 (1–2 years old) and 1 (3 years and older). Weights at age were similar as in previous years. The relevant data are presented in Table 2.1.2.

2.1.3 Horse mackerel

Horse mackerel is introduced as an 'other predator', as a predating biomass separated in artificial age classes. At present, two stocks of horse mackerel are recognized in the North Sea. These are the North Sea stock, which spawns in the Southern North Sea, and migrates partly westwards through the English Channel in winter, and the Western stock, which spawns on the Western slope of the European shelf, and migrates partly into the Northern North Sea in the autumn to feed (ICES 1990/Assess:24, ICES 1991/Assess:22, ICES 1996/Assess:3).

The Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy has provided percentages for the part of each stock present in the North Sea in each quarter in 1995 (ICES 1996/Assess:3). For the North Sea stock, 10%, 100%, 100% and 50% are suggested to be present in the North Sea in quarters 1–4 respectively. For the Western stock, the corresponding percentages are 0%, 0%, 5% and 50%, valid for ages 4 and above. It has not been attempted to establish percentages for previous years. In the absence of more information, these percentages were applied in all years. However, since the presence of Western mackerel was probably triggered by the exceptionally strong 1982 year class (Borges *et al.* 1996), the Western stock was assumed to be present with these percentages in the North Sea from 1985 onwards.

For the years prior to 1985, the North Sea stock was assumed to be 5% of the 1985–1995 average of the Western stock. This is virtually an artificial number, since there is hardly any information about the size of this stock at that time.

For the years 1985 and onwards, the North Sea stock was assumed to be 5% of the Western stock year by year. This corresponds to approximately 240,000 tonnes SSB around 1990, which is the biomass indicated by egg surveys at that time (Eltink 1991). The Western stock at ages 4 and above were assumed to enter the North Sea according to the given percentages. The stock numbers at age were taken from the most recent assessment (ICES 1996/Assess:3), and applied to all quarters.

Since the stomach data were worked up in length classes <20 cm, 20–29 cm and >30 cm, and no proper age length key was available at the meeting, these length classes were taken to represent ages 1–2, 3–7 and 8+ respectively, based on the mean lengths at age given in the Working Group report, which are referred to as age classes 0, 1 and 2.

It should be pointed out that the amount of horse mackerel in the North Sea is very uncertain due to the lack of assessment for the North Sea component.

2.1.4 Grey gurnards and starry rays

Analyses in the past based primarily on the results of English Groundfish Surveys (EGFS) and International Bottom Trawl Surveys (IBTS) have showed that the considerable biomasses of grey gurnards (*Eutrigla gurnardus*) and starry rays (*Raja radiata*) existed in the North Sea (Yang 1982; Sparholt 1987, Daan *et al.* 1990). Although no analytical assessments have been carried out on these species so far and the available estimates probably only indicate the order of magnitude, it was decided to incorporate some of the dynamics of these stocks based on survey information, taking into account possible changes in the size composition.

Population indices by size class of these two predator species were made available from the IBTS data base at ICES. These surveys have been carried out annually in February from the late 1960s onwards and therefore can be used to estimate the annual signal in abundance during the winter season over the entire period for which the MSVPA can be run. Also, in the period 1991 to 1995 quarterly surveys have been carried out, that can be used to estimate seasonal patterns in abundance. Because of the limited number of years of quarterly surveys, the average seasonal pattern 91–95 was used in connection with the 1st quarter abundance estimates to obtain indices for all quarters according to the formula:

$$\text{Index(Year, Size, Qu[2,3,4])} = \text{Index(Year, Size, Qu1)} \; * \; \frac{\text{Average (91:95,Size, Qu[2,3,4])}}{\text{Average(91:95,Size, Qu1)}}$$

The original length composition data were grouped in 5 cm classes and for each of these a mean weight was established according to the methods described in Section 2.3 (?). The data were then further combined to four size classes (<10 cm; 10–19 cm; 20–29 cm; >=30 cm). The mean weights for each of these were determined by using the numbers in each 5 cm size class as a weighting factor. The same values were applied to all quarters.

The total population size in numbers, required for MSVPA, in each year and quarter was estimated by multiplying the survey indices with the mean weights to obtain a biomass index. These were then averaged over all years and quarters in order to obtain a raising factor by quarter and size class that would match an average biomass for the entire period provided in the literature. The procedure can be seen as using the average biomass as a forcing function on the dynamics as observed during the surveys.

In the end, the smallest size class was not incorporated in the MSVPA, because the small numbers and small weights would not contribute to the final results. The procedure was entirely consistent between the two species.

2.1.4.1 Grey gurnards

Table 2.1.4.1a,b provides the survey indices by size class for each year 1973–1997 and the average seasonal pattern during the years 1991–1995. Figure 2.1.4.1.1a,b provide the same information but restricted to the MSVPA years. It shows large changes from year to year up until 1981 and a more consistent pattern afterwards. This is probably partly due to the fact that some data sets from individual countries are still missing. The seasonal pattern appears to be fairly consistent with a peak in the fourth quarter and relatively low values in the second. These changes may be associated with the marked seasonal migration pattern observed by Knijn *et al.* (1993). The estimate of average biomass considered most reliable for gurnards was taken from Daan *et al.* (1990) and amounted to 204,000 tonnes for the period 1977–1986 based on English Groundfish surveys. Tuning the survey data to this average resulted in the biomasses plotted in Figure 2.1.4.1.2, which were used as input for MSVPA. For comparison the biomass estimates from EGFS are shown, which indicate that the dynamics as estimated for the earlier period from the IBTS are probably too pronounced.

2.1.4.2 Starry rays

Table 2.1.4.2a,b provides comparable data for starry rays and plots are presented in Figures 2.1.4.2.1a,b. The available IBTS data indicate clearly a considerable increase particularly in the larger size class since the early 1980s. According to the quarterly surveys the highest catch rates are observed in the 1st and 4th quarter.

The average starry ray biomass was estimated by Sparholt (1987) at 100,000 tonnes for the period 1974–1986, which is considerably below the average values given by Daan *et al.* (1990) based on the EGFS (ca. 300,000 tonnes). Figure 2.1.4.2.2 presents the MSVPA input data based on the tuning process to 100,000 tonnes. Again the data are compared to the EGFS. The sharp increase observed in the IBTS is apparently not reflected in the EGFS data.

2.1.5 Seabirds

The main source of information was Hunt and Furness (eds.) 1996. No information was available on the numbers of birds present in the North Sea in each quarter of the year. However, Hunt and Furness give counts of seabirds at breeding colonies in the North Sea (Table 2.2 in Hunt and Furness). Eight species of seabirds were chosen for inclusion in the MSVPA run. These eight species either ate primarily fish (Table 2.19 in Hunt and Furness), or had population numbers so large than even a minority of fish in their diets might represent a noteworthy source of predation mortality on some fish prey. For these eight species of seabirds the numbers of breeding birds were totalled and then multiplied by a factor of 1.5. This factor is derived from Table 2.4 in Hunt and Furness, to allow for non-breeders at the colonies, augmented as per their text to account for birds not present when the censuses were made.

These abundances were combined into an aggregate "fish-eating seabird" following the arguments in ICES (1997), when they created an aggregate "discard-eating seabird". In the present case their abundances were weighted by each species' annual energy requirements in the North Sea, taken from Table 2.18 in Hunt and Furness, to account for both differences in body size and bioenergetics. The resulting number was taken to represent the size of the seabird population in the second and third quarters of the year. Numbers in the first and fourth 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 and Furness) and down-sizing the summer numbers accordingly.

Population trends over the period 1974–1996 were modelled to conform with information given in Lloyd *et al.* 1991. The trends for individual populations in Lloyd, or as summarized in ICES (1997), show that for several species of seabirds the numbers breeding in the North Sea have increased substantially since the late 1960s. The trends of the individual species were weighted and aggregated as described above, and calibrated by assuming that the estimates in Hunt and Furness represented the situation in 1990. The resultant "fish-eating seabird" population in the North Sea was 2.01 times larger in 1996 than in 1974. The final form of the seabird population data used as inputs into the model is given in Table 2.1.5.

2.1.6 Grey seals

Annual estimates of total population numbers for the period 1974–1996 were made available to the Working Group by the Sea Mammal Research Unit, St Andrews University, Scotland (SMRU). The annual value from Table 3 in the Hammond *et al.* Working Paper was used in each quarter. Table 2.1.6 lists the annual grey seal numbers used as inputs for the period 1974 to 1996.

2.1.7 Other predators

In addition to the fish predation generated by the five MSVPA predators and the predators dealt with in Sections 2.1.2 to 2.1.6 the North Sea harbours a number of other fish and cetaceans which also include fish in their diet.

According to Hammond (pers. comm.) cetaceans such as harbour porpoises, minke whales and dolphins eat in the order of 500 thousand tonnes of fish annually in the North Sea. The minke whales are only present in the North Sea in the second and third quarter. For this reason the total amount of fish consumed in the second and third quarter was assumed to be twice the amount eaten in the first and second quarter. Cetaceans were thus assumed to eat 83 thousand tonnes of fish in quarters one and four, and 167 thousand tonnes in quarters two and three.

Sparholt (1990a) estimated the biomass of other fish eating fish in the North Sea from catch rates obtained during bottom trawl surveys. Other fish eating fish comprise species such as dogfish (*S. acanthias*), pollock (*P. pollachius*), ling (*M. molva*), long rough dab (*Hippoglossoides platessoides*), hake (*M. merluccius*) and monkfish (*L. piscatorius*). Table 1 in Sparholt (1990b) gives the estimated mean biomass of fish predators in the North Sea in 1983–1985. Excluding western mackerel and Raja sp. from the table leaves a biomass of 180 thousand tonnes of 'other fish eating fish'.

Sparholt (1990b) estimated the predation mortality generated by these species by assuming that the consumption per unit of biomass and diet of the group 'other fish eating fish' was the same as the average of the five MSVPA species. We have followed a similar approach. In 1991 the ratio between annual food intake and biomass of the five MSVPA predators was 4.2 and 32 percent of their diet consisted of fish. Assuming that 'other fish eating fish' has the same proportion of fish in their diet and a food intake to biomass ratio of 4.2 they should annually consume 740 thousand tonnes of food of which 240 thousand tonnes would be fish.

Adding the food intake by 'other fish eating fish' and cetaceans together the total quarterly intake of fish and other food can be estimated (Table 2.1.7). These data were used to generate a population of other predators where the 'dummy' population numbers were set equal the total food intake and the weight and quarterly food intake of one individual both were set to one.

2.2 Stomach Data

A brief history of the stomach data used in recent meetings of the MSVPA

During the last three meeting of the MAWG many changes have been made to the stomach contents data used as input to the North Sea MSVPA. The basic data have been corrected from time to time and new or revised processing methods have been applied. It is important to document these changes before senility afflicts those past and present members of the Working Group who were responsible for the changes to the extent that they can no longer remember who did what, and with which, and to whom.

Stomach data used during the 1993 Meeting of the MAWG

This was the first occasion when the stomach contents data collected in 1991 were included in the MSVPA.

The 1981 stomach data were those used in previous meetings of the MAWG. The data for the cod and haddock meeting had been processed by the ISR programs developed in The Netherlands. The 1981 saithe data had been processed by Danish programs, those for whiting had been processed by programs devised in Aberdeen and the mackerel data by programs prepared in Bergen. There were fundamental differences between the four methods.

The stomach data for cod and whiting collected in the first and third quarters of 1985, 1986 and 1987 had been processed by the ISR programs. Saithe stomachs, sampled in the first quarter of 1996 and the first and third quarters of 1987 had also been processed with the JSR programs.

All the new data for cod, haddock, whiting, saithe and mackerel, collected in 1991, had been processed by the ISR programs.

After the 1993 meeting it was discovered that some of the 1991 stomach data used in the MSVPA were incorrect. The errors were attributable to recent modifications to one of the ISR programs. The 1981, 1985, 1986 and 1987 data were not affected by this fault. The programming error was rectified. Also, in order to improve the internal consistency of the stomach contents data set the 1981 whiting data were completely re-processed, using the ISR programs.

Stomach data used during the 1995 Meeting of the MAWG

The 1981 stomach data for cod, haddock and whiting had been processed by the ISR programs. As before, the saithe had been processed by the Danish programs and the mackerel by the Bergen programs.

The 1985, 1986 and 1987 stomach data (cod, whiting) and 1985 and 1987 (saithe) data had all been processed by the ISR programs.

The 1991 data for cod, haddock, whiting, saithe and mackerel had been processed by the ISR programs.

After this meeting a number of minor data entry errors in the stomach contents data set were identified and corrected. More significantly, it was discovered that the ISR programs still had some shortcomings. In the first place, they failed to pick up some of the records of sandeels within the stomach contents data base. Secondly, the programs were unable to make use of fish prey that had been identified only to group level (i.e. Gadidae, Clupeidae, Unidentified fish). Thus some of the sandeels and all the incompletely identified fish ended up as 'other ' food. This meant that all the stomach data from 1981, 1985, 1986, 1987 and 1991 were to some extent suspect, with the exception of the 1981 saithe and mackerel data, which had not been processed by the ISR programs. However, because the saithe and mackerel data had been processed in a radically different way and, in the case of mackerel, it was believed that the data set included some stomachs collected outside the North Sea, they too posed problems.

During 1996 the ISR programs were modified to pick up all records of sandeels and to distribute over named species most of the fish prey items that had been identified only to family level. It should be noted that prey in the category 'Unidentified fish ' are NOT allocated to species and end up as 'other' food, even though an unknown fraction of prey in this category consists of MSVPA species. In the remainder of this report the modified programs will be referred to as the 'new' programs.

Prior to the 1997 meeting of the MAWG the 'new' ISR programs were applied to the data from all species from all years (including the 1981 saithe data) except the 1981 mackerel data . The task of assembling the 1981 mackerel data into a format that would allow them to be processed with the ISR programs was begun, but little progress was made before the meeting.

Stomach and other feeding data used during the 1997 Meeting of the MAWG

At the start of the meeting the members of the Working Group had the following feeding data at their disposal:

2.2.1 The five 'traditional' MSVPA predators

The data sets were:

The 1981 stomach data for cod, haddock, whiting and saithe, all processed by the 'new' ISR programs, and the original mackerel data, processed by the Bergen programs.

The 1985, 1986 and 1987 stomach data for cod, whiting and saithe, all processed by the 'new' ISR programs.

The 1991 stomach data for cod, haddock, whiting, saithe and mackerel, all processed by the 'new' ISR programs.

It should be noted that ALL the stomach data for the five MSVPA predators (cod, haddock, whiting, saithe and mackerel) had been modified to a greater or lesser extent since the 1995 meeting of the MAWG. In addition, a revised set of mean weights at age of ingested prey was used in the analysis. The revised data are an average of the annual data from the various stomach sampling exercises and were estimated by applying a new raising factor to the observed weights of prey in the stomachs (1.6 c.f. 2.0). (See ICES 1996 for the rationale underlying the revision, but be aware that the Tables included in that report contain errors and the data were not used in the 1997 MSVPA).

During the first two days of the meeting strenuous but ultimately unsuccessful efforts were made to bring the 1981 mackerel data into line. During this exercise some anomalous records were discovered. Since it was not possible to determine whether these had arisen during the preparation of new data files or whether they had been present in the data that had been used in all previous meetings of the MAWG, the Working Group decided that it would be safer to exclude the 1981 mackerel stomach data from the MSVPA.

2.2.2 Other fish predators: Western mackerel, horse mackerel, grey gurnard and starry ray

The Western component of the mackerel stock, entering the North Sea in the autumn on its feeding migration, probably has a distribution in the North Sea different from the North Sea component. Part of the juveniles enter the North Sea either through the English Channel or in the North-West and remain there until they join the

spawning migrations. Adults move northwards along the shelf edge and into the Norwegian Sea after spawning, and gradually move southwards towards the North-Eastern North Sea. (ICES 1990/Assess:19).

The mackerel stomachs collected probably represent a mixture of the two stocks. However, since the food composition varies between areas, the stomach material to be applied for the Western stock should represent the areas where this stock is most likely to appear. Food composition data from the 1991 sampling by predator age split on roundfish areas were made available, and summed over relevant areas and age groups. Weights at ingestion were weighted averages according to the amount in the stomachs. For the ages 1–2 (age group 0), roundfish areas 1, 3, 5, 6 and 7 were included. For ages 3 and older, data from roundfish areas 1, 3 and 7 were used. Data from 1981 were not used (Table 2.2.2.4).

Stomach content data were available for grey gurnard (cf. De Gee and Kikkert 1993), starry ray (Daan *et al.* 1993) and horse mackerel. Most of these data were collected in 1991, for which all quarters have been sampled. In addition, data were available for gurnards in the first three quarters of 1990. The data were processed with the ISR programs. Because there are no adequate North Sea data on length at age for these species, the stomach data were aggregated on a 10 cm length class basis.

Since these data have not been published in the Cooperative Research Report (Hislop ed. 1997), average stomach content weights and average prey weights as observed in 1991 are documented in Tables 2.2.2.1–3. Grey gurnards feed, with the exception of sandeels, virtually only on 0- and 1-group fish of all MSVPA prey species. Starry rays have a wider age spectrum of prey. Haddock has not been observed in these samples. Horse mackerel feed almost exclusively on 0-group. The few samples that were collected during the first quarter (when horse mackerel is rarely caught in the surveys) indicate very low stomach content weights and no feeding on commercial fish prey. Virtually all fish predation is restricted to the 3rd and 4th quarter.

2.2.3 Seabirds

The main source of information was Hunt and Furness (eds.) 1996. This report gives the quarterly food consumption by nine species of seabirds, which together account for 95% of the total energy requirements of seabirds feeding in the North Sea. The data were derived from the literature and span a wide time period. In the report the North Sea was divided into eight sub-areas and the food eaten by seabirds was split into eight categories (sandeels, sprat, live gadoids, large mackerel, large herring, offal, discards and other food). In the case of sandeels, which are an important component of the diet of many seabirds, data on the age composition of the fish eaten by birds was available for one sub-area of the North Sea. The Working Group used this information to estimate the age composition of the total quantity of sandeels eaten in the North Sea, using a simple raising factor and ignoring the fact that the growth rate of sandeels exhibits considerable regional variation. Sprat and live gadoids were assigned to age classes on the admittedly simplistic assumption that all individuals eaten during the first and second quarters of the year were 1-group and all those eaten in quarters 3 and 4 were 0-group. This assumption is consistent with the size information presented in Table 5.1 of ICES 1997. The live gadoids were divided equally between cod, haddock, whiting and saithe. Large herring and mackerel are only eaten by gannets. For both species it was assumed that the consumed fish were in the length range 25–30 cm and that the weights of fish consumed were distributed between age classes using age length keys for the northern North Sea given in Hislop (ed.) 1997 (ICES Cooperative Research Report 219).

Using the annual bioenergetic requirements of the aggregate fish-eating seabird (Table 2.1 in Hunt and Furness) and the information they report on metabolic rates and energy conversion values of fish prey for seabirds (Sections 2.3, 2.5 and 2.6 of that Report) the MSVPA seabird weighs approximately 1 kg and consumes 40kg of food per quarter. These figures applied to their Table 2.18 convert back to a population of seabirds within about 15% of the estimates MSVPA population, as described in Section 2.1.5 of this report. Given the many approximations in the procedures used to estimate both the population trends and the consumption estimates, this seems reassuringly close.

2.2.4 Grey seals

Data on the estimated total consumption of the nine MSVPA species by the North Sea population of grey seals in 1985 were also provided by the Sea Mammal Research Unit, St Andrews University, Scotland (SMRU). Diet was determined by identifying otoliths found in seal faeces and total food consumption was estimated on the basis of the energetic requirements of the seals and the caloric density of the individual prey species. The data were disaggregated by quarter and, for the nine MSVPA species, by prey age class. It should be noted that grey seals

are the only predator in the MSVPA that 'officially' consume saithe, plaice and sole. Grey seals consume mostly sandeels, but a problem identified with the data was that the amount of age 6+ fish taken was calculated as much larger than any other age class in all four quarters. This is partly because the age length data used were for *Ammodytes marinus* but grey seals are also known to consume other larger sandeel species, such as the greater sandeel, *Hyperoplus lanceolatus* (Hammond *et al.* 1997). Sandeels consumed by grey seals were therefore assumed to be "other prey".

For the purpose of the MSVPA, data from the Working Paper of Hammond *et al.* (Table 6 in that Paper) was used, yielding the following estimates: an average grey seal weighs 100kg and consumes the following weights of food in each quarter: Q1: 654kg; Q2: 456kg; Q3: 440kg; Q4: 751kg. The fact that consumption is lower during the middle of the year reflects the tendency of seals to eat energy-rich food at that time.

2.2.5 Anonymous other predators

Anonymous other predators include different other fish eating fish and cetaceans. They have been entered as anonymous predators because their food composition has not been quantified with sufficient precision to allow them to be included among the named predators, even though they are known to consume fish.

The quarterly composition of the fish food of these anonymous predators was assumed to be equal to the average food composition of the five MSVPA predators over the time period 1974–1991. The average food composition of the MSVPA predators was calculated from an early baseline run and used to estimate the relative composition by prey age of the fish part of their food. Other food was then added to provide a total food composition in accordance with the values given in Table 2.1.7.

2.3 Consumption Rates

2.3.1 New data on gastric evacuation

With respect to the status of the work on gastric evacuation the timing of the meeting of the MAWG was too early. An ongoing EU project aiming at the investigation of gastric evacuation and bioenergetic modelling of food consumption of 6 fish predators (saithe, grey gurnard, mackerel, haddock, horse mackerel and hake) will end in two years from now. For two of the species investigated (saithe and grey gurnard), results were not available for this meeting at all and the evacuation models used for the other species (haddock, mackerel and horse mackerel) must still be considered preliminary. New results for cod and whiting were available from another EU project, which was finished recently. For all species a careful check against a bioenergetic model is still to be done. Table 2.3.1 gives an overview of the evacuation studies which contributed to the present estimates. Since all the work is unpublished yet and since in most cases the people who have produced the data have not had a chance to see the results from the model fits, the documentation of the results of gastric evacuation modelling is not extensive. The resulting consumption estimates should not be used elsewhere without prior consultation of the scientists responsible for the experimental work (see Table 2.3.1).

2.3.2 Fitting gastric evacuation model

Gastric evacuation modelling was done as described in Temming & Andersen (1994) for all data sets. The model has, however, been extended to estimate all prey specific constants in one run. With this technique data from all prey species contribute to the estimation of the non prey-specific parameters for the predator weight-, the meal size- and the temperature effect. For some of the data sets it was not possible to estimate all the parameters from the total data set, in these cases estimates were taken from other species. This was necessary for rays (meal size- and predator weight effect taken from whiting), mackerel (predator weight effect taken from whiting). For grey gurnards and saithe no experimental results were available therefor gastric evacuation in grey gurnard was assumed to be as in haddock, while for saithe the parameters of cod were taken.

2.3.3 Prey specific evacuation constants

Since it was demonstrated in recent experimental work, that evacuation rates can differ substantially for different prey types (e.g. Jones 1974, dos Santos and Jobling), a decision had to be made about the choice of the appropriate value for the prey specific evacuation constant. It was decided to use evacuation constants, which refer to lean fish prey such as gadoids or lean 0-Group sprat and sandeel, since most of the predation in the system refers to these prey types. All these prey types were evacuated at similar rates (within a predator species at

least). Fat fish like older sprat and sandeel are evacuated slower, while many of the invertebrate (e.g. krill or polychaetes) are evacuated much faster than lean fish. The effect of this choice will be, that while the predation impact on gadoids, 0-groups and most I-groups of other species will be estimated correctly, the predation impact on sprat and old sandeel will be overestimated, and the total consumption of predators relying largely on small invertebrates, like e.g. mackerel, will be underestimated.

2.3.4 Estimation of consumption

2.3.4.1 Procedures for the 5 MSVPA predators

Ideally the spatial interactions of predator density, mean stomach contents, percentage empty and temperature should have been taken into account. With the limited amount of time and given the preliminary nature of most of the evaluation rate estimates, however, a simpler approach was chosen. The mean stomach content of the non-empty stomachs by age class as presented in the Hislop *et al.* (1997) were raised to the respective power of the evacuation models (shape parameter B in the terminology of Temming & Andersen 1994) and subsequently adjusted for the number of empty stomachs ad multiplied with the evacuation constant (including the predator weight- and the temperature term) The mean ambient temperature was taken as before from Anon (1987). The mean weights of the predators were estimated from the mean length at age as given Hislop *et al.* (1997) and length-weight relationships (Coull *et al.* 1989, see Table 2.3.2). Thereafter a correction factor was applied to account for the bias, that is introduced by raising a mean stomach content to the power instead of raising individual stomachs before averaging (Ursin *et al.* 1985). The factor was preliminary estimated to be 0.9 based on for subsets of data from the North Sea (individual stomachs of haddock and whiting sampled in 1992 and 1996) and cod data sets from the Newfoundland Area.

The resulting raw consumption data by age class were then smoothed with an allometric function (consumption as a power function of predator weight) as described in Anon. (1987). A common allometric exponent was used for all quarters within a predator species, the constants were kept quarter specific. The allometric exponents were in a second step standardized to 0.8 for all predators. The reason was that in two data sets the exponents were either too low (<0.667, mackerel) or too high (>1.0, saithe) due to limitations in the stomach contents data sets (field data) and that the other three exponents were all very close to 0.8.

2.3.4.2 Procedures for horse mackerel, rays and grey gurnard

The quarterly feeding rate (g/h) of each size class of horse mackerel, rays and grey gurnard was calculated by applying the consumption model described above to the mean stomach content weight. The mean stomach content weight was provided as the mean for fish sampled, including those with empty stomachs. Before being entered into the model, this mean was adjusted to the mean for non-empty stomachs by multiplying by the number of stomachs examined and dividing by the number of stomachs with food (where the number with food includes those with skeletal remains only and those recorded as regurgitated).

The size of the fish is expressed in weight rather than in length. The average weight of individuals of each length class was determined approximately as the average of the weights calculated for fish at the lower and upper limits of the class. The weights were calculated from length-weight relationships in Vinther (1989) for spiny skate and Coull *et al.* (1989) for horse mackerel and grey gurnards. Coefficients of the allometric equation ($W=aL^b$) are as follows:

	a	b
horse mackerel	0.0034	3.2943
rays	0.005248	3.11
grey gurnard	0.0062	3.1003

A temperature considered appropriate for each species in each quarter was calculated from the temperatures recorded during the 1991 IBTS survey. The value used was the mean of the temperatures in those survey squares in which the species was caught, weighted by the catch. This weighted mean temperature was applied to all size-classes. The temperature used for each species and quarter was as follows:

	1	2	3	4
horse mackerel	6.44	9.59	17.75	13.73
rays	6.58	7.20	7.88	9.64
grey gurnard	6.94	8.13	11.76	10.81

2.3.5 Comparison of old versus revised consumption estimates

It has been reported that the Working Group in the 80s knowingly chose moderate values in order not to overemphasise predation effects. Furthermore differences between old and revised estimates as displayed in Figure 2.3.1 may originate from 5 biological sources:

A) The main effect is the choice of the prey type used in experiments. In old experiments often prey types were used, which are evacuated slowly, like sprat and sandeel (non 0-Groups). The new estimates are referring to lean fish like gadoids or 0-group sprat and sandeel.
B) The old estimates were based on a standardized temperature effect using an exponential coefficient of A= 0.1, while the new experiments suggest that predators can be grouped into two groups, one with a strong temperature dependence (A>0.1, cod, mackerel, horse mackerel, rays) and another with a weak temperature effect (A<0.1, whiting and haddock). If experiments were done at higher temperatures than those experienced in the sea, the high coefficients lead to low evacuation rates when extrapolated to low temperatures.
C) The allometric scaling of consumption was based in the old estimates on theoretical considerations with a constant scaling exponent of 0.667. If the new evacuation parameters are combined with stomach contents, the resulting allometric scaling is usually close to 0.8.
D) In some experiments unnatural high meal sizes were fed, which lead to an overestimation of the evacuation time required by the Daan consumption model. This was at least the case for whiting.
E) Since only the 1991 stomach content data were used, some differences are due to peculiarities of the stomach data, this is especially true for the mackerel.

Cod: Revised consumption estimates are significantly higher than the old values. The old estimates were based on (non 0-group) sprat as a food, which is much slower evacuated than most other prey. The new values are also influenced by a higher allometric scaling exponent, which is now derived from data, while it was in Daan's model a theoretical assumption.

Whiting: Revised consumption estimates are significantly higher than the old values: Old experiments were based on sandeel (probably fat and therefore slowly evacuated). Since most of the whiting live at temperatures below those applied in experiments, the low temperature effect predicts faster evacuation at lower temperatures. This effect will also change the relative consumption in different quarters. Additional effects result from high meal sizes in the old experiments and a higher allometric scaling exponent.

Haddock: The old values used were purely based on guesses, but they happen to be most close to the new results. (Why do people do all these experiments?)

Mackerel: The revised mackerel figures are much lower than the ones previously used. The reasons for this are threefold: 1) Temperature extrapolation (downwards) is done with higher exponent now (this higher exponent is consistent with an even higher earlier estimate by Mehl and Westgard (1983), which was, however, not applied by the Working Group); 2) evacuation rate in old experiments referred to krill prey (which is evacuated fast, e.g. in cod it is evacuated twice as fast as lean fish prey), and finally; 3) the mean stomach contents were low in three quarters in the 1991 data. The revised consumption data have not been used in the key run, because the appeared too unrealistic at first glance. Later during the meeting, however, some plausibility checking was tried based on the estimation of gross conversion efficiencies.

Plausibility check of mackerel consumption data: Estimation gross conversion efficiencies

Gross conversion efficiency cannot be calculated using the estimated rations as they were used in the model run, since those were based on the evacuation parameters for fish prey, in order to get a correct estimate of the predation impact on the fish prey rather than a best estimate of the total consumption of all food of mackerel. Approximately 60% of the mackerel diet consists of invertebrate prey such as krill and copepods, which are evacuated much faster than fish prey. In case of cod as a predator the krill was estimated to be evacuated twice as fast than (lean) fish (data from dos Santos & Jobling 1995, remodelled). Therefore the evacuation constant to be

used for a rough estimation of the gross conversion efficiency was modified taking into account a two times higher evacuation rate for all invertebrate prey. This raised the overall consumption estimates (based on lean fish parameters) by a factor of 1.6. These revised consumption figures were compared with growth rates estimated from the mean weights in the sea as given in the MSVPA input files. Estimated gross conversion efficiencies were 40%, 9%, 6%, 5% and 4% for the ages 1, 2, 3, 4 and 5, respectively. Except from the value for age 1, which is in line with a cod of age 1, the values for older ages are not too high to be judged unrealistic. Similar values have been reported for other fast swimming scombrids like *Thynnus thynnus* (with gross conversion efficiencies of 15 to 8% for weights between 1 and 28kg, Vincent 1981) or skipjack tuna (between 10 and 4% for a 1 kg fish, Kitchell *et al.* 1978). It must also be kept in mind, that the rough estimates given here for the mackerel are derived from a comparison of consumption estimates that were based on 1991 stomach contents with some average growth pattern. Growth may well have been low in 1991, which would have given lower gross conversion efficiencies. It can therefore not be concluded that the 1991 based consumption figures are severely biased.

Saithe: No new experimental data have been available. The new values, which are based on the cod evacuation parameters and saithe 1991 stomach data, are only slightly higher than the old values. Using the parameter set for cod, which is based on more than 2,000 data points, was considered an improvement, even though it refers to another species. The saithe date were originally based on only 16 data points and neither the predator weight- nor the temperature effect were estimated from the 16 data points for saithe, but were previously taken from other species as well. Nothing can be said about which set is closer to reality, but it gives some confidence that both sets are quite close together.

2.4 Weight at Age

A review of weights at age used in MSVPA was performed to check if there had been any significant trends, particularly in recent years. The data were found on the ICES system among data saved by various Working Groups. After the initial retrieval the data were edited into a spreadsheet for comparison with the MSVPA assumed values. Where possible the time series were extended back to 1974. The MSVPA data for the 2nd and 3rd quarters were averaged for comparison to the time series which were annually aggregated. For the 5 traditional predator species (cod, haddock, mackerel, saithe and whiting) ages 4, 6 and 8 were chosen for display. As prey, cod, haddock, mackerel, saithe, whiting Norway pout, sand eel, plaice and sole were chosen and ages 1, 2 and 3 were plotted. For many of the plots (Figures 2.4.1 to 2.4.15), no time serious time trends were seen. However, mackerel, saithe and whiting at predator ages show a decrease in weight at age. At prey ages, only mackerel display a trend compared to the overall variation. Statistical analyses were not performed on these data.

None of these observations were felt to be sufficiently serious as to cause revision of the MSVPA weight at age inputs.

2.5 Mean Weights of Prey at Ingestion

Mean weights of prey at ingestion by predator age and quarter used as input for MSVPA are calculated as the average of observed prey weights in the stomach contents at all stages of digestion (pristine, partially digested and skeletal remains) following the procedures described in Anon. 1991. These mean weights are calculated for each prey age/ predator age combination on a quarterly basis and the 1.6 raising factor is applied for all prey species and all predators irrespective of prey or the predator age. The analysis compares the weights at ingestion of herring as a prey in 1991 cod stomach samples obtained as described above with weights of pristine prey found in the stomachs. Also, the estimated weights at ingestion for 1981, 1985, 1986, 1987, and 1991 are analyzed and results are used to comment on the current method to obtain these estimates.

The analysis uses generalized additive models (GAMs) (Hastie and Tibshirani 1986, 1989) and incorporate the gamma variance $V(\mu) = \mu^2/\nu$, and a logarithmic-link $\log(\mu)$ functions to relate the expected weight to the predictors. First, the weight of pristine herring as a prey in cod stomachs was modelled as a function of the predator age, North sea Roundfish areas and quarters using the number of prey in the stomach samples and catch per unit effort for cod at age as a weighting factors. Data are from herring ages 1 to 6 from 1991 stomach contents. No age 0 pristine prey were found in the stomachs. Roundfish areas and quarters were incorporated as fixed factors and predator age as a continuos variable. Predator age was modelled nonparametrically using scatterplot smoothers described in Chambers and Hastie (1992). Analysis were performed with routines contained in the S-plus computing environment (Becker *et al.* 1988). Results of the analysis are shown in Figures 2.5.1 to 2.5.3. These figures represent the influence of quarter and predator age on fitted values of

herring mean weight. Units in the y axis correspond to the fitted weights scaled so the average is zero and broken bars and dashed curves indicate two standard errors. Results show the significant increase of the mean weights with season in herring of all ages and in most cases no significant effect of the predator age on the prey weight except for herring age 1 where the fitted weight increases with the age of the predator. Second, a similar analysis was applied to the weights used as input in MSVPA. In this case the model includes only quarter and predator age because the estimates are for the whole North Sea. Previous processing of the data accounts for the differences between areas and predator abundance. Predator ages are from 1 to 5. Results are shown in Figures 2.5.4 to 2.5.6. In this case a significant increase of fitted weights with age of the predator is observed for herring age 1 to 3 and the seasonal patterns shows a consistent increase in weight from winter to spring at all prey ages but inconsistent patterns for summer and fall. The differences observed between the two analysis suggest that the estimated mean weights at ingestion need further attention.

Estimated weights at ingestion used as MSVPA input were further investigated for all MSVPA prey species and years 1981, 1985, 1986, 1987 and 1991. Mean weight was modelled as a function of year, quarter, predator and predator age. Results are presented in Figures 2.5.7 to 2.5.8. Results show that for most cases fitted prey weight increases with predator age and levels up at older ages. Exceptions are for cod and herring age 0 where mean weights decrease at old predator ages and for cod age 2 where the mean weights do not vary with predator age. The weight variation with seasons is not always consistent with the expected increase from winter to summer. The comparison between years indicate that haddock mean weights were higher in 1991 than in 1981 for all three ages, also mean weights of sprat, whiting and herring did not vary between those years, the age 0 Norway pout weight was lower in 1991 than in 1981, weights of sandeel age 1 was lower in 1991 than in 1981 and weight of age 0 cod was also lower in 1991 while weight of age 3 cod was higher that year.

Comparison of patterns observed above with results from analyses based on pristine prey (not always available) or with fluctuations of mean prey in the sea could give more inside in potential problems associated with estimated weights at ingestion. For example, this analysis indicate that estimated weight of age 0 sandeels in 1991 was similar to 1981 which might not be the case since actually the size of age 0 sandeels in the predator stomachs in 1981 was smaller than in 1991, particularly in the fourth quarter. The current MSVPA allows for censoring the mean weight data of prey ages older that 2 using weights of prey in the sea. When the weight of a prey is lower than 0.05 the weight in the sea it gets replaced by half of this weight. Results from running MSVPA using this option with results using uncensored data shows no important differences. The censoring procedure, nevertheless, does not address the most likely problem which occurs at prey ages 0 and 1.

Potential sources of bias in the current estimates are the high growth rates of age 0 prey, the age-length conversion and the unique raising factor applied to obtain the mean weights at ingestion for all prey/age and predator/age combinations. An alternative approach is to estimate the mean weights of age 0 prey based on a growth model and a length-weight relationship and to use pristine prey weights at older prey ages.

2.6 Data Problems

2.6.1 Grey gurnards and starry rays

The algorithm developed for grey gurnards and rays must be seen as a first trial to estimate biomass trends in some of the not regularly assessed by-catch fish species. Although there was too little time to explore other possibilities, there is an obvious need for further work. First of all, improvements may be expected from the ongoing effort to make the earlier survey data available to the IBTS data base, but also the incorporation of the EGFS data in the algorithm can be expected to create a more consistent picture in the development of these stocks. Also possible changes in catchability should be explored in order to provide better estimates of the seasonal cycle in the biomasses by size class. This could not be done during the present meeting because the data were not available, but should be taken up before a next meeting.

2.6.2 Mackerel and horse mackerel

The results of MSVPA in terms of appropriate M2 levels to be used depends heavily on the quality of the input data and in particular the estimated stock sizes of the main predator. In terms of biomasses, North Sea mackerel and horse mackerel as well as the estimated components of the Western mackerel and horse mackerel stocks that enter the North Sea during part of the year represent by far the largest predator stocks, but their assessments are influenced by many *ad hoc* assumptions and guesses in creating the input data. The results are in several cases not in agreement with other data series or with the general history of the fisheries. For instance, the yields and

biomasses of North Sea mackerel produced by the MSVPA are consistently larger than the values given in the recent assessment report (ICES 1996) and the estimated fisheries mortalities are higher in the 1980s when the stock was protected in most of the North Sea than in the 1970s, when it was fished down to a very low level.

Migration of the Western mackerel stock into the North Sea has increased in recent years. Nevertheless, the input data used reveal some very high figures in the early years (notably 841,000 tonnes in 1975) compared to a value of less than 100,000 tonnes assumed for 1977.

For the horse mackerel stock the input data used are even more arbitrary. Given the impact of all these stocks particularly on 0-group fish, there is a strong need to scrutinize the figures used.

2.6.3 Grey seals and birds

The Working Group welcomed the information given by working groups and individuals to be used in creating input data for estimating predation on various fish prey by age. However, the information was far from complete and simple assumptions had to be made in order to have the input data match the model requirements. The Working Group therefore welcomes any criticism and/or suggestions for improvement from more knowledgeable scientists on this subject.

2.6.4 Mackerel stomach data

Some obvious differences between 1981 and 1991 appear in the data sets.

1. In the first quarter stomach contents are much lower in 1991 vs 1981 due to very high percentages of empty stomachs especially for the older ages. The percentage empty in the age group 1 is only 30% compared with 90% in age group 2 and older age groups.
2. In all quarters but the third the mean stomach content is considerably lower in 1991 than in 1981, which is in these cases not an effect of a high percentage of empty stomachs.
3. In quarter 2 the larger mackerel eat significantly less copepods and euphausids in 1991 compared with 1981
4. In quarter 4 the consumption of euphausids is low in 1991, which is compensated partly by increased shares of copepods and fish.
5. Overall the number of stomachs analysed is low compared with the other predator species, especially in quarters 1 and 4 for mackerel of ages 3 and older (1991 quarter 1: N=20, 1991 quarter 4: N=188). It is therefore not clear if the observed differences between years reflect the normal variability between years or just too small sample sizes.

3 NORTH SEA MSVPA RUNS

3.1 Key Run

3.1.1 Description of inputs

The MSVPA for the North Sea presently includes 10 fish species for which catch at age data are available (cod, whiting, saithe, mackerel, haddock, herring, Norway pout, sandeel, plaice and sole) and six other predators for which stock size at size is available (western mackerel, starry ray, grey gurnard, grey seal, seabirds and a group labelled other anonymous predators). For horse mackerel stomach content data for 1991 and some indications of population trends within the North Sea are available, but since the data are subject to a large uncertainty it was decided not to include horse mackerel in the keyrun.

The following options and data sources were used in the keyrun:

- The Helgason-Gislason feeding relationship (Gislason and Sparre, 1987) with a constant amount of Other Food (30 mill. tonnes).
- Revised M1 values assumed to be constant with age (see below), Table 3.1.1.
- Weight at age in the sea and in the catch as used at previous meetings.
- Maturity at age as used at previous meetings, Table 3.1.1.
- Catch at age from ICES Assessment Working Groups, Table 3.1.2.1.
- Population estimates for other predators from various sources (Sections 2.1.2 to 2.1.7).

- Revised estimates of consumption at age for cod, haddock, whiting and saithe (see Section 2.3).
- Revised stomach content data for 1981 all quarters (cod, haddock, whiting and saithe), 1985–1987 Q1 & Q3 (cod and whiting) and 1991 all quarters (cod, haddock, whiting, mackerel and saithe) (see Section 2.2).
- Sprat excluded from the named MSVPA prey species and included in Other Food.
- Western mackerel, grey gurnard, starry ray, seabirds, grey seals and anonymous predators included as other predators with food composition data from 1985 (grey seals), 1990 (seabirds and grey gurnards), and 1991 (western mackerel, starry ray, grey gurnard, and other predators).
- Weight at age at ingestion for prey items based on the average of the observed prey weight at age in the stomachs (for cod, haddock, whiting, saithe and mackerel) or assumed equal to the weight at age of the prey in the sea (for all other predators).

In previous years estimates of the residual natural mortality at age, M1, were derived by adding the predation mortality generated by other fish eating predators to the conventional values of constant M at age used by the assessment Working Groups (see Sparholt, 1990b). This approach generated values of M1 at age which decreased with the age of the prey. This year the predation mortality caused by other predators was included in the predation mortality, M2, and M1 should therefore only reflect deaths due to disease, spawning stress etc., but not predation. New M1 values were therefore derived. This was done by assuming that the total natural mortality for the oldest age groups (M1+M2) should equal the conventional values of M used by the Single Species Working Groups, and, for simplicity, that this value of M1 could be applied also to the younger age groups. The values of M1 used in the keyrun are given in Table 3.1.1.

3.1.2 Output from the key run

Table 3.1.2.1 shows the output from the keyrun in terms of the stock sizes in numbers at age ('000), the annual fishing mortality age and the yearly predation mortality, M2, at age. For most of the species M2 fluctuates without any trend, but for sandeel, and to some extent also for herring, M2 shows a decline with time. Saithe, mackerel, plaice and sole are now eaten by grey seals and contrary to the key runs from previous meetings they are now subject to a small predation mortality.

An output summary by species is given in Figures 3.1.2.1 to 3.1.2.10. The Figures include stock and spawning stock biomass 1 January, yield, mean fishing mortality, biomass eaten by species included in the MSVPA and biomass removed due to other causes (M1). Recruits are given for the 0-group, third quarter.

Figure 3.2.1.11 shows the changes in SSB, yield, mean fishing mortality, recruitment, amount eaten, and biomass removed due to M1 mortality summed over all species in the MSVPA. The values from the current key run are compared to the values obtained in the keyrun at the previous meeting 1995. The inclusion of other predators has led to an increase in the total biomass in the North Sea from around 6 mill. tonnes to 8 mill. tonnes from 1981 onwards. The yield has been reduced somewhat by the exclusion of sprat from the model. Together with the changes in total natural mortality the removal of sprat has also increased the yield biomass ratio slightly. The addition of other predators has increased the biomass of fish eaten. Instead of a steady decline in the amount of fish eaten from 6 mill tonnes in 1974 to around 1.5 in the beginning of the 1990s the total predation shows an initial decline from a high of 10 mill. tonnes to a level of 5 mill. tonnes around which it fluctuates from 1977 onwards without any particular trend. Reducing M1 has halved the amount of fish biomass removed by residual mortality. The P/B ratio was estimated by dividing the sum of the total biomass removed during the year plus the change in stock biomass over the year by the average stock biomass. Where the P/B ratio of the exploited fish community estimated in 1995 showed a steady decline with time, the P/B ratio from the present key run is remarkably stable. After an initial slight decline it stabilizes around a level of 1.1. Table 3.1.2.2 shows the total biomass, average biomass, yield and a number of other summary statistics for the 10 MSVPA species and for the Other predators. Note that the total amount of fish eaten by the Other predators is at the same level as the fish consumption of the five MSVPA predators.

Table 3.1.2.3 shows a comparison of estimates of natural mortality for some North Sea fish species used by the assessment Working Groups and values of M1 and M2 derived from the key run. The values of M2 are mean values over the time period from 1974 to 1994. M2s for the 0-group are for 3rd and 4th quarter only. Even though additional predators have been added the values of total natural mortality at age from the keyrun are surprisingly close to the values used by the Single Species Assessment Working Groups. The predation of young herring in the Skagerrak/Kattegat area is not included in M2.

Mean predation mortality for the years 1974–1984, 1985–1994 and 1974–1994 are given in Table 3.1.2.4. Comparing the two decades the mean predation mortality is almost unchanged for cod and Norway pout and decreased for haddock, herring, sandeel and whiting.

Figure 3.1.2.12 shows how much of the predation mortality at age is generated by each of the predators, the panels to the left show average 0-group M2 over the years 1974–1995, those to the right M2 for ages 1 to 6. Most of the predation mortality on 0-group cod is generated by gurnards, while whiting is the most important predator on 0-group whiting, haddock and herring. Western mackerel generates most of the predation mortality on 0-group Norway pout and sandeel. For the older ages of prey the most important contributors to the total predation mortality are cod,whiting and saithe. However, for sandeel mackerel is also of importance.

3.2 Alternate Runs of the MSVPA

During discussions of data to include in the key run, there was substantial discussion on several points. In several cases the Working Group decided that although certain data were inappropriate for inclusion in a key run, it would be informative to run an alternate scenario, with the key run data replaced by or augmented with the alternative data set. There were several purposes in making the various runs. Some could be viewed as sensitivity (or robustness) tests of the North Sea MSVPA to alternate assumptions. Others provide reference points, for linking key runs in past meetings with the much expanded key run of this meeting. Still others provide insight into the strength and sensitivity of ecological linkages in the North Sea. Finally, the comparison of current key run formulations, but with only the 1981 and only the 1991 stomach data, continue the long-standing efforts of the Working Group to evaluate the assumption of stable suitabilities in MSVPA.

Three types of information are presented for each of the pairs of runs to be contrasted:

1. Graphs showing the time course over the MSVPA assessment period of essential variables:

    - Total biomass of all species in the model, including predators entered only by their biomass.
    - Yield, according to the MSVPA input catch data.
    - Total biomass eaten by the fish prey accounted for in the model.
    - Biomass of the all MSVPA species dead by other causes.
    - Yield per biomass for the species where catches are specified.
    - Production/biomass ratio for the same species.

2. Graphs showing the M2 by prey species, as generated by each predator species. The predator species are indicated by x-axis categories referred to by numbers, and the species corresponding to these numbers are stated in Table 3.2.1. The graphs on the left hand side show the M2 on the 0-group, and those on the right hand side the M2 values for the older prey.

3. A tabulation of the frequency of occurrences of changes in suitability and M2, between the key run and alternate run. In the contrast of 1981 and 1991 data, these frequency distributions are broken out by predator species. In the other contrasts they are aggregated by both predator and prey species, as well as ages of both predators and prey, and quarter. In all cases they are the average M2 over the period 1974 to 1995 from the respective MSVPA run (the suitabilities, of course, are the same in all years for any run).

In many of the contrasts of runs, it was expected that the M2 and hence the reconstructed biomasses of the species would be altered if the suitability times were changed by the different input data or model structure. In these cases it is important to determine if the changes in predator or prey biomass was systematically related to the changes in suitability and M2, or, from an alternate perspective, if any changes in some model outputs (the suitabilities, for example) were compensated for by changes in other outputs (the biomasses). Therefore the changes in suitabilities and M2s were examined relative to changes in biomasses. Using results of analyses at past meeting several different models were fit to the differences. Both absolute changes in biomass (log10 transformation), and to the percent change in biomass relative to the mean estimated for the two runs (arcsin transformation). Regressions were also made with both aggregate biomass, and with separate slopes for each predator and each prey species. A fixed effects model of just predator and prey species, quarter, and their two way interactions was also fit, to see if there was systematic changes in suitabilities or M2s with species unrelated to changes in biomass. At this meeting time did allow exploration of many of the more complex models, with possibly more appropriate error structures.

Although the changes were examined from many perspectives, the major messages are clear with results aggregated at a fairly high level. Analyses disaggregated by predator and prey species, and with a variety of transformations of various covariates are consistent with the patterns reported below, but require readers to wade through much more detail in results and tables.

The results of the regression analyses of each alternative run vs the key run (or 1981 vs 1991) are presented in the same way. In the results table (For example Table 3.2.1.2), where a model fit was not significant ($P<0.027$, to allow for multiple comparisons) on the same variable) the table entry is NO. Where the fit was significant, the r^2 value is entered. Although r^2 is one of the more superficial indicators of the properties of the fit, it conveys a readily interpretable message. For the aggregate slope model, significant fits have the sign of the slope in ( ). For the separate slopes model, the species with parameter estimates significantly different ($P < 0.023$ for predators; $P < 0.018$ for prey) from zero are listed, with the sign of the slope.

3.2.1 Key run 1997 vs. run with censored weights

3.2.1.1 Descriptions of runs and rationale

It has long been recognized that in some instances, the weights of individual prey in the predator stomachs have some apparent outliers. In previous years, some of outliers have been corrected *ad hoc*. With the revision of the stomach data, all such weights have been left as they were produced by the ISR conversion programme. There has been concern as to how much such outliers would influence the overall results.

The MSVPA has an option to censor these data, although the key run used uncensored weight data. A run was made where this was used. For prey of age 2 and older, where the prey weight in the stomach was less than 5% of the weight of that prey in the sea, the weight in the stomach was substituted by 50% of the weight in the sea. Applying this rule led to 75 substitutions.

3.2.1.2 Results

Figure 3.2.1.1 gives an overview of the effect of using the censored weights. The censoring of the weights shows virtually no effect on the results. The biomass, yield, and biomass lost to various sources of mortality are indistinguishable between the runs. The partial M2 values (how much mortality each species of prey suffered from each species of predator, summed over the life of a cohort) are also indistinguishable form the key run, and have not been presented in a figure.

The changes in suitabilities were almost all minuscule, with over 95% of the changes between -.0005 and +.0005 (Table 3.2.1.1). Changes in M2 were comparably small (Table 3.2.1.1) None of the change in suitability was due to changes in estimated predator biomasses between the runs. A very small amount of the change in M2 is explained by higher biomasses of cod in the keyrun than in the censored run, both as predator and as prey. The effect is more likely to be a scaling factor because in this case predator switching to alternative prey is not a possibility, because identical stomach data was input for both runs, and the censoring affects outliers in the prey size data, not the frequency with which various prey are eaten.

3.2.2 Comparison of the 1981 and 1991 stomach data sets

3.2.2.1 Rationale and description of runs

The 1991 stomach sampling programme provided a second data set for MSVPA and thus allows statistical tests to be made of the central assumption of the constancy of suitability of prey items for the various predators. A number of such tests were made at the 1993 Working Group meeting and its report contains a discussion of the tests adopted at that time and a discussion of the consequences of different models of predation on the constancy of suitability.

Since the 1993 meeting the 1981 and 1991 data sets have been revised and standardised. Thus, while there was no explicit term of reference requiring the working group to test the stability of suitability estimates at this meeting it seemed appropriate that such tests should be initiated. Pressure of time and technical problems-made this testing difficult to complete and further inter-sessional work will be required to bring this to a satisfactory conclusion.

To conduct the tests two run of MSVPA were made adopting all "key run" assumptions and data except that in the first run only the 1981 stomach data set was used and in the second run only the 1991 stomach data set. The results of these two runs were interrogated to provide extraction of results suitable for statistical tests.

3.2.2.2 Results

3.2.2.2.1 Statistical method for fittings of suitability surface

Introduction

It was noted in Section 6.1 of Anon. 1994 (1993 MAWG) that departures from constant suitability either implied a more complex model or that year to year variation occurs that could not be explained. This section makes preliminary tests for departures from the constant suitability assumption.

Specific question/hypothesis and biological rationale

The hypothesis to be tested is that changes between the suitability estimated using the 1981 data set and the 1991 stomach data set arise only from chance. The stomach data sets do not allow of replication within years. It follows that the only possibility of obtaining a measure of within year variation is by fitting smoothing functions to suitabilities estimated by fitting the MSVPA separately to the 1981 and the 1991 sets of stomach content results. If suitabilities do indeed change significantly from year to year this might be due to:-

1. The underlying model being more complex than the MSVPA.
2. Random variation in suitability through time.

Statistical method

The data set used was the non zero estimates of suitability made with 1981 data and separately with the 1991 data. These were used together with information on quarter, and on prey and predator species and weight. Data were censored to exclude points where the ln(predwt/preywt) term was less than 0.1 and also for predator ages greater than 5. This was because for older ages problems arise with multiple entries in the data. This results from the use of age length keys to convert stomach content results by size to stomach content results by age. In the 1993 analysis data were augmented by adding data points for zero suitabilities for prey predator age feeding combinations which did not occur in the stomach sets but where the prey had been observed to be eaten by other predators. Technical difficulties precluded doing this in the course of the current meeting but further analysis using such augmented data do need to be conducted intersessionally because what is not eaten is also of significant in the fitting and comparison of suitability estimates.

Traditionally the Working Group has adopted smoothing functions based upon the product of the Ursin log-normal size preference function* predator species effects with prey species*predator species*quarter year scaling effects. Additional terms for predator species size and a term to introduce the possibility of skewness in the size preference function were also used in the basic smoothing procedure. In 1993 this model was coupled to the Poisson log-link function fitting approach but since no zeros were included in the preliminary analyses conducted this year it was possible to use a logarithmic transformation of suitability and an identity link function with normal variation. The smoothing model adopted was thus of the form,

$$ln\{Suit(pred,prey,quarter)\} = a(pred,prey,quarter) + b(pred)*x + c(pred)*x^2 + d*\ln(predwt) + e/x^2 + e$$

Where $x = Ln(predator\ weight/prey\ weight)$ and where e is an error with a Normal error structure. This smoothing model was fitted using the GLIM package.

The degree of difference between the two sets of suitability data may be judged by seeing whether the inclusion of a year factor into the various elements of the smoothing function improves the fit to the joint set of 1981 and 1991 estimated suitabilities.

Results

Table 3.2.2.2.1 shows the sums of squares and degrees of freedom resulting from progressively fitting the combined data set with terms for:

* the fit about the mean,
* The basic scaled Ursin model,
* the predator weight effect,
* the skewness effect,
* the scaling terms nested under year,
* the size preference terms (Ursin + ln(predwt) + skew) nested under year.

The fits were made separately for each predator species and indicate that the basic model together with the predator size effect explains from 38.8% (cod) to 50.5% (whiting) of the total variance. The skewness term was small for all predators except saithe (2.1%). The effect of fitting year effects on the prey species*quarter scaling factors explained from an extra 5.7% (whiting) to 26.4% (saithe) of the variance. Including year effects on the size selection terms increased the fit by at most 2.4% (saithe).

The degrees of freedom available to test the significance of these effects was sufficiently large that even minor effects are statistically significant. Only predator size term for saithe, the skewness effects for all species except saithe and the year.size suitability factors for all species except saithe failed to attain the 5% level of significance.

GLIM provides the parameter estimates fitted by the full model and estimates of their standard error (SE). However, it is somewhat difficult in these results to compare the prey.quarter effects across years since they are affected differentially by the different size preferences fitted. Thus in order to interpret these results more readily they have been converted into the canonical form;

$$Suit(pred,prey) = exp(Scaling(pred,prey,quarter,year))*sqrt(2*\pi*\sigma^2)*exp(.5(\mu/\sigma)^2)$$

Values of the canonical parameters and scalings are shown in Table 3.2.2.2.2 for predator species where a "n" shaped parabola was fitted. For saithe in 1991 and for haddock in both years a "u" shaped parabola was fitted and the canonical forms of selection cannot be computed. This is a problem largely associated with the lack of the augmented zeros. The table also shows the preferred predwt/preywt ratio for cod and whiting and saithe (1981) predator. Generally these appear sensible. The extreme forms of the size preference function fitted to mackerel in 1991 and to haddock precludes making the comparison for these species. The table also shows annual sums for each species and quarterly sums of the fitted canonical suitabilities as a check on inter comparability. Where sums are similar direct inter comparison is more appropriate. Where they are not, correcting the scaling factors for the sums may be more appropriate. A blank value appears in the estimate column where no data was available for a parameter to be fitted.

A similar table (Table 3.2.2.2.3) shows the canonical suitability estimates when the size preference was fitted across all data (i.e. not nested by year). Again the saithe and haddock ln(suitabilities) were fitted with "u" shaped parabolas and could not be interpreted in the canonical form.

Indications from both tables are that while cod and whiting tend to have characteristically high or low suitability values for particular prey species these can vary by more than a factor of 2 between years.

Conclusions on statistical fits

Analyses are preliminary and will need completion in intersessional work. About 40% or more of the variation in suitability estimates can be explained by a single model fitted to the estimates of both 1981 and 1991. However fitting separate year effects to the scaling and to a lesser extent to the size selection terms improves the fit to between another 6% to 29%. These results are thus similar to those found with the comparison of the 1985, 1986 and 1987 partial year studies of stomachs reported in Anon 1989 and Rice *et al.* 1991 and the analysis of the 1993 Working Group. This study does therefore indicate that some variation in suitability estimates does occurs between 1981 and 1991. This raises the question of whether these inter annual changes are predictable using additional covariates such as prey stock biomass. If they are this might indicate that a more complex prey switching model might be appropriate. Preliminary work was attempted in Section 3.2.2.4 but this will need to be augmented by further intersessional investigations.

The importance of these changes to fisheries assessments is difficult to judge from the suitabilities alone. This is better judged by considering the impact of the different suitability measures on assessment outputs. These impacts are discussed in Section 3.2.2.3.

3.2.2.2.2Summary output of the runs

The run using only 1991 data suggests that total fish biomass was slightly larger than either the run with all data (key run) or the run with only 1981 data. (Figure 3.2.2.2.1) The difference is greatest in the first half of the historic series. However, the 1991 run suggests even more biomass was lost to predators and other causes, so despite the higher biomasses, yield per unit of biomass was less in the 1991 run that in the others. These effects of greater biomass and greater mortality nearly cancel, so the production biomass (just of the species included in the MSVPA - not including other food, where production is not an appropriate concept within the options of any of the runs) ratios are nearly identical among the runs.

There are a number of marked differences between the two runs in the predation mortalities suffered by various prey, and inflicted by various predators (Figures 3.2.2.2 and 3.2.2.3). Older herring and Norway pout suffer substantially more mortality in the 1991 run, whereas sandeel and haddock suffer substantially less predation mortality. (Note these mortalities are the average over the 22 year time series, constructed using each of the stomach data sets, and not the difference between the two specific years 1981 and 1991). 0-group cod also suffer much greater mortality in the 1991 run, Differences in impacts of individual predators are hard to isolate in these figures.

3.2.2.3 Statistical contrasts of differences

The analyses were intended to evaluate how widespread and how large the changes in suitabilities were between the runs with the two single years of stomach data. They also examined how much of the differences in suitabilities were further manifest as differences in predation mortality (M2) for particular predator and prey age combinations.

Frequency of changes of various magnitudes

Suitabilities estimated for the 1981 run and the 1991 run were matched by quarter, predator species, predator age, prey species, and prey age, and differenced. The differences should have been rescaled so the sum of the suitabilities in both years were identical, but the chairman forgot this step when the analyses were done. (Because of more intensive sampling in 1991, there were more prey classes found in the aggregate stomachs of each species of predator in 1991 as well. Because MSVPA scales suitabilities to 1.0, this means suitabilities were spread over more prey items in 1991. When a prey class was missing in either year, the case was not included in the differencing, because it would be incorrect to assume zero suitability and zero predation mortality for prey not observed because of incomplete sampling.) This should introduce a small bias towards a decrease in suitabilities in 1991, although the bias is expected to be small, because important prey should be present in diets in both years.

Table 3.2.2.2.3-1 presents the frequency distribution of these differences for each species, aggregated across quarters and prey species. For all species there are a few large changes in suitabilities in each direction. (A negative difference meant suitability in 1981 was greater than in 1991; a positive difference means the suitability in 1991 was larger.)

For cod as predator, if changes in suitability of .05 or greater are considered (an arbitrary value, as there are no analyses to suggest this value has special biological meaning), there were more increases in suitabilities of prey between 1981 and 1991 then decreases. For saithe and haddock, the asymmetry was in the other direction, with more "large" changes being decreases. For cod the majority (56%) of changes in suitabilities were between -0.05 and +0.05, whereas for whiting, saithe, and haddock, the proportions of changes which were not "large" is less than 50% in all cases.

Although it is interesting to examine the sizes of changes in suitabilities, the biological concern is how these changes may be reflected in different estimates of predation mortality. Table 3.2.2.2.3-2 has the corresponding frequency distribution for changes in M2. It is apparent that there are many changes in suitabilities, the impacts on M2 estimates is very small. Maintaining our arbitrary guide of changes of + or - 0.05 or larger, less than 5% of the M2 values exceeded that benchmark. Even for saithe, where most suitabilities changed substantially between the two data sets, only 6.4% of the M2 changed by 0.05 or more. Note that both M2s and suitabilities showed a surplus of increases over decreases in the 1991 run compared to the 1981 run. This suggests that the fish predators were eating more fish prey, and less other food in 1991 (so suitability of Other food absorbed the deficit in summed suitabilities).

Do the changes in suitabilities reflect prey switching?

One of the major concerns about the assumption of constant suitabilities is that predators may show prey switching, either to prey which become relatively abundant, or away from prey which become rare (Gislason 199x, Rice *et al.* 1991). For this reason, the Working Group again explored how much of the change of suitability could be explained by changes in the biomass of either predators and prey. Table 3.2.2.2.3-3 summarizes the results of these model fittings.

Changes in suitabilities are very weakly related to changes in prey biomass, with the effect concentrated on sandeels, whose suitability increases slightly with increases in biomass. The fixed effects model which did not contain biomass terms at all, captured much more of the variance in suitabilities overall (25% vs. 4.1%). Most of the pattern was small but consistent changes in suitabilities of prey for whiting and saithe, and of whiting, Norway pout and haddock as prey. These changes were not related to changes in biomass, however, because none of these species had significant slopes in the regressions of change in suitability on change in predator or prey biomass.

Changes in M2 were slightly more systematically related to changes in biomass, although none of the associations were strong. The increase in M2 with increase in the biomass of whiting as a predator seems the largest effect, but captured only 7% of the variability in M2 between the runs. In the fixed effects model less of the variance in M2 was systematically organized by species than was the variance in suitabilities, with suggestions that aside from the weak trends related to changes in prey biomass, most of the differences in M2 between the 1981 and 1991 runs may be random.

3.2.2.4 Summary and conclusions

Statistical comparisons of the results of the separate runs based upon the 1981 and the 1991 data suggest that some differences in suitability have occurred between the two years sampled but that the similarities are greater than the differences. This is an encouraging result when it is considered that the North Sea had undergone a regime shift between 1981 and 1991 with the return of herring to abundance in 1991. The frequency distribution of changes in centered on zero, but with a moderate spread for each of the predators, particularly for saithe. It is reassuring that although there are a number of changes in suitabilities, the changes in M2s are much smaller, and closely centred on zero. Although the suitabilities do not show absolute fixed values with the two data sets, the model seems capable of reconstructing slightly different population histories, which buffer some of the biological consequences of the changes in suitabilities. Reassuringly, the evidence for predator switching, although present in these preliminary investigations, is very weak.

Results from forward projections (Section 2.3) also indicate that some differences in projections occur as a consequence of choosing one or other of the two data sets but that the conclusions, except perhaps for herring and haddock, remain far more similar to each other than to the results of single species forecasts.

3.2.2.5 Another Year of the Stomach?

Clearly, all these analyses need inter-sessional work to bring to completion. However, the initial interpretations indicate that the 1981 and 1991 data sets taken separately or collectively and with the additional data from 1995–1997 serve to broadly characterise fish predation sources of mortality in the North Sea.

The results of these and subsequent analyses are very relevant to any decision as to a repeat of the North Sea stomach sampling programme in 2001 as a continuation of a decadal series. There are a number of arguments that can be raised for and against such a programme. Points in favour are:

1. The analyses and in particular the levels of residual variation found in the ANOVA would suggest that the sampling variation associated with stomach sampling is high and that therefore any requirement to make operational use of MSVPA/MSFOR would benefit from the better average levels of suitability that increased sampling could be expected to provide.

2. Future sampling (not necessarily in 2001) might provide a synoptic picture of feeding in the North Sea in different regimes; high gadoids, high mackerel or at lower fishing levels (clap your hands if you believe in fairies).

3. Repeating widespread collections with a comparable (but possibly improved) sampling scheme would also maintain the compatibility and the expertise associated with the 1981–1991 stomach sampling work.

4. Fresh samplings would help to maintain the credibility of multispecies results as being based on reasonably current information rather than data from some distant time in the past.

Counter points are:

1. Key areas of imprecision in the data are probably associated with some particular species (saithe for example) and species specific samplings designed to rectify these problems might be more effective at reducing uncertainties than a broad scale shot gun sampling scheme.

2. The level of sampling error are such that a few extra years of general stomach sampling might not greatly enhance precision.

3. New and less intensive approaches should be developed to estimate the sub-components of suitability.

4. Following the Rodney Jones dictum "that once you had collected some data on a particular subject you should collect data on something else!" it could be argued that the stomach data are broadly adequate and attention needs shifting to other pressing questions. Examples could be, the migration rate of pelagic species into the North Sea from other areas, understanding "0" group processes, sampling stomachs in adjacent areas such as the eastern channel, Kattegat and Skagerrak, and West of Scotland, or the development of comparative multispecies models in other areas such as area VII.

The decision ultimately must depend on the degree of advisory and scientific precision required from multispecies analyses. This will depend on the future uses ACFM and others foresee for such analyses. Potentially it should be needed both by the Ecosystems Effects of Fishing Working Group and by the North Sea Area Working Groups and they might be asked to comment on their future needs. To progress a 2001 stomach sampling scheme a decision would need to be taken no later than (and preferably earlier than) the 1999 ICES ASC. However, beyond the maintenance of a sampling dynamic there is no strong scientific reason that, if sampling is required, it should be conducted in 2001 rather than say 2002.

The Working Group acknowledges that it is unlikely that ICES would call for another "Year of the Stomach" to be conducted in 2001 (or later) without a strong endorsement from this Working Group. Such an endorsement was not forthcoming at this meeting. The Working Group feels that performance of MSVPA in the North Sea may be more limited now by inadequacies in the input catch data than by inadequacies in the input stomach data. Moreover, many multispecies questions being asked about the North Sea, particularly questions about the well-being of prey stocks and their causal role, if any, in the variations in predator stocks, are not readily investigated within an MSVPA framework. The Working Group feels that it is a high priority to identify the properties of multispecies fisheries models which are appropriate for such investigations. Planning and implementation of major field sampling programs to parameterize multispecies models should only be done when the data requirements of such multispecies models are understood. In the meantime, many other areas of interest to ICES besides the North Sea would benefit from applying MSVPA. Well designed stomach sampling programs in those areas would have high value.

3.2.3 Keyrun 1997 vs. run with 5 traditional predators and old M1 values

3.2.3.1 Description of runs

This year, several new predators have been introduced in the MSVPA. The predation pressure imposed by these predators was previously included in M1. To elucidate, both the impact of introducing these predators specifically, and the appropriateness of the previous M1 values, a run with only the 5 traditional MSVPA predators cod, whiting, saithe, North Sea mackerel and haddock, and using the old values for M1, was compared with the key run.

3.2.3.2 Results

The main result of this comparison is that more prey is consumed according to the key run, which in turn leads to higher estimates of prey biomass. (Figure 3.2.3.1). The deviation is more apparent in the later years, indicating that some of the role of the 5 traditional predators has been taken over by the new predators in recent years. In addition, the previously used M1 values appears to have been insufficient to cover the predation pressure induced by the other predators. The results also indicate that both the biomass and the amount consumed have been quite stable for most of the assessment period, while including only the 5 traditional predators indicated a declining trend in both these variables.

Comparing the M2s on various prey between the 5 predator run and the key run,(Figure 3.2.3.2 vs. 3.1.2.12), the obvious difference is that M2s on sandeels, herring, and young Norway pout are all lower in the 5 predator run. These differences, particularly the lower mortality on sandeels, reflects the high use of sandeels by many of the additional predators, such as seabirds and grey seals. Many of the minor prey (numbers 8 and higher in the figure, including mackerel, plaice and sole, suffer no mortality in the 5 predator run. This is because they are not eaten by the traditional MSVPA predators, and were not included in prey in analyses at earlier meetings of this Working Group.

Looking at the changes in suitabilities between the two runs, the changes are skewed to positive values (Table 3.2.3.1), suggesting, on average, the 5 traditional MSVPA predators showed higher suitabilities for fish prey in the key run than they did when all the other predators were removed. The changes in M2 are much smaller (Table 3.2.3.2), and much less skewed, but still indicate a net greater level of M2 on the fish prey in the key run than in the 5 predator run.

This is an interesting result, with several possible interpretations. Perhaps because some of the added named predators eat substantial amounts of "other food" as well as fish, the key run had the traditional predators eating less Other food than they were estimated to eat in the 5 predator run. This would suggest previous Working Groups made a wise choice of predators to start with, if the goal was to model impacts of predation on prey stocks. Much more time must be spent with these results before any conclusions are drawn, however.

In the 5 predator run there is major impact of predator biomass on the suitabilities; with suitability not decreasing as rapidly as predator biomass. This is likely to be complex consequence of the differences in biomass and fish biomass eaten between the two runs (Figure 3.2.3.1), but it was not possible to investigate the relationship. It is noteworthy that although suitabilties changed systematically with predator biomass, M2 changes were almost completely unrelated to changes in the biomasses of either predators or prey between the runs.

3.2.4 Keyrun 1997 vs. run with all predators plus horse mackerel

3.2.4.1 Rationale and description of runs

Horse mackerel as predator was not included in the key run due to the uncertainty about the actual amount of horse mackerel having been present in the North Sea in the assessment period. An alternate run was made to show the impact of this additional predator with biomass estimated as described in Section 2.1.3 and with the stomach content data observed for horse mackerel. Other parameters in the key run, including M1, were left unchanged. According to the estimates in Section 2.1.3. large amounts of western stock horse mackerel has entered the North Sea in the 4th quarter to feed from 1985 onwards. Prior to that, the horse mackerel was only represented by the much smaller North Sea stock. The stomach data, which are from 1991, have not been weighted according to this presumed area distribution of the horse mackerel.

3.2.4.2 Results

Figure 3.2.4.1 gives an overview of the effect of including horse mackerel as predator. Figure 3.2.4.2 shows a comparison of the M2-values. Apart from other food, horse mackerel preys exclusively on 0-group fish, notably on herring, and to a lesser extent on sandeel. The effect in terms of higher biomass of fish eaten, and higher total biomass is largely confined to the years from 1985 onwards, and not very impressive, which is in accordance with this species feeding mainly on crustaceans. Since the yield remains constant, the yield per biomass is slightly lower. The P/B ratio is slightly lower in these years for the run with horse mackerel, indicating in comparison to the key run a slightly higher decrease in total biomass from year to year.

The inclusion of horse mackerel led to a small number of large changes in suitabilities (Table 3.2.4.1), but most of the suitabilities showed extremely little difference (over 90% of changes were between -0.001 and +0.001) between the key run and the run with horse mackerel. Likewise, only a small number of M2s changed, going up substantially. This suggests the impacts of another major predator were experienced by only a few of the predator - prey combinations in the analyses. Almost all the relationships between changes in suitabilities and M2s and changes in predator biomasses were related directly to the additional horse mackerel biomass (Table 3.2.4.2).

3.2.5 Key run 1997 vs. run with old consumption rates for cod, whiting, haddock and saithe

3.2.5.1 Description of runs and rationale

Changing consumption rates and adding new predators are both changing fundamental inputs to the MSVPA. If results of these runs are to be compared to results of previous meetings, it is important to have a run which uses the old consumption estimates and the new suite of predators, just as we have included runs with only the traditional predators and the new consumption data. Together these contrasts allow one to begin to partition the effects of each class of changes from key runs of earlier meetings to the key run of this meeting.

The key run was compared to a run where the only change was that the consumption rates used in past MSVPA runs were used. All other inputs were as in the key run.

3.2.5.2 Results

Figure 3.2.5.1 gives an overview of the effect of using the old consumption rates. Figure 3.2.5.2 shows a comparison of the M2-values. The old consumption rates generated a slightly lower amount of fish biomass eaten and dead due to other causes, which is reflected in slightly higher yields per unit of biomass to fisheries rather than to predation. This is completely consistent with expectations as comparisons of the old and new ration estimates in Section 2.3 show that in general, consumption of predators is higher with the new values than was thought when the old values were derived. The overall ecosystem biomass, yield and P/B ratios are almost unchanged by the different consumption estimates, however. Correspondingly, there is generally slightly less M2 per prey age in the run using the old consumption estimates than using the new ones.

The slight decrease in M2 also appears in the tabulated differences in M2 between the runs (Table 3.2.5.1), appearing as surplus of small positive differences, but with almost none of these as large as + or - 0.01. Almost all suitabilities showed some change, however again very few were large enough to expect to be noticeable in applications of the results. Interestingly, nearly a third of the changes in M2 were related to changes in predator biomass (a shift in abundance between whiting and haddock) suggesting that the relative consumption rates of these two species may be incorrected scaled (at least relative to each other) in one (or both) of the sets of consumption figures.

3.3 The Implication of Alternate MSVPA Runs for a Long-Term Equilibrium Forecast

Long-term equilibrium predictions are one of the end products of the multispecies model, and comparisons between the outcomes for different fishing patterns is often used for management advice. It is therefore important to see how much such predictions would depend on the source of the stomach data, and on the range of predators included.

MSFOR was run until convergence with appropriate input values generated by the key run of MSVPA. Each of the alternate runs above (see Sections 3.2.1 to 3.2.5) took its input numbers from the corresponding alternate MSVPA runs. The following options were used:

- Recruitment was taken as the average over the years 1974–1994, and assumed constant.
- Fishing mortalities, weights at age and maturities at age were taken as the average of the years 1990–1994.
- The biomass of other predators was taken as the average over the years 1990–1995.

Figure 3.3.1 shows the long-term yields, Figure 3.3.2 the spawning stock biomasses, and Figure 3.3.3 the yearly consumption of each prey species by all predators included in the run.

The option including only the five MSVPA predators, but using the M1s from previous years, is the oddest of the alternate runs. The amount of MSVPA prey eaten is much smaller, indicating that the previous M1s have been insufficient to account for the predation pressure induced by introducing the new predators in the model. The yield and SSB of Norway pout and sandeel are markedly increased whereas, for the other prey, these are only moderately increased.

The overall effect of adding horse mackerel to the predators is not very impressive. Altogether, the amount of MSVPA prey eaten by horse mackerel is about 600,000 tonnes, which is about 5% of the amount eaten by all predators.

Using the old 'rations data' leads to a marked reduction in total food consumption by whiting, and to some extent by cod. For the other species, there were only minor differences. This leads to lower estimates of the amount of prey eaten, in particular of whiting, haddock and, to a lesser extent, of sandeel.

Censoring the weights in the stomachs had virtually no effect on the results of the long-term forecast.

The effect of using only the 1981 or the 1991 stomach data is illustrated both in the Figures 3.3.1–3, and in Figures 3.4 and 3.5 which show the impact on the estimated yield and SSB of a 10% reduction in the fishing mortality for all species. All the predators represented in both years stomach data get a larger total consumption using the 1991 data than using the 1981 data. To some extent this may be because the stock of these predators becomes larger, but the per capita consumption of MSVPA species also appears to be higher. This corresponds to generally higher recruitments for all species except herring, and a lower fraction of other food in the diet when the 1991 data set is used. The results from the key run, using all the stomach data, is not always intermediate between the two single years. This, probably more than anything else, illustrates the complexity of the impact of the stomach data on the final model results. So does the effect of a 10% reduction in fishing mortality. The discrepancies are particularly prominent for haddock and herring. For haddock, the 1981 data indicate a 17% reduction in SSB, while the 1991 data indicate a 4% increase. For herring, these results are an 11% decrease and an 11% increase, respectively. The difference in yield is also very large for these two species. The results of the key run are generally closer to results using the 1981 data than to those using the 1991 data. A similar study was undertaken by the MAWG in 1993 (ICES 1993/Assess:9). The results this time, after the data have been cleaned up, differ considerably from those obtained in 1993, and the contrast between the data sets is greater now for several species.

3.4 Summary and Conclusions for the North Sea MSVPA Runs

The most important MSVPA contrasts examined at this meeting may still be the contrasts between the runs using only the 1981 and 1991 stomach data. These remain the most direct tests of the assumption of constant suitability in MSVPA. These results are already summarized in Section 3.2.2.4. Suitabilities do move around from run to run, but M2s are quite stable. The stability in M2s is even more marked on an aggregated basis, which is the biologically relevant factor to consider. (A prey population fluctuates according to total predation mortality suffered; not how the mortality is distributed among predators). The larger total recruitments in runs using only the 1991 data than in the runs using only the 1981 data were also interesting. Time did not allow that point to be pursued further either.

With regard to the other contrasting runs:

- Including horse mackerel had surprisingly little impact on most prey, although there was some increase in M2 on herring, especially 0-group.
- Censoring the weight data had surprisingly little impact, beyond removing some of the biggest instabilities in suitabilities estimated separately with the two years of stomach data.
- The change in consumption estimates also had very little impact on suitabilities, although in this case there was greater impact on M2s. With the revised consumption estimates, predators eat the same things; just more of them.
- The run with only the 5 traditional MSVPA predators (cod, haddock, saithe, mackerel, and whiting) showed clearly that we have not been allowing for enough non-fishing mortality with the M1 values used in our past runs. This may have some wider implications, because previous M1 values were chosen to match roughly the amount of natural mortality on older ages assumed by the Assessment Working Groups. More work is needed on how the shortfalls are distributed among prey ages, though.

Information from the run with 5 predators, combined with contrasts between the 1993 key run and this key run (Figure 3.1.2.11) also indicate that we now estimate that many properties of the North Sea, such as the total biomass, total biomass eaten by predators, and P/B ratios have been much more stable over the past 25 years than we used to estimate. This is likely because we are doing a much more complete job of accounting for the biomass in the ecosystem. Predation is playing an even greater role in the dynamics (or stability) of the North Sea in the present view of things than in the past.

Some details are clearly different between the two forecasting runs particularly with regard to herring and haddock. Problems with consistency of the haddock forecasts were seen in analyses at previous meetings. The differences between the MSFOR runs in the responses of herring to changes in F is new at this meeting. It will be pursued intersessionally, first by examining the consequences of changing F in each fleet separately, to isolate the major fisheries which contribute to these differences.

It was regrettable that the 1981 mackerel data had to be excluded from all runs, but it was thought even more regrettable to include data which were not consistent with all the other data in the runs. This is another problem which must be addressed intersessionally.

Overall, our confidence in MSVPA continues to grow (as does our exhaustion with it). The robustness of the results to many modifications explored at this meeting, and the ability of MSVPA to show proper responses to specific alterations (e.g. when consumption levels of predators are raised, M2s do go up), are sources of our growing confidence. Moreover, those reasons, and the improvements in performance going from the this year's 5 predator run to the key run suggest that although it is possible that MSVPA may go wrong because of things not included in it at all, MSVPA has not formulated the things it does contain in any seriously erroneous way.

The Working Group sees little opportunity to add yet more predators to the North Sea data base, as the diets of few remaining major predators are largely unknown. As discussed in Section 3.2.4 there is substantial room to improve the input data on fish catches and population trends, however.

We feel the present picture of the level of predation in the North Sea is more realistic than past views. This should be considered by other Working Groups which address multispecies relationships in the North Sea.

4 MULTISPECIES CONSIDERATIONS IN THE DEVELOPMENT AND PROVISION OF PRECAUTIONARY ADVICE

4.1 Overview of the Issue

In a series of international agreements summarized in ICES (1997/Assess:7) (ACFM Study Group on the Precautionary Approach to Fisheries Management) and ICES (1997/Assess:15) [1997 ComFIE Report], the precautionary approach has been endorsed as a basis for fisheries management. ICES has adopted the approach in principle as a basis for the advice it provides on fisheries management (1996 ACFM Report, Spring 1997 ACFM Report), although it is unclear exactly what new or different biological reference points will be adopted by ACFM to implement that approach. Both a Study Group of ACFM and ComFIE have pursued analytical approaches to include precautionary concepts in fisheries assessments and advice. Although this work is not completed, the general direction is becoming clearer.

To this point the work within ICES is developing an analytical and graphical approach based on the work of Sissenwine and Shepherd (1987), and illustrated in Figure 4.2.1. However, this approach is intrinsically single-species. Although natural mortality does affect components of the equations or curves used in the approach, it is not explicit nor dynamic in any of the analyses. Likewise the examples developed in the ComFIE and ACFM Study group reports deal exclusively with single-species dynamics. The Multispecies Assessment Working Group was asked to review this work, to evaluate if and how multispecies interactions might affect the properties of relationships or parameters in the models promoted by the other groups, and ICES advice on biological reference points and rebuilding strategies.

The evaluation has several objectives. First of all, it is desirable to determine if multispecies interactions matter in the selection and estimation of biological reference points and rebuilding strategies. If they do matter, the evaluation may make it possible to differentiate single species biological reference points which are sensitive to multispecies effects, from reference points which are robust to those interactions. It may be possible to identify

new biological reference points for either single species or multispecies applications. It may also be possible to modify the methods used to estimate single species biological reference points, to incorporate the effects of multispecies interactions explicitly.

4.2 Two-Species Interactions and Precautionary Advice

4.2.1 Algebraic / graphical extensions of the approach in the 1997 ComFIE Report

WGCOMP97 lists and defines various biological reference points. Figure 2.2.2 of WGCOMP97 (reproduced as Figure 4.2.1) illustrates the calculation of yield (Y) as a function of fishing mortality (F) following the approach of Sissenwine and Shepherd (1987) and is largely self explanatory.

In considering the implications of multispecies interactions for rebuilding strategies and for biological reference points it is worth considering first if any algebraic or graphical representations can provide general insights to the likely effects. In practice algebraic representations are only likely to be possible for steady state cases and given the added complications of multispecies theory only for the simplest of these. During the meeting of MSWG it has proved possible to construct algebraic Multispecies theory for two simple cases. In both cases it is assumed that calculations follow the approach adopted by WGCOMP97. Firstly, a VPA (or MSVPA) is conducted to estimate fishing mortality at age and year {F(a,y)} and recruitment{R(y)} and spawning stock biomass {SSB(y)}. Following the steps shown in Figure 4.2.1, such estimates are then used to:

1. calculate Y/R and SSB/R
2. estimate stock recruitment relationships
3. estimate R and SSB to be expected for a given F
4. given R, Y/R to estimate Y

The resulting estimates are then used to plot Y on F and on SSB and to calculate F_{MSY}, B_{MSY} and F_{crash}. The other reference points may also be calculated through the products of this approach.

In constructing the theory we have viewed the problem from the perspective of a VPA world. Within that world we have considered that the multispecies interpretation was the truth and that the single species assessment was an approximation. The difference in the two simple cases is that the single species assessment ignores the predation mortality rate (M2) and only uses the other natural mortality rate (M1). Moreover we note that in general M2 may be a function of both predator and prey biomass and thus cannot be entirely substituted by a constant average of M=M1+M2 as is attempted in current single species assessments. We also note that typically multispecies assessments tend to produce higher total M levels, particularly on younger ages.

Case 1. A cannibalistic species where all the M2 is generated on pre-fished ages and only by the spawning stock. M2 is proportional to SSB size alone.

In this case Cumulative M2 on pre-recruits = c*SSB.

Step 1. The mortality between t_0 and from t_c in the Multispecies case (ms) is $(t_c - t_0)$*M1 +c*SSB. In the single species case it is just $(t_c - t_0)$*M1. Since there is no difference in Y/R or SSB/R calculations at ages older than t_c in the single species case(ss).

SSB/R(F¦ss) = SSB/R(F¦ms)*exp(c*SSB)

and

Y/R(F¦ss) = Y/R(F¦ms)*exp(c*SSB).

N.B. Thus $F_{0.1}$, F_{max} and $F_{x\%}$ will be distorted.

Step 2. Lacking the M2 terms single species assessments will underestimate recruitment at t_0 by exp(c*SSB). Thus

SSB/R(SSB¦ss) = SSB/R(SSB¦ms)*exp(c*SSB).

R(SSB¦ss) = R(SSB¦ms)*exp(-c*SSB).

Thus in the single species case the SSB at which maximum recruitment occurs will be distorted and R on SSB curves will show a greater reduction of recruitment at higher SSB. $B_{50\%}$ will normally be altered in this case, and in general for populations where recruitment follows a Ricker model.

Step 3. Because SSB/R(SSB¦ss) and SSB/R(F¦ss) are both distorted by exp(c*SSB), there is a correspondence between F and SSB in the ms and ss cases

Step 4. Because R(SSB¦ss) and Y/R(F¦ss) have distortions of exp(-c*SSB) and exp(c*SSB),

Y(F¦ss) = Y(F¦ms)

Y(SSB¦ss) = Y(SSB¦ms).

N.B. Thus F_{MSY} , F_{crash} and B_{MSY} will not be altered in this case.

More subtly, F_{max} , F_{low} ,F_{high} and F_{loss} would not appear to be altered in this case. It is not immediately clear what will happen to $B_{90\% \text{ R } 90\% \text{ Surv.}}$

Figure 4.2.2 illustrates and summarises the changes implicit in the steps if Multispecies effects are not accounted for in this case.

<u>Case 2.</u> **A forage species where the only M2 is generated equally on all-fished ages by a constant stock of a predator. M2 is proportional to Predator stock size only and is thus constant between realisations. (Note this is simpler than the typically multispecies assessment where M2 might be expected to increase as prey stock decreased). F and M1 are considered to be constant through realisations of VPA.**

In this case simple considerations of the VPA process suggest that if M2 is omitted from single species VPA then

F(ss) = F(ms)+M2.

In other words, the underestimate of M will be interpreted as an overestimate of F. In the case where F, M1 and M2 are constant it can also be shown that

R(y¦ss)=R(y¦ms)*F(ms)/(F(ms)+M2)

and

SSB(y¦ss)=SSB(y¦ms)*F(ms)/(F(ms)+M2)

The distortion of F, R and SSB is more subtle if F varies through time or with age and hence only the simplest steady state case is considered here.

Step 1. It is assumed that $t_0 = t_c$. Since F(ss) = F(ms)+M2.

Z(ss) = Z(ms).

Hence

SSB/R(Z¦ss) = SSB/R((Z¦ms)

and there is a translation of +M2 of the curve on the F axis in the ss case.

For Y/R calculations

Y/R(Z¦ss) = Y/R((Z¦ms)* F(ms)/(F(ms)+M2)

Thus in the ss case, there is both a variable increase in the curve at each Z value and a translation of +M2 of the curve on the F axis, for any value of Z.

N.B. Thus $F_{0.1}$, F_{max} and $F_{x\%}$ will be distorted. An effect of the assumptions is that F will be estimated as M2 when F → 0. This makes it impossible to estimate the case for F(ss) = 0 though it is suspected that ss assessment Working Groups might pick up the discrepancy in this case which might lead to a smearing of the relationships in this region.

Step 2. Lacking the M2 terms, single species assessments will underestimate recruitment and SSB. Thus

SSB(SSB¦ss) = SSB(SSB¦ms) * F(ms)/(F(ms)+M2)

R(SSB¦ss) = R(SSB¦ms)* F(ms)/(F(ms)+M2).

It follows that.

SSB/R(SSB¦ss) = SSB/R(SSB¦ms)

Thus, in the single species case the SSB at which maximum recruitment occurs will be distorted and R on SSB curves will show increased reduction of recruitment at higher SSB, when presumably F is low relative to M2. The distortion can also create a backward curl in stock recruitment curves which may make them more difficult to interpret. $B_{50\%}$ will normally be altered in this case and other cases where Ricker recruitment models apply.

Step 3. Because SSB/R(SSB¦ss) is not distorted but SSB/R(F¦ss) is translated on the F axis by M2, there is not a correspondence between F and SSB in the ms and ss cases. Thus, for a given F level, the ss case will predict a higher SSB but a lower recruitment.

Step 4. Because R(SSB¦ss) and Y/R(F¦ss) have different distortions

Y(F¦ss) ≠ Y(F¦ms)

Y(SSB¦ss) ≠ Y(SSB¦ms).

Thus F_{MSY} , F_{crash} and B_{MSY} will be altered in this case. F_{max} , F_{low} ,F_{high} and F_{loss} would also appear to be altered in this case. Again it is not apparent how $B_{90\% R 90\% Surv}$ will be affected.

It should also be noted that systematic shifts in M2 by a change of predator biomass will be interpreted as regime shifts in a ss stock recruit curve.

Figure 4.2.3 illustrates and summarises the changes implicit in the steps if Multispecies effects were not accounted for in this case.

Summary: Within the VPA framework used here the two simple case suggest that stock recruitment curves and yield curves will become distorted if single species assessments are made which disregard these first order multispecies effects. While the cases are simple they indicate the more general effects that may occur if even first-order multispecies effects are neglected.

These are that:

1. Recruitment and stock size will be underestimated and F may be overestimated. Y/R and SSB/R curves may be overestimated and suffer +ve F translations as a result.

2. R on SSB curves will generally be lower and bend down more at higher stock sizes. R on SSB relationships may thus become distorted and be more difficult to establish and the relationship of R to environmental factors may be obscured.

3. Biological reference points will be distorted in the absence of multispecies effects being considered.

The cases considered used rather mild multispecies interactions which might be expected to be larger in reality. Moreover, the effect of prey stock size on M2 was ignored. Generally for a given predation pressure M2 might be expected to be maximal at low prey stock size and reduce at high prey stock size (the predator saturation effect). This effect would undoubtedly increase the distortions indicated in case 2 and may need to be a serious consideration in stock rebuilding programmes where the size of the predator stock and its exploitation may need to be considered as well as the size and exploitation of the prey stock.

Figure 4.2.4 indicates the more general distortions to be expected. The Working Group also stresses that these two species models, although an important beginning, can capture only a part (and possibly only a small part) of the multispecies effects on biological reference points and rebuilding strategies. True systems may show many higher-order relationships as well, as the predator, prey, and other interacting species respond to changing biomasses and M2 levels of all constituent species.

4.2.2 Simulation of single species precautionary analysis of a two species system (Revised)

Standard ComFIE output plots of yield per recruit analysis linked to a stock-recruitment relationship are used as a framework to assess the potential impact of using single species analysis of a two stock system. An age structured model which has 9 ages is used for both yield per recruit analysis and a yield model in which a Ricker recruitment model is imbedded. The main age specific parameters are shown in the following table (Table 4.2.2.1) which is start of the Excel program. The weight at age pattern is codlike and the partial recruitment and maturity ogive are hypothetical. The mortality at age is from the "cannibalism" rum in which M2 is a function of the spawning stock biomass. Three scenarios are explored, 1) is a prey species which is susceptible throughout its age range (called all-ages), 2) only young are susceptible and independent of predator biomass (called sequential), and 3) only young are susceptible and dependent on predator biomass (cannibalism). Only the 'cannibalism' scenario can be thought of as a two species system, the other scenarios are a single species with a mis-specified natural mortality. In all cases the two species model was run to equilibrium, catch generated and a single species VPA performed to estimate stock size and a stock-recruit relationship. Hereafter, the results of the single species VPA estimates will be denoted SS-VPA. M2 multipliers were chosen so that the average M2 over all ages was 0.1 in all three scenarios. Ricker stock-recruit functions were used in all cases. The a and b parameters were solved algebraically from the visually estimated point of maximum recruitment. See Table 4.2.2.2.

First a test run was performed (Figure 4.2.2.1) in which the natural mortality was 0.2 at all ages to check the internal consistency of the program. The output format is similar to the ComFIE format with 'multispecies' and single species estimates in each. The 3 sub-plots in the left had column are SSB per recruit, yield per recruit and Yield all as functions of fishing mortality. Beside these are SSB per recruit, stock recruit and yield all as functions of SSB. The lower right sub-plot is the single species yield. The output curves correspond quite well with the main source of disagreement being introduced by the cohort approximation which fails at higher Fs.

As expected, the all-age simulation (Figure 4.2.2.2) shows that the stock and recruitment is consistently underestimated by the VPA which assumed m= 0.2. The SS-VPA yield per recruit (line with symbols) has a similar shape but lower yield compared to the true yield per recruit (simple line). However, when the yield per recruit and recruitment estimates are combined into yield as a function of fishing mortality the curves superimpose on the ascending limb and the SS is slightly higher on the descending one. F_{crash} is also overestimated in the SS results. The yield as a function of SSB results are similar although the VPA output suggests a lower B_{virgin}.

The "sequential" run (Figure 4.2.2.3) is made with an M2 constrained to the first four ages (See Table 4.2.2.1). The discrepancies between the stock-recruit and yield per recruit figures when comparing the True and SS-VPA versions are larger than was seen for 'all-age's above. However, again we see a large degree of compensation when the yield curves are estimated. Although the average M2 is the same as for the 'all-age' simulation, the true yield is reduced by almost a half when M2 is concentrated on the younger ages. The SS-VPA estimate of that yield overestimates the right-hand limb and thus F_{crash}. The true and SS-VPA yields as a function of SSB are quite similar.

The "cannibalism" run (Figure 4.2.2.4) uses the same M2 pattern as the 'sequential' run. The magnitude of the difference in yield per recruit patterns is less than seen above but the shape is more distorted. The SS-VPA stock-recruit is essentially identical to 'all-age' peaking a t lower biomass and recruit levels than the true relationship. The SS-VPA yield as a function of F underestimates the right-hand limb, as opposed to the two above scenarios.

Again the compensation in the biomass per recruit and stock recruit relationships produces an SS-VPA yield as a function of biomass that is a good approximation to the truth although it is less symmetric about the maximum.

These simple simulations suggest that on whole ignoring M2 does not seriously affect the yield curves. F_{crash} is probably the most sensitive target to ignoring M2. The estimation of the yield curve for higher Fs, and hence F_{crash}, is strongly dependent on the stock-recruit curve near the origin. The Ricker model, which has been assumed in this study, may not fit data from actual fisheries well in this region and care will have to exercised in choice of model.

4.3 Extension of Models to 3-Species Interactions

4.3.1 Simulations using a 3 species model

Several simulations were performed based on a spreadsheet version of the Baltic multispecies MSFOR developed at the Danish Institute for Fisheries Research (Henrik Gislason, pers. comm.). A 3 species model was developed to explore some of the implications of more complicated systems compared to single species analysis. Two versions of the model were used both of which were based on Baltic Sea fisheries data and the cod-sprat recruitment model developed by Sparholt (1996). Input parameters have been derived from the report of the Working Group on Multispecies Assessment of Baltic Cod (ICES CM 1996/Assess:2), i.e. weight at age, M1, food intake of cod, average recruitment, fishing moralities and maturity ogives. The suitabilities were taken from Sparholt(1995). The model performs a 30 year prediction of the biomass and yield of the three species with annual timesteps. It is emphasized that the results from this study are not meant to represent the Baltic Sea, but rather to act as examples of possible future analysis using more complicated models than is common practice.

The basic model has cod preying on sprat and herring as well as their own young. There is a secondary interaction in that the amount of herring and sprat available as prey affect the amount small cod lost through cannibalism. Sprat and herring Ricker relationships were fit by eye through data found in Table 10.6 of Anon 1997. (ICES CM 1997/Assess:12). See Figure 4.3.2.1. Two versions of recruitment functions were used for cod: in one case Sparholt's model is used in which where recruitment is proportional to cod biomass but a declining function of sprat biomass, presumably due to sprat predation on 0-group cod, and in the other case all three species are fit to Ricker curves. Because the Sparholt recruitment modelled tended to blow up when sprat biomass was low and cod biomass high, a Ricker curve was substituted for most of the following analysis. These two versions of the model will be called respectively 'Cod-Dynamic' and 'Cod-Ricker'. In all cases recruitment for sprat and herring were modelled by the Ricker functions. The model has starting populations based on the above assessment document and they were forecast for 32 years. Because the populations often shoed oscillatory behaviour, the last twenty years of each run were averaged to form the basic outputs, SSB, recruits, yield, etc. Two control variables are varied one called 'Cod F' and the other is 'Prey F'. These variables are actually multipliers of the underlying fishing mortality for cod in the first case and haddock and sprat in the second. The cod fishing mortality is approximately 1 so 'Cod F' may be interpreted as fully recruited F. The underlying herring and sprat fishing mortality are respectively 0.3 and 0.15 so that the variable 'Prey F' is actually a coefficient of the current practice.

The 'Cod-Dynamic' model was capable of complicated behaviour as is shown in Figure 4.3.1.2. In this figure note the stock recruit series shows a complicated path having a period in which the sprat are influencing recruitment followed by a cannibalism dominated regime. The modelled equilibrium cod SSB as a function of cod and prey fishing is shown in Figure 4.3.1.3. At high prey F this surface shows monatomic decrease with increasing 'Cod F' as would be expected from single species analysis. At low 'Prey F' the SSB increases again as 'Cod F' attains higher values.

The analogous surface to above figure for the 'Cod-Ricker' model is given in Figure 4.3.1.4. The SSB surface has a similar form but is scaled down from a maximum of 1100 KT to 800 KT for the virgin ecosystem. Again the SSB surface is relatively unaffected by prey F with a tendency for lower values as prey F increases. As well as a high ridge when cod F is low a lower ridge is seen at middle cod F values. If all predation effects are removed but the S-R functions still operating, the SSB is much more sensitive to predation. See Figure 4.3.1.5 which compares the SSB for the multispecies model when prey F is held at 1.0 (marked MS) to M2 = 0 (SS) results. The single species M1 was scaled to approximate the inclusion of M2. The interactive multispecies model is seen to be much more stable to fishing pressure.

The final analysis using the 'Cod-Ricker' model was to map the regions in which 1 or 2 of the prey species collapse, Figure 4.3.1.6. For this study collapse was defined as when the biomass fell to 5% or less of highest biomass seen in model runs. The highest prey biomasses were seen when 'Cod F' was set at 1.6 and 'Prey F' was zero; 2.3 and 1.3 MT for herring and sprat respectively. The upper left corner (low prey F and high cod F) is safe from a prey collapse. As the lower left corner is approached first and then 2 collapses are predicted. Recall that cod are quite stable to exploitation and do not collapse under the F ranges that were used. Most of these results depend upon extrapolation using models, often well beyond observed ranges. Also, the dynamics of recruitment at very small stock sizes may well not be represented by the Ricker model used here. Furthermore, this model does not include any spatial heterogeneity - there may well be areas where the predators and prey don not overlap. An example of these problems is that this model makes the highly unlikely prediction that if all fishing left the Baltic, both herring and sprat would collapse.

4.4 Implications of Multispecies Interactions for Rebuilding Strategies

4.4.1 Simulation of single species recovery strategies analysis of a two species system

The same 4 models as in 4.2.2, Test, 'all-age', 'sequential' and 'cannibalism', were used to examine the difference in MS and SS recovery trajectories from a heavily exploited stock. In each case, the MS stock was run to equilibrium at an F of 0.8. Because there was the tendency for oscillatory behaviour in some cases, the equilibrium point was set at the average numbers at age of the last 5 years of the run at F = 0.8. It is noted that although the biomass recovery curve is smooth, the recruitment has a jog in year two reflecting that the starting point for the recovery was not quite at equilibrium. The recovery strategy was to set an F of 0.1 and the true and SS-VPA estimated trajectories were followed for 22 years (Figures 4.4.1.1–4). See Section 4.2.2 for definition of abbreviations. In each case the biomass, recruits at age 1 and yield were tracked. The test run (Figure 4.4.1.1) shows that the program was internally consistent.

The 'all-age' trajectories (Figure 4.4.1.2) show a tendency for the SS-VPA estimate of biomass and yield to be too optimistic. The recruits are initially over estimated and then constrained by the maximum of the VPA based S-R relationship. The biomass and yield time series from the 'sequential' run (Figure 4.4.1.3) are similar to 'all-age' in that the recovery is over estimated. The recruits are consistently underestimated. The "cannibalism" curve (Figure 4.41.4) shows perhaps the greatest degree of overestimation in terms of biomass.

It is difficult to compare the recovery paths because there are different fundamental parameters in each. Perhaps some sort of normalization (to Max recruitment and SSB?) would help. For example the recruitment trajectory for 'all-age's levels off at about year 15 and appears to fall behind the MS series, but what this actually shows is that the system has reached an area of maximum production in 15 years while the MS is still climbing after 25. The tendency to overestimate recovery is to some degree a factor of the adoption of a Ricker recruitment model. The rate of change is stock size is dominated by the parameter a when the biomass is low.

$$dR / dS = ae^{-bS}(1 - bS)$$

In the 'all-age' and "cannibalism" cases, the a is very similar to the true a so the increase in recruitment will be about the same, but the survivorship to spawning age will be higher. We see that maximum recruitment is reached for these two cases after about 15 years. However, in the 'sequential' run where the SS parameters are both scaled down , the two (MS and SS) trajectories are quite similar.

The only recovery strategy considered was one of constant F. If a TAC had been set from VPA results the overestimation would have been more severe. This is because the yield estimates were under constant F were already too high.

The Working Group stresses that these investigations are preliminary, and much more work is required before the full implications of multispecies interactions for rebuilding strategies and the generality of these findings is known.

4.5 Implications of Multispecies Lotka-Volterra Interactions for Biological Reference Points

The Precautionary Approach has conventionally been discussed based on precautionary stock-specific reference points which are calculated using single-species models. These reference points therefore account, *inter alia*, for the reproductive capacity and resilience of a stock, the characteristics of fisheries exploiting the stock, as well as

other sources of mortality and uncertainty. However, they do not explicitly incorporate the effects of fishery management strategies on related or dependant species in a multispecies system, or on the existing ecological relationships within the ecosystem. A preliminary attempt has been made (Bulgakova 1997, WP no. 1) to illustrate the necessity of including multispecies considerations in precautionary fisheries management advice. Precautionary biological reference points are conventionally based on simple single species production models. This approach uses a simple multispecies model as the preliminary basis for extending theories concerning the optimal management of harvested fish species within the context of a classic two-species predator-prey system. The necessity of considering inter-specific trophic interactions as they pertain to the choice of a rational set of fishery management parameters is illustrated below.

The preliminary analysis assumes an elementary predator-prey model, based on the original Lotka-Volterra model, and with a single non-trivial stable equilibrium solution:

$$\begin{aligned} \frac{dx_1}{dt} &= x_1(a_1 - bx_1 - cx_2) - F_1 x_1 \\ \frac{dx_2}{dt} &= x_2(a_2 x_1 - M) - F_2 x_2 \end{aligned} \tag{1}$$

where x_1 = the prey abundance level;
x_2 = the predator abundance level;
a_1, b = logistic growth rate parameters for the prey population;
cx_2 = the prey mortality rate attributable to the predators (described by a "Volterra term");
a_2x_1 = a predator growth rate term, proportional to the number of prey individuals;
M = the predator natural mortality rate; and
F_1, F_2 = the fishing mortality rates, for the prey and predator species respectively.

It follows from equation (1) that the predator species goes extinct in the absence of the prey species. Under conditions of zero fishing mortality, the equilibrium is given by: $X_{10} = M/a_2$; $X_{20} = D/a_2c$ with positive solutions for the case:

$$D = a_1 a_2 - bM > 0 \tag{2}$$

It is assumed that condition (2) is always true in this analysis.
Under the assumption of a constant fishing mortality rate, system (1) has equilibrium stock numbers:

$$X_{10} = \frac{M + F_2}{a_2}; \quad X_{20} = \frac{D - (a_2 F_1 + bF_2)}{a_2 c} \tag{3}$$

The equilibrium co-ordinates above lie in the positive quadrant provided that the fishing mortality rates satisfy the condition:

$$a_2 F_1 + bF_2 < D \tag{4}$$

This point is asymptotically stable for $b > 0$.

Using the fishing mortality rates $\{F_1, F_2\}$ as co-ordinates, Figure 4.6.1 illustrates the region (triangle MON together with its boundaries ON and OM) corresponding to an area of allowable management of the two-species system, as derived from conditions (4) and $F_1 \geq 0$, $F_2 \geq 0$. The equation for line MN is obtained by changing equation (4) from an inequality to an equality and solving for F_1:

$$F_1 = D / a_2 - F_2 b / a_2 \tag{5}$$

It is possible to investigate the effects of managing a fishery of the first species under the assumption that the population is isolated, i.e. we neglect any effects of the predator on the prey population. Then $F_1 = a_1$ gives the

maximum possible prey fishing mortality rate[1] F^*_{1crash} and the maximum sustainable yield (MSY) corresponds to a value $F^*_{1MSY} = a_1 / 2$ (point S in Fig. 4.6.1), where $MSY_1^* = a_1^2 / 4a_2$.

In general, F_{1crash} will be less for a more realistic case in which predators are included. Under zero predator fishing mortality, $F_{1crash} = D / a_2 \quad < a_1$, whereas if F_2 increases as in equation (5), F_{1crash} decreases linearly. The line MN represents a scenario in which fishing mortalities F_1 and F_2 are such that they result in the extinction of the predator population (i.e. $X_{20} = 0$). This is an example of a limiting **crash line** which corresponds to a collapse of a multispecies fishery system.

The annual sustainable yield of the first species is given by:

$$Y_{10} = F_1 X_{10} = F_1 (M + F_2) / a_2$$

The function $Y_{10}(F_1,F_2)$ does not have a maximum in the positive quadrant, but increases linearly with increasing F_1 and F_2, up to the line of intersection with a plane perpendicular to the plane { F_1,F_2} and passing through the line MN.

There are two possible cases:

<u>Case (I): a1/2 < D/a2</u> In this case, the point S lies inside the allowable area, so that the MSY of the prey population on line MN is given by $MSY_1 = a_1^2 / 4b$, with corresponding co-ordinates $F_1 = a_1/2$ and $F_2 = (a_1a_2/2b\text{-}M)$. This is indicated as point Q on the boundary of the allowable management area (Figs. 4.6.1 and 4.6.2a) and is not a target point but rather a crash point with respect to the predator population. Point Q appears to be a target point for the prey species because it lies on line MN which corresponds to the greatest steady state prey yields, but it is not a valid management point because it results in the extinction of the second species. To manage the fishery using a precautionary approach, it is necessary to select a point within the area ONM. The precise choice of a management reference point depends on *inter alia* the relative biological and economic value of the two species as well as multispecies management conventions which are presently unknown. For example, if a 90% control criterion were adopted, the line MN would have to be shifted parallel to itself to pass through the point $F_1 = 0.9*D/A_2$. The shifted line would obviously then be included in the new allowable management area.

<u>Case (II): a1/2 > D/a2</u> (i.e. $M < a_1a_2/b<2M$) In this case, the point S lies outside the allowable area, implying that attempts to manage the first species using the conventional MSY criterion for an isolated population will result in the extinction of the predator population, even in the complete absence of any fishing on the predator population. This case is therefore synonymous with a collapse of "community" structure, so that case 2 represents the most dangerous scenario for a multispecies fishery system. The maximum yield of the first species is now given by DM/a_2^2 with corresponding co-ordinates $F_1 = D/a_2$ and $F_2 = 0$ (point M in Figure 4.6.1). For a precautionary approach, a point corresponding to a smaller F_1 value should be chosen (with possible F_1 values up to $F_1 = 0.9*D/a_2$).

We now consider fishing strategies for a predator population. The steady state predator yield is given by:

$$Y_{20} = F_2 X_{20} = F_2 \left(D - a_2 F_1 - bF_1 \right) / a_2 c \qquad (6)$$

For fixed F_1, the predator yield is maximised at:

$$F_2 = \left(D - a_2 F_1 \right) / 2b \qquad (7)$$

represented by the line ML which is inside the allowable management area and is a median of angle OMN. By substituting (7) in (6) we obtain Y_{20} as a function of F_1 as shown below:

$$Y_{20}\left(F_1\right) = \frac{\left(D - a_2 F_1\right)^2}{a_2 bc} \qquad \text{(see Figure 4.6.2b)}$$

[1] The sign * means that the formula concerns a model of an isolated population.

For any fixed F_1, the line ML therefore gives both F_{2MSY} and MSY_2 for the predator. Predator yield is maximised at point L on the boundary of the allowable area. As expected, the corresponding co-ordinates $\{F_1,F_2\} = \{0,D/2b\}$ correspond to a scenario of zero prey fishing mortality. Point L is therefore a target reference point for the predator. An example of a precautionary reference point is 0.9*D/2b.
The model system (1) was used to construct functions $Y_{10}(F_1,F_2)$ and $Y_{20}(F_1,F_2)$, shown in Figure 4.6.2, for the following parameter values which satisfy the Case I condition ($a_1/2 < D/a_2$): $a_1=0.5$; $a_2=5*10^{-11}$; $c=5*10^{-10}$;$M=0.2$; $D=2.3*10^{-11}$.

Consideration of the problem of optimal control of a multispecies system as a whole warrants investigation of the problem of maximisation of the economic profit of a two-species fishery in an equilibrium state and during a set time period (for example, one year) inside the allowable area of control MON. In its simplest form, economic profit can be expressed as the function:

$$P(F_1, F_2) = A_1F_1 (M + F_2) /a_2 + A_2F_2 (D - a_2F_1 - bF_2) /ca_2 - B_1F_1 - B_2F_2 \quad (8)$$

where the parameters A_1 and A_2 = the cost per unit yield of populations I and II respectively; and B'_1 and B'_2 = the respective expense per unit of fishing effort f. Assuming the fishing mortality rate is proportional to fishing effort, i.e. $F_i=q_if_i$, where the q_i are constant factors, we have $B_1=B'_1/q_1$ and $B_2=B'_2/q_2$. Equation (8) may be written as:

$$P(F_1,F_2) = k_1F_1 + k_2F_2 - k_3F_1F_2 - k_4F_2^2 \text{ where} \quad (9)$$
$$k_1 = A_1X_{10} - B_1 ; \qquad k_2 = A_2X_{20} - B_2$$
$$k_3 = -A_1/a_2 + A_2/c ; \qquad k_4 = A_2b/ca_2$$

In this case, X_{10} and X_{20} are the co-ordinates of an equilibrium point of the unexploited system - (2) (at $F_1 = F_2 = 0$) and therefore, k_1 and k_2 represent the profit per unit fishing mortality rate in this initial equilibrium point. If the fishery is cost effective at this point, k_1 and k_2 are positive constants. The sign of k_3 can be either: for example, if $A_2/c >> A_1/a_2$, then the predator population is more valuable than the prey, $k_3> 0$, and vice versa.

Analysis of function (9) indicated that it has neither a minimum or a maximum, so that its greatest value is achieved on the boundary of the allowable area. The function P on each of the boundary lines is given by the following functions of one argument:

$$P_1(\text{on line ON}) = k_2F_2 - k_4F_2^2.$$
$$P_2(\text{on line OM}) = k_1F_1$$
$$P_3(\text{on line MN}): \quad P_3(F_2) = F_2^2 * \alpha_2 + F_2 * \alpha_1 + \alpha_0 \quad (10)$$

where $\alpha_2= - A_1 b/ (a_2)^2$; $\alpha_1= A_1 (D - bM) / (a_2)^2 + B_1 b/a_2 - B_2$;and
$\alpha_0= (A_1 M/ a_2 - B_1) D/a_2$

It is necessary to consider four separate cases:

1. $k_1 > 0, k_2 > 0$

On line ON (with zero fishing on the first species), $P_1(F_2)$ is maximised at the point R $\{0, k_2/2k_4\}$which lies left of point L {0, D/b2}, because $k_2/2k_4 = D/b2 - B_2/2k_4$. The value of P at this point is $(k_2)^2 / 4k_4$.

On line OM, $P_2(F_1)$ increases with increasing F_1 so that on this line the greatest value of the profit occurs at point M and is equal to k_1D/a_2.

On line MN, $P_3(F_2)$ has a maximum for $F_2 = - \alpha_1 /2\alpha_2$ (point U), provided $\alpha_1 >0$; and the maximum is $P_3 = \alpha_0 - (\alpha_1)^2 /4\alpha_2 > P$ (point M).

If the condition $\alpha_1 > 0$ holds, it is therefore necessary to calculate and compare the value of the function P at each of the points U and R, since profit is maximised at one of these two points. If this condition does not hold, the value of P at points M and R should be compared instead.

2. $k_1 < 0, k_2 > 0$ - the fishery for the first species is not cost effective

On line MN, $P < 0$. On line ON, the maximum occurs at point R.

3. k1 > 0, k2 < 0 - the fishery for the second species (predator) is not cost effective

On line OM, the greatest value of P occurs at point M.

4. k1 < 0, k2 < 0 - the fishery for either of the two species is unprofitable

The task of **maximising the summed yield of two species,** given that they have different economic values, can easily be solved by substituting zeros in place of B1 and B2 in the profit function. From (9) it follows that the factors k_1 and k_2 are now positive, so that it is fair to assume that the conclusions of case (1) hold.

Point U will therefore coincide with point Q, and point R with point L. Using the 90% criterion for F rates, precautionary management points now correspond to points Q, M and R, so that the values of P at these points should be compared. For example, point U will change to the corresponding precautionary point Uprec = $\{0.9*F_1(Q), 0.9*F_2(Q\}$ and so on. Thus

$P(Uprec) \cong A_1 (D^2 - M^2 * b^2)/ (2ba_2^2)$ [2]
$P(Rprec) \cong A_2 D^2 / (4bca_2)$

The choice of the optimal control strategy will depend on the relationship between both the biological and the economical (A_1 and A_2) parameters.

The task of optimisation of a fishery comprising **two species competing for the same common resource** according to Gause's model (Gause 1935; Gause and Witt 1935) has previously been considered (Bulgakova 1970).

Competition is manifest only in an environment with limiting resources and hence a logistic growth model was used for each population, with population interactions described as in Gause's model.

The set of equations describing an exploited set of species of this sort has the form:

$$dX_i/dt = X_i a_i/K_i (K_i - X_i - b_i X_j) - F_i X_i \ , \quad i = 1,2 \qquad (11)$$

where K_i = the maximum abundance of species *i* in the absence of a competing species.

The competition parameters b_i mean that, in terms of the competition interaction, X_j individuals of species j are equivalent to $b_i X_j$ individuals of species i (i.e. they consume equivalent quantities of the limiting resource).

Further details pertaining to the analysis of this system are presented in Bulgakova (1970), and only the main features of the results are described here. The area of allowable control for system (11) is shown in Figure 4.6.3. The line F_{1crash} is the line where the equilibrium point of the first species $X_{10} = 0$, i.e. the first population goes extinct. The line F_{2crash} is similarly a boundary where the second species goes extinct. For this model, the allowable area is therefore bounded by two crash lines!

It is clear from Figure 4.6.3 that an increase in F_2 corresponds to an increase in the allowable F_1 value. For an "isolated" first population, MSY_1 is reached at the point U such that $F^*_1 = a_1/2$. In the presence of the competitor (the second population), MSY_1 increases with increasing F_2 and occurs on the line AR. The maximum of Y_{10} corresponds to point R which lies on the crash-line for the second population. This implies that control of this sort results in the displacement of the second species and therefore in a collapse of ecosystem structure. To avoid displacing the second species with the first, it is necessary to select a point of control which lies inside the allowable area on the line AR.

Analogous calculations may be performed by drawing two precautionary lines on the area of management as was done for the predator-prey model.

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[2] sign $\cong$ arised from $0.9^2 \cong 0.8$

Conclusions

1. The management strategy chosen for an exploited multispecies fishery system should be selected on the basis of the relationship between the parameters of the interacting species. It is important to decide whether the type of interactions correspond to case 1 or case 2 as described in the text. A different precautionary approach has to be applied for different types of interacting species.

2. As a solution to the problem of optimal control, it is useful to construct an area of allowable control using as co-ordinates the fishing mortality rates of the species in the two-species system. This concept of an allowable area is consistent with the construction of 'permissible areas' used in graphical representations of the precautionary approach. See for example NAFO, 1997.

3. Consideration of inter-species interactions suggests that the effects of fishing can be very risky to a multispecies fishery system because the fishing of one species can result, for example, in the extinction of the predators in the system. We considered a simplified model only, with a predator feeding on a single prey type, whereas the structure of real ecosystems is obviously much more complicated. The risk of extinction in a real multispecies system may be reduced because a predator might switch to an alternative prey type if supplies of the original prey species become limiting. The model (1) represents the simplest case and may serve as **to illustrate the necessity of elaborating the theory of a precautionary approach to multispecies fisheries management.** More advanced models with more species have been developed (for example, Collie and Spencer 1994), and these show the possibility of the existence of 1 or 2 stable equilibrium points in a predator - prey model.

4. The fishing of a population of a species at a lower trophic level (such as a prey species), without consideration of the influence of predators, is not precautionary. There are a number of natural ecosystems in which a number of predators rely on the same prey species (e.g. capelin in Barents Sea).

4.6 Summary and Conclusions - Precautionary Approach and Multispecies Realities

The Working Group stresses that the theoretical and analytical development presented in the previous sections hardly scratch the surface of the relevance of multispecies consideration to implementation of a precautionary approach to fisheries assessment and management. In particular, the expansion of the Sissenwine - Shepherd models to the two-species case and the two and three species simulations were all equilibrium-based investigations. They followed first-order effects of predator-prey interactions, but did not include possible dynamic responses of these systems. The Lotka-Volterra models were a valuable first look at applying dynamic predator-prey models to evaluation of biological reference points, but they also require further development.

In the time available the Working Group was taxed to begin to develop and explore even these preliminary models and simulations. There is no question that further work is required even with these equilibrium-based and two-species predator-prey models, before the wider implications of multispecies interactions for precautionary approaches is revealed. This work will not be easy, but the further work on the dynamic responses of these system, and on the properties of systems with more species and interactions will be even more challenging. **As a priority, the Working Group recommends investigating the use of MSVPA to develop contours of zones of species crashes under different fishing regimes on an interacting suite of predators and prey, similar to Figure 4.2.3.5.**

Despite the small steps taken in this Working Group meeting some important conclusions are justified. **The Working Group feels it has demonstrated that multispecies interactions have direct effects on biological reference points, and on responses of populations to rebuilding strategies.** There are influences on many, and possibly all, of the reference points considered by ComFIE and ACFM, and on the trajectories of stocks when recovery programs are implemented. We expect the estimated effects will be even larger when it becomes possible to include the higher-order effects of changing levels of predation mortality caused by changing abundances of the rebuilding species.

It has been stressed in several places (reviewed in ACFM Study Group Report) that an important component of a precautionary approach is including valid stock recruitment relationships within the analyses used to develop the reference points. **Failure to comprehend and address multispecies relationships leads to distorted estimates of the S-R relationship** (Figures 4.2.2, 4.2.3, 4.3.2–5), whereas there are suggestions that under at least some conditions, including the effects of multispecies interaction in the estimates of recruitment may actually bring

some order to otherwise noisy estimates and help untangle unclear functional relationships. **It is important to note that multispecies interactions may also distort estimates of yield per recruit, as well as estimates of recruits per spawner.** Under a condition of constant F these two distortions may largely compensate for each other (Section 4.2.2). However, when F is changed, particularly when it is reduced quickly, ignoring the multispecies effects can lead to substantial overestimates of the yield available at the lower target F. This can arise both because recruitment may be estimated incorrectly if stock-recruit relationships are used to predict recruitment, and because predictions of yield per recruit may be false (in the cases investigated, overly optimistic) even if the recruitment estimates come from surveys.

The Lotka-Volterra models suggest that zones of two-species persistence under fishing can be estimated within models, as well as fishing regimes likely to lead to the loss of either the predator, the prey, or both species. This work should be pursed further, and applications with real predator-prey system should be explored. The present results suggest strongly, thought, that the management strategy chosen for species in a multispecies system should consider the parameters of the interactions among the predators and prey. These may be very relevant to estimating "permissible areas" of fishing strategies, in the sense considered by NAFO (1997) for example.

The Working Group identified several specific factors which must be addressed if ICES is to implement precautionary approaches to assessment and management advice.

1. In a system with multispecies interactions it is quite possible that F_{crash} may be over-estimated by single species approaches. The Working Group is unable at this time to evaluate by how much the value may be over-estimated, so it cannot propose an algorithm to correct the estimates. However, to be precautionary it will be necessary to maintain an even lower probability of approaching F_{crash} than may be suggested by single species analyses.

2. In a system with multispecies interactions, recovery of a population which has been depleted by a period of high F may take much longer than predicted by single species models. The slower than expected recovery will be increased if the stock is fished to a target F during the recovery period, and if the recruitment and yield levels are estimated using only population data from the time of high F.

3. Rebuilding of predator stocks may change greatly what is perceived to be precautionary approaches to stocks of its prey. Rebuilding predator stocks without complementary measures for prey stocks may simple change which stocks are depleted. It is not yet possible to determine general guidelines for the "complementary measures" (or even if there are general rules), so each case needs to be considered directly.

4. Systems with multispecies interactions will show much more complicated behaviour than was observed in our two-and three species simulations. These makes the reliability of reference points based exclusively on single species considerations even more uncertain.

5. The Working Group was unable to conduct a systematic evaluation of all the single species biological reference points currently being considered by ACFM, with regard to their sensitivity to multispecies effects. Significant work would be required before such an evaluation would be possible.

6. There is not a single universally appropriate way to treat multispecies associations in addressing questions about rebuilding strategies and reference points. Even the preliminary work here has shown that the form and magnitude of impacts on reference points, for example, depends on the relative timing of predation mortality and fishing mortality experienced by a cohort (Sections 4.2 and 4.3), and on the bioeconomics of the fisheries on the interacting species (Section 4.5). Other complications are likely to be uncovered as these investigations are pursued further.

7. As a final note, the Working Group observes that within a precautionary framework complexity, like uncertainty, is not a reason to delay coming to grips these important questions.

5 FURTHER DEVELOPMENTS IN MULTISPECIES ASSESSMENT MODELLING

5.1 Applications of the Existing MSVPA

This issue is discussed at some length at the end of Section 3.4. Briefly, the Working Group feels in the short term there may be higher payoffs by extending the application of MSVPA to other areas, such as West of Scotland, the Skagerrak and Kattegat, etc., than adding further detail to the treatment of the North Sea. Improvements to MSVPA of the North Sea would require improvements to the fishery catch data bases, particularly for pelagic species. New versions of MSVPA, possibly from a separability framework would be welcome, as would versions which allowed for extensive investigations of uncertainty within the parameterization steps.

5.2 Length Added to MSVPA

A group at Strathclyde University (Scotland), in collaboration with the Aberdeen Marine Laboratory, has been making a sustained effort to create a version of MSVPA in which as many as possible of the modelling assumptions are length-based, (Banks, Dobby, Veitch 1997 [WD]). An additional objective has been to have a much smaller number of parameters to be fitted than in the standard MSVPA method. By borrowing some MSVPA FORTRAN code and rewriting other such code they can run models in which 'species-age' is extended to 'species-age-length'.

This extension is made, not as an end in itself, but to allow for predation, catch data, stomach contents data, consumption rate data, and weight, to depend upon length rather than on age. The primary part of the research is to find a length-based feeding rule that will predict stomach contents (nearly) as well as MSVPA can, but using the smaller parameter set mentioned already. The rule at present in use is based upon extended suitability numbers $U_{pa_pl_psa_sl_s}$ with six subscripts instead of the usual four, where p refers to predator, and s refers to any fish as prey. The quantities a_p, a_s, l_p, and l_s refer to ages and length classes of predators and prey. These U numbers are used in the same way as MSVPA suitabilities but are defined through a formula:

$$U_{pa_pl_psa_sl_s} = \mathrm{N}\upsilon_{ps}\lambda^{\alpha}(\lambda_{\max} - \lambda)^{\beta}$$

where N is a normalising factor and υ_{ps}, α, β, and $\lambda_{\max}$ are parameters to be fitted, and λ is the ratio of the mean length in the prey length class l_s to the mean length in the predator length class l_p at the ages considered. The parameter υ_{ps} is to depend on the two species p, and s, only and not their age or size. The other parameters are allowed to depend upon p only and on the quarter considered. The resulting suitability as a function of λ rises from zero at length ratio zero to a maximum and falls back to zero at $\lambda_{\max}$. The function can be skewed left or right depending on the values of α, and β.

The introduction of length requires the introduction of growth rules of length against age. Curves of the von Bertalanffy type are fitted from fish size data , and the model assumes that any fish remains within the same size class that it is initially recruited to, and grows according to the growth rate of that class. Fitted formulae are also used for weight at length and for ration at weight.

The parameters α, β, and $\lambda_{\max}$ are fitted by making preliminary runs in which they are adjusted to give the minimum error in predicting the stomach contents data in years when this is available. The parameters υ_{ps} are adjusted iteratively during the runs in a similar manner to the iteration of suitability in MSVPA.

To run the model, the catch data must be distributed over size classes for each species-age, and a similar process is required for terminal fishing mortalities. This is done in fixed proportions chosen before doing such a run.

At present the model has been run using data in the forms prepared for MSVPA key runs and their relatives. The procedure has been to use some of the stomachs data to 'train' the model; that is to determine those parameters that are not determined during a run. The rest of the stomachs data has been used to determine how well the model is doing, and the quality of its performance is compared with MSVPAs.

Its predictive performance is quite similar to MSVPAs, sometimes better, sometimes worse and sometimes about the same. It is not as good as MSVPA when the training error is examined. This is to be expected because MSVPA fits a single year of complete stomachs data exactly and suffers training error only as a result of such

data being used from two or more years. The length based model suffers from training error because of its smaller parameter set, even when a single year of data is used.

The Strathclyde team is at present concerned about comparisons of the predation mortality rates for prey that come from their model when these are compared with the same rates from MSVPA. While larger mortalities of species-age groups correlate quite well between the two models the actual partial M2 values themselves do not agree particularly well. Current work in hand on better methods of fitting the parameters is expected to improve this aspect of performance.

The Strathclyde group were strongly encouraged to complete the validation of their model, as a successful outcome could lead to significant improvements in multispecies modelling. Amongst these would be:

(1) the ability to use length based data directly without the problems that can arise in the determination and application of age-length keys;
(2) the opening of a way for making the growth of fish depend upon their diet when length and weight are dynamic variables; and
(3) a resolution of the problem that causes problems in present MSVPA/MSFOR runs when intra-cohort predation occurs, most usually larger 0-group members eating smaller ones.

Further model testing should use files created directly from the stomachs databases for 1981, 1985–1987, 1991, rather than files prepared for MSVPA runs. This is because the data manipulation requirements of MSVPA are not the appropriate ones for tuning a new model. They were also advised to conduct trials with prey preference formulae equivalent to those given in Section 6.6.2 of the Multispecies Assessment Working Group report of November 1993.

6 FUTURE OF MULTISPECIES ASSESSMENTS IN ICES

Although there appears to be no need for routine multispecies assessment in the North Sea or other areas, it is foreseen that management requests will be put forward that can only be addressed within a multispecies framework. The question arises as to how the data base, modelling capabilities, and expertise can best be maintained within ICES. Of course, multispecies assessment can be taken up in a variety of working groups and study groups, but the maintenance of the North Sea MSVPA data base and the associated software requires special attention.

6.1 Supply and Care of Necessary Data

MSVPA requires specific data, which are not usually available in Single Species Working Groups, and which require special care before the model can be run satisfactorily. These include catch at age data, mean weights at age in the sea, stomach content, average prey weights, consumption rates, everything on a quarterly basis.

CATCH DATA

The provision of quarterly catches in numbers by age group has been a routine task in the past of Single Species Working Groups. It is important that these data are routinely assembled and published in Working Group reports, because only in that case it can be expected that *ad hoc* updates of the model will be possible in the future. Since such data represent essentially a intermediate step in raising national statistics by area and month to total annual values, it should be considered as a formal step in the IFAP processing. Mean weights at age in the catches, and where appropriate in the sea, should also be included. Although it has not been possible to incorporate such information up till now, more complex questions can be addressed when such data would be routinely made available.

A special problem arises from the recent redefinition of the unit stock areas of some major fish stocks, in particular the inclusion of the Skagerrak/Kattegat area in the 'North Sea' for some species. In order to maintain a consistent data base, such quarterly catch data should be provided for the North Sea proper and for the traditional areas. This would not only allow continuity in the MSVPA as carried out until now but also pave the way for a future adaptation of the stock units to be considered in the MSVPA.

It is therefore recommended that ACFM requests the Assessment Working Groups to provide quarterly catch at age and weight at age data by traditional area in their reports.

STOMACH DATA

There has been considerable progress in exchanging the basic information in a standardised exchange format and in producing input data for MSVPA, which have been processed in a consistent manner. This applies to most of the data sets collected in 1981, 1985, 1986, 1987 and 1991. There are only a few problems left, particularly with the 1981 mackerel data, which can hopefully resolved in the near future.

Also, for other predators new information may become available, which needs to be processed in a consistent manner. Nevertheless, there seem to be no great problems in maintaining the database as long as all data are all stored at ICES.

A special case is the data collection in 1991 in the Skagerrak/Kattegat area. These stomachs have been analysed, but are as yet not part of the data base. If in the future the MSVPA is to be run for the new assessment area, some work is required here.

A second problem is related to the censoring of outliers in the average prey weight data. At present this can only be done within the programme, based on some algorithm. It would seem better to do this, if necessary, outside the programme on the input data. In fact, the prey weights averaged over all data sets are likely to cause less problems in creating extraordinary suitability indices than the present procedure which calculates averages within the program.

One aspect that must be taken into account in relation to further applications of MSVPA is that the feeding research carried out in this context over the last 20 years has created an expertise, which one might want to preserve. This is particularly the case if a new international stomach sampling programme is going to be initiated in 2001. The rationale for such a project would largely be to get more empirical evidence of possible changes in suitability over time in relation to changes in the species ecosystem in the system. Although the chosen 10 year time span is fairly arbitrary, it would be unwise to delay such an exercise, if considered appropriate by the scientific community of ICES, too long because that might mean that expertise has to be built up from scratch again.

CONSUMPTION DATA

The quarterly consumption rates are likely to be revised in the future, when more extensive work is carried out on this subject. However, revising the input files accordingly will not a big problem.

6.2 Supply and Care of Necessary Modelling Capability

The development of MSVPA in its present form has virtually come to an end. Since the program is not exactly user-friendly to add to or delete species from the file, it would be helpful to document how such changes can be made, because that is the only way to allow new people to use this tool while the creators can slowly age and loose their mental sanity. This very much depends on the effort that can be put into a manual at DIFMAR. However, models of such complexity will always require a specialist training to make essential modifications.

It is noted that single species models increasingly address uncertainty in their performance and this is not yet a feature of the existing model. It would require quite some additional modelling effort to incorporate more elaborate statistical models, but it would seem that in principle a separable MSVPA would be possible.

6.3 Peer Review of Multispecies Results and Advice

To evaluate new models of this sort and produce sensible advice requires considerable experience and it would seem a waste to let the existing knowledge slowly dissolve. The kind of problems that the MAWG has been concerned with is not normally addressed by Single Species Working Groups. In fact, the reports of ComFIE have so far hardly been touched upon multispecies issues. However, this does not mean that the MAWG must be kept alive, because there is overlap with the Multispecies Assessment Working Group for Baltic Fish and the Working Group on Ecosystem Effects of Fishing Activities. Whereas the MAWG has addressed the issue to estimate the effect on fisheries yields, the WGECO is clearly focused on the effects on the system, but MSVPA is an important tool for the latter (e.g. Rice & Gislason 1996) and there is an overlap here.

7 FOOD FOR THOUGHT

7.1 Multispecies Models with More Trophic Levels

Throughout its history, the Multispecies Assessment Working Group has dealt primarily with top fish predators and their fish prey. This has been true both when using MSVPA and when using the primarily cod-capelin models of boreal systems. Such an approach implicitly assumes that the dynamics of fisheries stocks are regulated by top-down processes. Bottom-up processes may affect recruitment, but MSVPA and boreal models generally take recruits as an input file, assume it is constant, or simulate recruits using a stock-recruit model. Bottom-up processes are thought to be important to the production of many ecosystems. Also, as ICES is asked for advice on an increasing range of biological topics, such as the likelihood that an action would disturb "natural ecological processes and relationships", or how to account for variability in the "well-being" (growth rate, condition factor, etc.) and abundance of boreal predators, variation in abundance or environmental influences on lower trophic levels may need to be included empirically in ICES advice. The Working Group considered whether it would be beneficial and practical to explore use of models including more trophic levels, perhaps to model recruitment variation better, or to permit studies of bottom-up forcing in the dynamics of fished stocks.

The Working Group notes that MSVPA has two structural assumptions which restrict the opportunity to add more trophic levels to MSVPA. One assumption is that all predators fulfil their ration each quarter, so the supporting food supply is never inadequate. The other is that MSVPA contains no growth dynamics, as all individuals change diet according to the data for their age, and are the mean weight for their age. These assumptions make the current version of MSVPA at ICES an inappropriate model for investigating questions about bottom-up processes. Both the modifications to MSVPA developed at VNIRO and presented to the Working Group at the Bergen meeting (Anon. 1994, Bulgakova *et al.* 1995 - [WD]), and the addition of length to MSVPA presented at this meeting (Section 5.2, Banks, Dobby, and Veitch 1997 [WD]) are steps which may free MSVPA of those restrictions eventually. Developments in both of those modelling initiatives should be reviewed periodically, in the context of relaxing these MSVPA assumptions.

Some other ecosystem tropho-dynamic models were discussed briefly. It was noted that mass-balance models can include connections among many trophic levels. However, there were reservations about the use of this class of models in investigating dynamics of fish predators. Sufficient conditions for uniqueness of solutions for MSVPA have been determined (Magnus and Magnusson 1983). In contrast, many approaches to mass-balance representations of predator-prey systems are either not unique representations of the systems, or the uniqueness properties of the approaches are unknown. This renders such approaches of uncertain status for representing static systems, and dangerous for representing dynamic systems.

The ERSEM is a multi-box ecosystem model of the North Sea, being developed as a collaboration among a number of European labs, under sponsorship of the EU model seems to be being developed for other purposes than those of this Working Group. No complete documentation on ERSEM was available to the Working Group, but the model is reported to integrate across trophic levels within spatial areas. The Working Group is not aware of any plans for ERSEM to operate at the level of the individual species on which ICES generally provides fisheries management advice. If ERSEM were proposed to operate on that scale, or otherwise be applied to fisheries management questions, the Multispecies Assessment Working Group might be an appropriate body to review model structure, inputs, and products.

There are diverse theoretical models of food webs, and some have been explored in fisheries management contexts (May *et al.* 1979; Pimm and Rice 1987; Yodzis 1994). None provide the species-level information needed for assessment purposes. Those which investigate simple representations of multispecies fish stock systems encounter serious problems with factors such as trophic forcing of maturation across life history stages (Pimm and Rice 1987) and convergence of many predators on common prey (Bakun 1996). These models are not thought to hold promise of providing multispecies assessment tools for several trophic levels in the short term.

The Working Group notes the MSVPA has achieved its success in part because it has cut out a part of the whole ecosystem which has proven to be of tractable size, and to have internal dynamics which are lawful and important to stock status and variation. The Working Group feels that an approach which deals with other internally coherent portions of the trophic system in similar ways is likely to be more fruitful than immediately working with a bigger piece of the ecosystem. This suggestion is consistent with the well established arguments of Steele (1985) and others, about the correlations of size related processes in space and time; the dynamics of lowest

trophic levels are studied best on small spatial scales over short time steps, with progressively higher levels studied at progressively larger areas over longer times. In the case of the North Sea, this suggests that if the objective were to link zooplankton dynamics to MSVPA fish stocks, the modelling should be of zooplankton effects on fish recruitment levels. These (hopefully) better recruitment indices would then be an input to MSVPA (or other multispecies models for fish stock assessment) from the outside, and not part of the multispecies assessment model.

The Working Group further notes that the category "Other Prey" is used to capture many species of prey beyond the few represented explicitly in MSVPA. It is tempting simply to pull prey of interest out of the pool of other prey, and to represent it directly as an additional prey species. This temptation has dangers, and manipulation of the category "Other Food" needs to be done intelligently, without distorting the size compositions, amounts consumed, or biomasses of the new named prey, the new anonymous prey mix, or the suitabilities. Towards that end, the Working Groups notes it would be valuable to bring together the information on abundance and size composition of as many fish species as possible in the North Sea. These data will largely come from bottom surveys. The size composition data, when available may contribute to calculations of input data for further prey species to MSVPA.

7.2 Stomach Data Base Analysis with Special Attention to Spatial Aspects of Feeding Parameter Estimation and to the Recovery of Gaps in the Data

Elaboration of an advanced methodology of estimation of consumption of prey species by years, quarters and age groups of predator is an essential part of problems associated with multispecies modelling of the Barents Sea fish community. Its necessity is obvious since data on mean stomach content (by weight) is used as input data for MSVPA and the ability of the model to describe real situation and to serve as reliable prognostic tool is strictly related to reliability and completeness of these data. From the other hand, the amount of information, necessary to produce statistically meaningful consumption estimates, often exceeds the potentialities of field sampling. The last gives rise to the necessity of implementation of interpolation or extrapolation technique for recovery of gaps in input data.

The source of information for consumption estimation is the joint Russian - Norwegian Barents Sea Fish Stomach Content Data Base (DB).

Importance of improvement of methodology for estimation of mean weights of preys in stomach was also outlined in recommendations of Multispecies Working Group (Anon. 1995).

Usually perhaps the simplest way of calculation of mean stomach content for predator age group (a) in year (Y), quarter (Q) with respect to age groups (j) of prey species (i) is used:

$$\bar{W}(Y,Q,a,i,j) = (SUM(W(Y,Q,a,i,j))) / NST,$$

where summing is made by all stomachs (1,...,NST), where NST=NST(Y,Q,a) - total amount of stomachs of age group (a) of the predator, investigated in quarter (Q) of year (Y), and W(Y,Q,a,i,j) - weight of prey (i) in age (j) in any given stomach of the predator of age (a).

Naturally, these values could be regarded only as very rough estimate of mean stomach content of given age group of the predator for the whole stock. This is caused by the following reasons, which are ought to be taken into consideration:

- as a rule the samples of stomachs in the DB are not uniformly distributed over the predator range;
- samples from different points of the area correspond to different concentrations of the predator;
- the above "simple" procedure does not reflect interannual differences in the overlap of spatial distributions of predator and preys.

It is necessary to mention that the DB also includes data on catch of the given age group of predator per effort (an hour of trawling) in points of sampling and these values could be used as weighting factors in calculation of mean stomach content if samples were uniformly distributed. But as a rule it is not the case.

The experience shows that often the data in the DB appears to be not representative (while containing huge number of stomachs): for example, it sometimes results in zero estimates of some age groups of some preys in average stomach for the whole stock of the predator. Analogously, sometimes it is impossible to get direct estimates of stomach content for elder ages of the predator because of their absence in the samples.

The presented paper (WD) is mostly devoted to four main problems:

1. Estimation of average weight of food in stomach from spatially distributed data;
2. Estimation of average partial stomach content W(Y,Q,a,i,j) of the predator of age (a) with respect to age group (j) of prey species (i) in quarter (Q) of year (Y) taking into account spatial aspects of sampling;
3. Replenishment of gaps and extrapolation on elder ages of total weight of food in average stomach;
4. Replenishment of gaps and extrapolation on elder ages of partial stomach content data.

7.2.1 The preliminary DB processing

Since ages of preys in stomachs are not given in the DB to calculate them it is necessary to use a special algorithm (and program) (see also Bulgakova *et al.*, ICES CM 1995/D:13). This program is intended for determination of ages for 7 prey species: cod, capelin, shrimp, herring, haddock, arctic cod and redfish.

The program determines the age of these prey species for all records in the DB, except those with undetermined length code (CODLEN=99999), for which the number of preys is undetermined (NPREY=9999999), or digestion degree (DD) is unknown, or DD=5.

Age determination is carried out by means of year- and quarter- specific age-length keys. Since, as a rule, each length code corresponds to several ages, the age attribution for preys is made according to proportions of fishes of different ages in age-length keys.

In the program a special algorithm for selection of age (among several possible ages for given length code) to be assigned to preys of given category (here the prey category is a combination of prey species and length code) in the stomach under consideration is used. This problem is complicated by the fact that we can give only the same age for all preys of given category in the same stomach and often it becomes impossible to held proportions, calculated from age-length key. We can only approximately approach the age distribution of preys of the same category for ALL stomachs in given quarter to proportions from age-length key. The algorithm in the process of age determination for every subsequent stomach compares sums of squares of residuals between age proportions in the key and cumulative proportions of already given ages and selects the variant giving the least value of current sum of squared residuals.

Another program is intended to facilitate the calculations of weighted by CPUE or unweighted mean stomach content (for 7 prey species) and total weight of food in average stomach. This program carries out calculation of mean stomach content for each age group of predator for any given year and quarter. As a result we obtain a table containing mean values of food weight per one stomach of each predator age by prey age for the 7 prey species.

All values of food weight in stomachs are rescaled into grams. The program "repairs" some errors in prey age determination:

- in I and II quarters zero ages for all considered prey species are changed into age = 1;
- in III quarter zero age of cod as prey is changed into age=1.

If information available in the DB does not give possibility to estimate prey ages, then content of prey of unknown age (99) for each of 7 prey species is distributed over age groups of this prey species in proportions, calculated for given predator age group in given quarter of the given year with respect to prey of the given species.

After that the program distributes preys with various degrees of species-indeterminacy by categories having higher degree of classification using predator age-specific proportions determined for items with known species or (and) ages.

Sometimes we may encounter with situation when for given predator age for one of our 7 preys we find only records with undetermined age. In such a case it is impossible to distribute the food with unknown age over other ages (those are absent).

There exist two ways to solve this problem.

1. To prescribe zero value of weight to these records and not to use them in distribution of preys with species indeterminacy at all. This way introduces no bias. But sometimes this approach may be regarded as undesirable, because it could possibly result in underestimation of stomach content with respect to this prey category.
2. The second approach to solve this problem is to leave these records unchanged on the stage of distribution over prey ages; in further distribution of records with "species indeterminacy" these record participate on the equal basis with others. It is necessary to remember that in such a case in order to obtain the input data for MSVPA the user will have to input ages "by hand" using his personal reasons.

7.2.2 Estimation of average weight of food in stomach

To take into account spatial peculiarities of stomach sampling the geostatistical methodology (kriging), which can be regarded as method for calculation of function Z(x,y) of two variables in knots of regular grid in cases when there are some estimates of this function in a number of points (x,y) (for example, these points could be the results of surveys) was applied both to stomach content data and to catch per unit effort (CPUE) data. Thus, the procedure for calculation of mean Wtot is the following. For the given (Q,Y,a):

1. To apply kriging (or some other) geostatistical technique to data on CPUE(x,y) for the given age group of the predator taking into account the co-ordinates of the place where this stomach was taken to obtain a smooth spatial distribution of concentration of the predator in age (a); to calculate the integral I(a) of this function by the area of distribution.
2. To apply the same procedure to Wtot(x,y).
3. To build the combination of the obtained "estimated" arrays {Wtot(x,y)} and {CPUE(x,y)} in the form of a function : F(x,y) = {Wtot(x,y)}*{CPUE(x,y}. The integral of this F(x,y) by area divided by I(a) will give the required spatially averaged and simultaneously weighted by CPUE estimate of mean total stomach content Wtot(Y,Q,a).
4. To obtain an unweighted (by CPUE) estimate of Wtot it is necessary to build spatial distribution for Wtot(x,y), calculate the volume of the resulting surface and divide it by the area of the base.

For correct implementation of kriging it is necessary previously to build and analyse variograms in order to detect their models and to estimate the parameters: range, search radius, scale, possible nugget effect (Rodionov *et al.* 1987).

To outline possible direction- dependent differences the variograms are to be built separately in longitude and latitude directions.

To exclude "false" anisotropy caused by different stretch of 1° of longitude and latitude, the co-ordinates of all points of initial spatial distribution were rescaled into kilometres, the origin point being the point having the lowest values of longitude and latitude.

Unfortunately it is necessary to mention that stations, where probes on feeding were taken, practically in all cases are considerably remote from each other. Hence variograms almost do not include points characterising variance on distances less than 20–30 km, what makes difficult the analysis of the variogram models. This is especially unpleasant because main peculiarities of the variogram possibly could be reviled on distances below 20 km (for example in (Conan *et al.*, 1989) the Range for northern shrimp was estimated as 13 km).

Examples of application of such a procedure are calculated for two years - 1990 and 1987, quarter 1, for cod of age 3. These years are characterised by various feeding conditions for Barents Sea cod: 1987 corresponds to lowest stock of capelin - its favourite prey species; 1990 corresponds to rise of capelin stock.

In most of the cases linear model was the only reasonable approximator of the variograms, only in some of them exponential model was also possible. Since we have to choose the same type of model for both directions, in all cases we applied linear model.

Surfaces of spatial distributions, obtained for Wtot , NH and NH*Wtot by means of kriging are shown on Figure 7.1.1a–c for 1990 and Figure 7.1.2a–c for 1987; all quarter 1.

Contour maps of Wtot distributions for 1 quarter of 1990 and 1987 and locations of stations are given on Figure 7.1.3a,b.

The estimates of Wtot(Y,Q,a) for 1990 and 1987, quarter 1, age group 3 of cod in comparison with the estimates obtained in implementation of weighted or unweighted by CPUE arithmetic averaging, are given in the table below:

Table 7.2.1a Comparison of the estimates of Wtot(Y,Q,a) (in grams) for 1990, quarter 1, for cod of age 3 as predator obtained by various methods. In brackets: confidence interval of mean Wtot estimate (p=0.95).

	weighting	
averaging	unweighted	weighted by CPUE
1. arithmetic	11.95 (2.5)	9.45 (2.1)
2. Kriging	13.34	13.71

Table 7.2.1b Comparison of the estimates of Wtot(Y,Q,a) (in grams) for 1987, quarter 1, for cod of age 3 as predator obtained by various methods. In brackets: confidence interval of mean Wtot estimate (p=0.95).

	weighting	
averaging	unweighted	weighted by CPUE
1. arithmetic	2.31 (0.59)	1.57 (0.41)
2. Kriging	1.21	1.12

As it can be seen, introduction of spatial factor into the process of estimation of Wtot obviously influences the results and in different years spatial consideration may increase or decrease the estimate. This discrepancy seems to be important for their further implementation in MSVPA.

If the information available in the DB does not allow to undertake the spatial analysis (number of samples is too low or (and) they are taken in too restricted area), the described above "spatial" approach has no advantages in comparison to traditional arithmetic averaging with weighting by CPUE. It is interesting to mention that for some options of spatial analysis (for example, if search radius in process of gridding is taken small) this procedure is simply reduced to traditional arithmetic averaging with weighting.

7.2.3 Estimation of average partial stomach content W(Y,Q,a,i,j) of the predator of age (a) with respect to age group (j) of prey species (i) in quarter (Q) of year (Y)

The procedure quite similar to what was described in the previous Section, is to be applied for estimation of W(Y,Q,a,i,j).

This approach is illustrated by calculated "partial" average stomach content W(Y,Q,a,i,j) for the first quarter of 1990 for cod of age 3 as predator with respect to age 3 of capelin as prey.

Surfaces of spatial distributions, obtained for Wp=Wcap, and NH*Wcap by means of kriging are shown on Figure 7.2.1a,b (spatial distribution of NH for predator age group 3 is the same as in the previous Section).

Estimates of Wp(Y,Q,a,i,j) for cod , age 3, as predator with respect to capelin, age 3, as prey in 1990, quarter 1, in comparison with the estimates obtained in implementation of weighted or unweighted by CPUE arithmetic averaging, are given in the table below:

Table 7.2.2 Comparison of the estimates of Wcap(Y,Q,a,i,j) (in grams) for Y=1990, quarter 1, for cod of age 3 as predator with respect to capelin of age 3 as prey, calculated by various methods. In brackets: confidence interval of mean Wcap estimate (p=0.95).

	weighting	
averaging	unweighted	weighted by CPUE
1. arithmetic	2.77 (1.18)	2.47 (1.18)
2. Kriging	2.44	2.28

7.2.4 Replenishment of gaps and extrapolation on elder ages of total weight of food in average stomach

As a rule more or less representative information is present in the DB for cod not older than 8–10 years old. For higher ages it is possible to find only a few records, often with empty stomachs or with stomachs containing extreme amount of prey of any single species or even of any single age of this prey species. Naturally it is not possible to spread such an information over the whole age class of the predator.

Thus, for age groups older than 8 (seldom - 11) of cod as predator, it appears to be inevitable to use some extrapolation technique for estimation of both partial stomach content and total weight of food in stomach.

The key problem in such an extrapolation is a meaningful choice of the dependence, describing age tendencies of these values. Unfortunately in most cases the existing data of the DB did not allow to estimate parameters of such a curve precisely enough, because the most of the data describes only initial part of the age curves and gives no information about its asymptotic properties.

More stable estimates were found in processing of two- dimensional arrays, composed of total stomach weight estimates Wtot for all predator ages by all years for the quarter chosen: here in contrast to usually used spatial co-ordinates it is proposed to use kriging to search a two-dimensional distribution of Wtot as function of two time variables: year and age of predator. As a reasoning for this procedure we assumed that the deficit of information for any single quarter of the given year could be compensated to some extent by information from other years.

Existing data for such an analysis for quarter 1 and quarter 3 are shown on Figure 7.2.2a,b. It is necessary to mention that only "representative" points were used for input. Lower limit of "representativity" was arbitrarily adopted as 5 stomachs. Such points were taken for further analysis.

Analysis of variograms showed that their models are much more apparent not for Wtot(Y,a) but for LN(Wtot(Y,a)). According to that we applied kriging to LN(Wtot(Y,a)). After that exponential transformation to resulting points to obtain estimates of Wtot was applied.

Analysis of variograms shows also that variability by year direction is lower than by age direction by an order (in nonlogarithmic representation). This also supports the idea that it is not reasonable to neglect age- dependencies in Wtot and to prescribe for all elder ages (not available in the DB) the value of Wtot equal to that for the last available age group (as it is usually carried out).

The resulting surfaces for Wtot (Y,a) for quarters 1 and 3 are given on Figure 7.2.3a,b, respectively.

Comparison of initial data with result of kriging shows that the resulting surfaces precisely pass through the initial points. This is caused by zero nugget effect and by choice of nodes of the resulting grid just in points of input data. Thus kriging works now as "precise approximator" of initial data. This procedure 1) does not change existing data and 2) produces estimates Wtot for points (Y,a) not available in the DB.

The above mentioned and shapes of resulting distribution of Wtot(Y,a) support the idea that they could be directly used as input data for MSVPA.

Age dependencies of Wtot in quarter 1 for several years are shown on Figure 7.2.4. The last "existing age point" for each year is outlined by a circle (see also Figure 7.2.1a). From this Figure it could be clearly seen that choice of one of "the last" points of age distribution of Wtot as approximator for older ages could cause strong bias in total food consumption estimates for older ages.

7.2.5 Replenishment of gaps and extrapolation of partial stomach content on older ages

Similar, but perhaps more difficult, problem is extrapolation of partial stomach content on elder ages of the predator and recovery of missing information about feeding of younger age groups of predator. For this purpose it seems to be reasonable for every quarter of every year and for every prey species to compose a two-dimensional array of partial stomach content estimates as a function of the predator age and age of the given prey species. The logic of such a procedure lies in expectation that the deficit of information on consumption of the given age of the prey by the given predator age group will be partially compensated by information on consumption of this prey category (i,j) by other age groups of the predator and by information on consumption of other age groups of the same prey species by the same age group of the predator (all - for the given (Y,Q)).

Rather often the estimates of partial stomach content W(Y,Q,a,i,j) from DB turn out to be zero. These zero estimates always are to be investigated more carefully, since they may both represent a really existing situation of very low consumption of prey category (i,j) in scale of the whole stock of the predator, or be a consequence of low representativity of samples. Naturally in the first case these zeros should be considered as true, while in the second situation these zeros should be substituted by some estimates, perhaps non-zero, obtained by means of some interpolation-extrapolation routine.

Unfortunately it is rather difficult to establish a marginal number of samples, from which it is to be treated as representative to consider the estimates of W(Y,Q,a,i,j) as "true". As it was mentioned, a very arbitrary lower limits of stomach numbers, sufficient to consider the estimates as true ones is chosen: 5 stomachs of the same age group of predator in the given (Y,Q) - for estimation of total food weight in stomach, and 5*m stomachs in the DB, where m is total number of ages of the given prey species (for example, for capelin as prey it will give 30 stomachs per quarter per age group of predator) - for estimation of partial stomach content.

This procedure is illustrated by distribution of partial stomach content Wcap(a,i) of capelin as prey in cod stomachs for quarter 1 of 1990. (Figure 7.2.5).

It is necessary to mention that there were several zero estimates of Wcap for elder ages of the predator for which it is difficult to decide are they "representative" or not. We treated them as nonrepresentative (absent information) because their existence in input data drew down extrapolative estimates for elder ages. The resulting estimates (after kriging) for such a points could be returned back to zeros in order not to change initial data (not to overestimate partial stomach content).

Figure 7.2.6 illustrates total amount of capelin in cod stomachs by age groups of cod for 1990, quarter 1, as a result of kriging approximation. This age tendency looks rather reasonable as approximator for elder ages of cod. Very high value for age 7 which looks like an outlier for this curve is nevertheless supported by sufficiently high number of stomachs.

CONCLUSION

The principal possibility to use geostatistical methods of spatial analysis of distribution of stomach samples and concentration of the predator for estimation of average partial stomach content and mean food weight in stomach was shown. Such a procedure takes into consideration spatial structure of predator feeding as additional factor and hence may probably result in better estimates of mathematical expectation of Wtot or Wp.

However for more reliable implementation of spatial analysis in estimation of Wp it is necessary to use more complete information about predator and prey spatial distributions (boundaries of range and their overlap) by ages and by quarters and years.

While the implementation of spatial analysis for estimation of Wtot is quite practicable and its results could be used for MSVPA right now, calculations of Wp for all possible combination of (a*i*j*Q*Y) are exceedingly time consuming without elaboration of special software.

The results show that method of kriging could serve as an appropriate tool for analysis of functions of not only spatial variables but variables of other nature too. Application of kriging to Wtot as function of predator age and year and to Wp as function of predator age and prey age gives possibility to settle the problem of extrapolation of these values on elder predator ages and problem of interpolation into ages badly represented in the DB.

Approximation of age tendencies in total stomach weight and in partial stomach content also seems to be very useful for preparation of input files for MSVPA.

The procedure of analysis of partial stomach content for given quarter and given prey species could be made more consistent and fast on the basis of application of 3-dimensional analysis (these three co-ordinates are 1) predator age, 2) prey age for the given prey species, and 3) year).

7.3 General Conclusions of Discussion on Future Directions in Multispecies Assessment Modelling

1. The Working Group sees value in continued work on analytical multispecies tools which cover more trophic levels. Such models are likely to be independent of assessment models, but may feed input values to assessment models.

2. It would be useful for size based multispecies modelling to begin to build up size composition data for as many species of other named food as possible.

3. It would be prudent to keep away from mass balance models for assessment and dynamic applications, at least until ones are available whose dynamic properties and quantitative reliability have been tested with the thoroughness given to tests of MSVPA and some of the boreal models examined at the last meeting.

8 CONCLUSIONS AND RECOMMENDATIONS

With regard to input data to MSVPA:

- The new stomach data are the correct data set to use in analyses. They have been processed in consistent ways, and can be compared across years and species. The 1981 mackerel data still contain anomalous records, and should only be used when they have been processed by the ISR routines at RIVO.
- The new consumption figures are better estimates for cod, haddock, and whiting. Analyses of mackerel data suggested consumption rates should be revised for that species, but more work is needed. Additional data are needed before saithe consumption estimates can be revised.
- It is possible that the estimates of weights at ingestion of younger ages of prey are too low. This requires further investigation, but could lead to the estimates of M2 in this report being too low on the youngest ages of some prey.
- Catch at age data suffer from many problems, particular for species important as prey in MSVPA. The data on North Sea mackerel, western mackerel in the North Sea, and horse mackerel in the North sea require special attention.
- The inclusion of new predators, including seabirds, starry rays, grey gurnards, and grey seals, went well, but undoubtedly could be improved. Experts in the appropriate species, including the Working Group on Seabird Ecology and the Working Group on Seals and Small Cetaceans are invited to comment on our work, and suggest specific improvements

Comparing MSVPA runs using only the 1981 and only the 1991 data suggest that:

- some differences in suitability have occurred but that the similarities are greater than the differences. This is an encouraging result when it is considered that the North Sea had undergone a regime shift between 1981 and 1991.
- the differences in M2s are much smaller, and closely centred on zero. The evidence for predator switching, although present in these preliminary investigations, is very weak.
- Some differences in forward projections occur as a consequence of choosing one or the other of the two data sets, but the conclusions, except perhaps for herring and haddock, remain far more similar to each other than to the results of single species forecasts.

The Working Group feels that performance of MSVPA in the North Sea may be more limited now by inadequacies in the input catch data than by inadequacies in the input stomach data. Moreover, many multispecies questions being asked about the North Sea, particularly questions about the well-being of prey stocks and their causal role, if any, in the variations in predator stocks, are not readily investigated within an MSVPA framework. The Working Group feels that it is a high priority to identify the properties of multispecies fisheries models which are appropriate for such investigations. Planning and

implementation of major field sampling programs to parameterize multispecies models should only be done when the data requirements of such multispecies models are understood. In the meantime, many other areas of interest to ICES besides the North Sea (e.g. West of Scotland, Skagerrak and Kattegat) would benefit from applying MSVPA. Well designed stomach sampling programs in those areas would have high value.

With regard to the other contrasting runs of MSVPA:

- Including horse mackerel had surprisingly little impact on most prey, although there were some increases in M2 on herring, especially 0-group.
- Censoring the weight data had surprisingly little impact, beyond removing some of the biggest instabilities in suitabilities estimated separately with the two years of stomach data.
- The change in consumption estimates also had very little impact on suitabilities, although in this case there was greater impact on M2s.
- The run with only the 5 traditional MSVPA predators (cod, haddock, saithe, mackerel, and whiting) showed clearly that we have not been allowing for enough non-fishing mortality with the M1 values used in our past runs. This may have some wider implications, because previous M1-values were chosen to match roughly the amount of natural mortality on older ages assumed by the Assessment Working Groups.
- We now estimate that many properties of the North Sea, such as the total biomass, total biomass eaten by predators, and P/B ratios have been much more stable over the past 25 years than we used to estimate.

Overall, our confidence in MSVPA continues to grow. For several reasons the Working Group concludes that although it is possible that MSVPA may go wrong because of things not included in it at all, MSVPA has not formulated the things it does contain in any seriously erroneous way.

The Working Group sees little opportunity to add yet more predators to the North Sea data base, as the diets of the few remaining major predators are largely unknown. There is substantial room to improve the input data on fish catches and population trends.

The Working Group feels it has demonstrated that multispecies interactions have direct effects on biological reference points, and on responses of populations to rebuilding strategies. There are influences on many, and possibly all, of the reference points considered by ComFIE and ACFM, and on the trajectories of stocks when recovery programs are implemented. The Working Group stresses that the theoretical and analytical development hardly scratch the surface of the relevance of multispecies consideration to implementation of a precautionary approach to fisheries assessment and management. We expect the estimated effects will be even larger when it becomes possible to include the higher-order effects of changing levels of predation mortality caused by changing abundances of the rebuilding species.

An important component of a precautionary approach is including valid stock recruitment relationships within the analyses used to develop the reference points. **Failure to comprehend and address multispecies relationships leads to distorted estimates of the S-R relationship. Multispecies interactions may also distort estimates of yield per recruit, as well as estimates of recruits per spawner.** Under a condition of constant F these two distortions may largely compensate for each other. However, when F is changed, particularly when it is reduced quickly, ignoring the multispecies effects can lead to substantial overestimates of the yield available at the lower target F.

The Lotka-Volterra models suggest that zones of two-species persistence under fishing can be estimated within models, as well as fishing regimes likely to lead to the loss of either the predator, the prey, or both species. These results may be very relevant to estimating "permissible areas" of fishing strategies.

The Working Group identified several specific factors which must be addressed if ICES is to implement precautionary approaches to assessment and management advice.

1. In a system with multispecies interactions it is quite possible that F_{crash} may be over-estimated by single species approaches. The Working Group is unable at this time to evaluate by how much the value may be over-estimated, so it cannot propose an algorithm to correct the estimates. However, to be precautionary it will be necessary to maintain an even lower probability of approaching F_{crash} than may be suggested by single species analyses.

2. In a system with multispecies interactions, recovery of a population which has been depleted by a period of high F may take much longer than predicted by single species models. The slower than expected recovery will be increased if the stock is fished to a target F during the recovery period, and if the recruitment and yield levels are estimated using only population data from the time of high F.

3. Rebuilding of predator stocks may change greatly what is perceived to be precautionary approaches to stocks of its prey. Rebuilding predator stocks without complementary measures for prey stocks may simple change which stocks are depleted. It is not yet possible to determine general guidelines for the "complementary measures" (or even if there are general rules), so each case needs to be considered directly.

4. Systems with multispecies interactions will show much more complicated behaviour than was observed in our two-and three species simulations. These makes the reliability of reference points based exclusively on single species considerations even more uncertain.

5. The Working Group was unable to conduct a systematic evaluation of all the single species biological reference points currently being considered by ACFM, with regard to their sensitivity to multispecies effects. Significant work would be required before such an evaluation would be possible.

6. There is not a single universally appropriate way to treat multispecies associations in addressing questions about rebuilding strategies and reference points. Even the preliminary work here has shown that the form and magnitude of impacts on reference points, for example, depends on the relative timing of predation mortality and fishing mortality experienced by a cohort and on the bioeconomics of the fisheries on the interacting species. Other complications are likely to be uncovered as these investigations are pursued further.

7. The Working Group observes that within a precautionary framework complexity, like uncertainty, is not a reason to delay coming to grips these important questions.

A successful validation of the model adding length to MSVPA could lead to significant improvements in multispecies modelling. Amongst these would be:

(1) the ability to use length based data directly without the problems that can arise in the determination and application of age-length keys;
(2) the opening of a way for making the growth of fish depend upon their diet when length and weight are dynamic variables; and
(3) a resolution of the problem that causes problems in present MSVPA/MSFOR runs when intra-cohort predation occurs, most usually larger 0-group members eating smaller ones.

Further model testing should use files created directly from the stomachs databases for 1981, 1985–1987, 1991, rather than files prepared for MSVPA runs.

With regard to future directions in multispecies modelling the Working Group:

- Feels that in general the ICES scientific community is well prepared to retain the capability to conduct multispecies assessments when needed, and the multispecies Assessment Working Group should have an important continuing role in providing peer review of multispecies models for both applications in assessments and investigating related ecological questions.

- Sees value in continued work on analytical multispecies tools which cover more trophic levels. Such models are likely to be independent of assessment models, but may feed input values to assessment models.

- It would be useful for size based multispecies modelling to begin to build up size composition data for as many species of other named food as possible.

- It would be prudent to keep away from mass balance models for assessment and dynamic applications, at least until ones are available whose dynamic properties and quantitative reliability have been tested with the thoroughness given to tests of MSVPA and some of the boreal models examined at the last meeting.

- Application of methods adapted from geostatistics to a number of aspects of multispecies assessment modelling and analyses may be of value. Statistical distributional problems related to the special aspects of how stomach data are collected may make applications complex in some cases, but in other cases the strengths of spatial analysis methods may actually contribute to overcoming some of these problems.

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Table 2.1.2 Estimation procedure and estimated stock size for the Western Mackerel stock present in the North Sea.

INPUT:

	Fishing mortality				Natural Mortality		
	1993	**1994**	**1995**	**1993**	**1994**	**1995**	
0	0.002	0.002	0.002	0	0.15	0.15	0.15
1	0.0415	0.0406	0.0414	1	0.15	0.15	0.15
2	0.1228	0.1204	0.1225	2	0.15	0.15	0.15
3	0.2128	0.2085	0.2122	3	0.15	0.15	0.15
4	0.2703	0.2649	0.2969	4	0.15	0.15	0.15
5	0.3026	0.2966	0.3019	5	0.15	0.15	0.15
6	0.2938	0.288	0.2931	6	0.15	0.15	0.15
7	0.3249	0.3184	0.3241	7	0.15	0.15	0.15
8	0.346	0.3391	0.3451	8	0.15	0.15	0.15
9	0.4354	0.4268	0.4343	9	0.15	0.15	0.15
10	0.3939	0.3861	0.3929	10	0.15	0.15	0.15
11	0.3632	0.3559	0.3622	11	0.15	0.15	0.15
12	0.3632	0.3559	0.3622	12	0.15	0.15	0.15

	Stock Numbers on 1 January				Proportion in the North Sea by quarter			
	1993	**1994**	**1995**		**1q**	**2q**	**3q**	**4q**
0	4598	1878	1994	1	0	0.2	0.3	0.3
1	2736	3949	1613	2	0.1	0.1	0.5	0.7
2	2177	2259	3264	>2	0.1	0.05	0.5	0.7
3	1532	1657	1724					
4	1969	1066	1158					
5	1022	1293	704					
6	1262	650	828					
7	522	809	419					
8	362	325	507					
9	555	221	199					
10	84	309	124					
11	75	49	181					
12	231	202	129					

continued

Table 2.1.2 continued

OUTPUT:

Mean Stock numbers by quarter

	1993				Total Stock				
	1	2	3	4		1	2	3	4
0	4512	4344	4182	4026					
1	2672	2547	2428	2314	1	2672	2547	2428	2314
2	2104	1966	1836	1715	2	2104	1966	1836	1715
3	1465	1338	1222	1116	>2	7209	6457	5785	5184
4	1869	1683	1515	1364					
5	966	863	771	688		Present in the North Sea			
6	1195	1069	957	856		1	2	3	4
7	492	437	388	345	1	0	509	728	694
8	340	301	266	235	2	210	197	918	1201
9	516	446	385	333	>2	721	323	2892	3629
10	79	69	60	52		Input to MSVPA			
11	70	62	54	48	1-2	210	706	1646	1895
12	217	191	168	148	3+	721	323	2892	3629

continued

Table 2.1.2 continued

Mean Stock numbers by quarter

	1994					Total Stock			
	1	2	3	4		1	2	3	4
0	1843	1774	1708	1644					
1	3856	3677	3506	3343	1	3856	3677	3506	3343
2	2184	2042	1908	1783	2	2184	2042	1908	1783
3	1585	1449	1325	1211	>2	6237	5596	5023	4509
4	1013	913	823	742					
5	1223	1094	979	875		Present in the North Sea			
6	616	552	495	443		1	2	3	4
7	763	679	604	537	1	0	735	1052	1003
8	306	271	240	212	2	218	204	954	1248
9	206	178	154	134	>2	624	280	2511	3156
10	289	253	221	193		Input to MSVPA			
11	46	41	36	31	1-2	218	940	2006	2251
12	190	167	147	130	3+	624	280	2511	3156

continued

Table 2.1.2 continued

Mean Stock numbers by quarter

	1995					Total stock			
	1	2	3	4		1	2	3	4
0	1957	1884	1813	1746					
1	1575	1501	1431	1364	1	1575	1501	1431	1364
2	3155	2948	2753	2572	2	3155	2948	2753	2572
3	1648	1506	1375	1256	>2	5657	5071	4546	4077
4	1096	980	876	784					
5	666	595	531	474		Present in the North Sea			
6	784	702	628	562		1	2	3	4
7	395	351	312	277	1	0	300	429	409
8	477	421	372	329	2	316	295	1377	1800
9	185	160	138	119	>2	566	254	2273	2854
10	116	101	88	77		Input to MSVPA			
11	170	149	132	116	1-2	316	595	1806	2210
12	121	107	94	82	3+	566	254	2273	2854

Table 2.1.3 Numbers ($*10^6$) of horse mackerel assumed in the North Sea.

	MEAN W	Before 85	85	86	87	88	89	90	91	92	93	94	95
Q1													
1-2	48	19	14	17	23	36	24	8	7	9	28	29	12
3-7	116	95	238	206	170	148	130	39	32	27	19	16	19
8+	260	43	10	15	23	22	18	102	84	66	54	41	36
Q2													
1-2	48	189	145	171	228	360	242	82	68	91	279	292	118
3-7	120	948	2383	2060	1697	1475	1303	391	319	269	190	156	190
8+	260	428	103	149	229	216	183	1016	839	663	538	411	361
Q3													
1-2	48	189	145	171	228	360	242	82	68	91	279	292	118
3-7	128	948	2662	4058	3341	2870	2507	600	617	501	366	263	258
8+	260	428	207	298	459	432	366	2032	1678	1327	1077	822	722
Q4													
1-2	44	94	72	86	114	180	121	41	34	46	139	146	59
3-7	110	474	3983	21008	17286	14681	12690	2293	3133	2454	1852	1148	773
8+	338	214	1085	1562	2409	2266	1923	10670	8811	6965	5653	4316	3791

Table 2.1.4.1
Survey indices of abundance of grey gurnard by size class from the IBTS data.

a. 1st quarter estimates by year

year	N rectangles sampled	< 10 cm	10-19 cm	20-29 cm	> 30 cm
1973	46	0.201	52.234	105.663	5.241
1974	58	0.026	15.658	18.318	2.066
1975	45	0.015	16.349	24.683	4.450
1976	49	0.264	16.054	16.584	4.338
1977	83	0.000	0.555	1.823	0.247
1978	99	0.029	12.295	34.268	2.807
1979	74	0.085	1.261	0.348	0.136
1980	90	0.053	1.502	2.537	0.305
1981	75	0.017	5.254	11.620	1.155
1982	100	0.946	3.337	31.775	2.977
1983	171	0.132	3.127	7.916	1.058
1984	170	0.137	5.714	21.838	2.872
1985	171	0.391	4.065	10.239	2.717
1986	170	0.055	2.868	12.793	1.677
1987	166	0.069	2.987	5.219	1.182
1988	161	0.087	1.775	4.156	0.996
1989	163	0.261	5.142	7.607	1.475
1990	159	0.259	6.251	6.231	1.188
1991	181	0.143	9.843	10.100	1.558
1992	181	0.620	23.329	23.617	2.386
1993	179	0.202	12.509	17.035	2.104
1994	180	0.805	6.267	11.260	1.631
1995	178	0.867	7.810	12.162	2.258
1996	169	0.160	18.344	16.642	2.706
1997	172	0.161	9.587	30.217	4.809

b. Mean from quarterly surveys 1991-1995

year	N rectangles sampled	< 10 cm	10-19 cm	20-29 cm	> 30 cm
1	174	0.979	54.924	69.912	9.881
2	171	0.358	30.282	40.773	4.424
3	176	0.115	37.034	66.308	8.644
4	167	1.406	59.278	126.146	22.111

c. Information used in tuning

Parameter	< 10 cm	10-19 cm	20-29 cm	> 30 cm
Total				
Mean number index	0.284	11.795	21.193	3.121
W at size	4.240	43.542	124.202	347.154
Mean biomass index	1.203	513.597	2632.242	1083.582
Numbers in '000	13752	571559	1026940	151248
1763498				
Biomass (forcing factor)				
205000				

Table 2.1.4.2
Survey indices of abundance of starry ray by size class from the IBTS data.

a. 1st quarter estimates by year

year	N rectangles sampled	< 10 cm	10-19 cm	20-29 cm	> 30 cm
1973	46	0.000	0.000	0.000	0.957
1974	58	0.000	0.034	0.009	0.629
1975	45	0.024	0.809	0.641	0.054
1976	49	0.000	0.027	0.147	0.020
1977	83	0.028	0.159	0.100	0.046
1978	99	0.031	0.247	0.391	0.186
1979	74	0.030	0.113	0.295	0.044
1980	90	0.020	0.072	0.312	0.326
1981	75	0.029	0.176	0.417	0.765
1982	100	0.030	0.033	0.108	0.266
1983	171	0.005	0.052	0.192	1.078
1984	170	0.046	0.160	0.345	1.496
1985	171	0.019	0.080	0.301	2.642
1986	170	0.057	0.123	0.312	1.990
1987	166	0.074	0.430	0.729	1.928
1988	161	0.057	0.136	0.312	1.109
1989	163	0.047	0.148	0.341	1.906
1990	159	0.019	0.056	0.200	1.152
1991	181	0.012	0.109	0.335	1.249
1992	181	0.012	0.324	1.030	3.324
1993	179	0.014	0.122	0.556	3.292
1994	180	0.154	0.135	0.408	1.175
1995	178	0.040	0.134	0.288	1.936
1996	169	0.039	0.154	0.334	1.478
1997	172	0.034	0.150	0.369	1.295

b. Mean from quarterly surveys 1991-1995

year	N rectangles sampled	< 10 cm	10-19 cm	20-29 cm	> 30 cm
1	174	0.066	0.777	2.612	11.823
2	171	0.030	0.339	0.997	7.551
3	176	0.001	0.378	2.019	7.423
4	167	0.121	0.594	1.956	12.491

c. Information used in tuning

Parameter	< 10 cm	10-19 cm	20-29 cm	> 30 cm
Total				
Mean number index	0.036	0.196	0.498	2.106
W at size	3.700	30.052	134.943	584.813
Mean biomass index	0.133	5.893	67.188	1231.407
Numbers in '000	2762	15032	38164	161399
217356				
Biomass (forcing factor)				
100000				

Table 2.1.5 Quarterly numbers ($*10^3$) of "fish-eating seabirds" in the North Sea. See text for explanation.

YEAR	Q1	Q2	Q3	Q4
1974	1138	1843	1843	1216
1975	1175	1902	1902	1256
1976	1213	1963	1963	1296
1977	1252	2027	2027	1338
1978	1292	2092	2092	1381
1979	1334	2159	2159	1425
1980	1377	2229	2229	1471
1981	1421	2301	2301	1519
1982	1467	2375	2375	1568
1983	1514	2451	2451	1618
1984	1563	2530	2530	1670
1985	1613	2612	2612	1724
1986	1665	2696	2696	1779
1987	1719	2782	2782	1837
1988	1774	2872	2872	1896
1989	1831	2965	2965	1957
1990	1890	3060	3060	2020
1991	1951	3159	3159	2085
1992	2014	3260	3260	2152
1993	2079	3365	3365	2222
1994	2146	3474	3474	2293
1995	2215	3586	3586	2367
1996	2286	3701	3701	2443

Table 2.1.6 Annual numbers ($*10^3$) of grey seals in the North Sea. Numbers do not differ between quarters. See text for explanation.

YEAR	NUMBER
1974	13.5
1975	13.5
1976	14.5
1977	14.3
1978	15.3
1979	17.3
1980	18.7
1981	20
1982	20.9
1983	20
1984	18.8
1985	21.3
1986	23.5
1987	25.2
1988	23
1989	27.6
1990	29.1
1991	35
1992	39.2
1993	42.2
1994	44.5
1995	47.6
1996	51.4

Table 2.1.7. Quarterly consumption of fish and other food by cetaceans and 'other fish eating fish' in the North Sea. (000' tonnes). See text for explanation.

Predator	Food item	Q1	Q2	Q3	Q4	Total
Cetaceans	Fish	83	167	167	83	500
Other fish	Fish	60	60	60	60	240
	Other food	125	125	125	125	500
Total		268	352	352	268	1240

Table 2.2.2.1 Total North Sea stomach content data for grey gurnard in 1990 by predator size class, prey age class and quarter.

A. Average stomach content weight (g) per 1000 fish).

	Quarter 1			Quarter: 2			Quarter: 3		
Size class	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm
Nr of stomachs sampled	157	91	2	104	161	56	194	258	55
Nr of stomachs with food	23	26	1	66	94	33	143	155	34
Nr of regurgit. stomachs	0	0	0	0	0	0	0	0	0
Nr with skeletal remains	0	0	0	0	0	0	0	0	0
Nr of empty stomachs	94	65	1	38	67	23	51	103	21
% empty stomachs	59.87	71.43	50.00	36.54	41.61	41.07	26.29	39.92	38.18
ALL PREY	75	24	755	198	168	3102	345	141	3061
COD									
age 0	0	0	0	30	69	238	0	0	0
HADDOCK									
age 0	0	0	0	0	0	0	0	0	290
WHITING									
age 0	0	0	0	0	8	0	0	6	427
NORWAY POUT									
age 0	0	0	0	0	8	0	0	0	115
HERRING									
SPRAT									
SANDEEL									
age 0	0	0	0	52	9	1174	7	20	638
1	0	0	0	21	0	1016	0	0	24
2	0	0	0	0	0	260	0	0	0
3	0	0	0	0	0	143	0	0	0
4	0	0	0	0	0	22	0	0	0
5	0	0	0	0	0	28	0	0	0
6	0	0	0	0	0	14	0	0	0
OTHER PREY									
All size classes	75	24	755	89	62	206	339	114	1566

B. Average prey weight (g) at time of ingestion.

		Quarter 1			Quarter: 2			Quarter: 3	
Size class	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm
ALL PREY	0.0191	0.0564	1.2100	0.1305	0.0386	2.5243	0.0437	0.0354	1.7835
COD									
age 0	0.0000	0.0000	0.0000	0.4180	0.5529	1.5030	0.0000	0.0000	0.0000
HADDOCK									
age 0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	5.0838
WHITING									
age 0	0.0000	0.0000	0.0000	0.0000	0.2957	0.0000	0.0000	1.2160	8.2011
NORWAY POUT									
age 0	0.0000	0.0000	0.0000	0.0000	0.7843	0.0000	0.0000	0.0000	4.4080
HERRING									
SPRAT									
SANDEEL									
age 0	0.0000	0.0000	0.0000	0.6701	0.4500	2.0600	1.0568	0.7110	2.9287
1	0.0000	0.0000	0.0000	1.3468	0.0000	3.8039	0.0000	0.0000	5.1322
2	0.0000	0.0000	0.0000	0.0000	0.0000	9.5600	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000	9.5600	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	5.2550	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	5.2550	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	5.2550	0.0000	0.0000	0.0000
OTHER PREY	All size classes	0.0641	0.0171	0.8202	0.0437	0.0290	1.1195		

Table 2.2.2.1 (continued)

Total North Sea stomach content data for grey gurnard in 1991 by predator size class, prey age class and quarter.

A. Average stomach content weight (g) per 1000 fish).

	Quarter: 1			Quarter: 2			Quarter: 3			Quarter: 4			
Size class	10-20 cm	20-30 cm	>300	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm	<10 cm	10-20 cm	20-30 cm	>30 cm
Nr of stomachs sampled	624	945	347	1778	2036	318	1262	2172	521	17	638	821	235
Nr of stomachs with food	242	391	156	953	1278	268	782	1315	325	14	323	360	79
Nr of regurgit. stomachs	150	190	72	551	474	16	370	671	145	0	139	230	62
Nr with skeletal remains	0	0	1	2	6	0	0	0	0	0	0	0	2
Nr of empty stomachs	232	364	118	272	278	34	110	186	51	3	176	231	92
% empty stomachs	38.35	78.14	67.69	26.76	27.62	23.78	33.59	17.00	42.68	17.65	72.69	56.72	130.82
All PREY	177	452	3456	389	1120	5461	418	1183	3568	142	202	656	3208
COD													
age 0	0	0	0	0	10	288	0	41	186	0	0	14	74
1	0	22	0	0	0	0	0	0	0	0	0	0	0
HADDOCK													
age 0	0	0	0	0	1	0	0	2	130	0	0	10	127
1	0	0	0	0	0	11	0	0	0	0	0	0	0
WHITING													
age 0	0	0	0	2	29	14	3	75	248	0	0	16	939
1	0	20	998	0	0	1049	0	0	77	0	0	0	0
NORWAY POUT													
age 0	0	0	0	4	30	14	4	61	161	0	0	0	7
1	0	24	943	0	0	273	0	0	98	0	0	0	0
2	0	3	68	0	0	95	0	0	6	0	0	0	0
3	0	0	5	0	0	9	0	0	0	0	0	0	0
4	0	0	0	0	0	2	0	0	0	0	0	0	0
HERRING													
age 0	0	0	0	4	0	15	0	0	0	0	0	0	0
SPRAT													
age 0	0	0	0	0	0	4	0	85	6	0	0	4	5
1	0	0	0	0	0	47	0	3	0	0	0	0	0
2	0	0	0	0	0	4	0	0	0	0	0	0	0
SANDEEL													
age 0	0	0	0	42	178	283	81	340	1485	0	4	65	532
1	8	96	251	26	149	982	0	23	80	0	0	13	26
2	0	1	24	0	60	319	0	0	2	0	0	1	1
3	0	0	13	0	10	76	0	12	14	0	0	0	6
4	0	0	2	0	2	16	0	0	4	0	0	0	1
5	0	0	3	0	2	9	0	0	3	0	0	0	1
6	0	0	1	0	1	11	0	0	3	0	0	0	2
OTHER PREY													
All size classes	168	2[illegible]	1148	311	644	1775	328	540	1063	142	198	532	1264

Table 2.2.2.1 (continued)

B. Average prey weight (g) at time of ingestion.

	Quarter: 1			Quarter: 2			Quarter: 3			Quarter: 4			
Size class	10-20 cm	20-30 cm	>300	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm	<10 cm	10-20 cm	20-30 cm	>30 cm
All PREY	0.1982	0.6058	4.7069	0.0292	0.0725	1.2248	0.0402	0.1299	0.8512	0.0200	0.0875	0.5806	3.8086
COD													
age 0	0.0000	0.0000	0.0000	0.0000	2.5008	1.8524	0.1937	2.7794	3.4730	0.0000	0.0000	1.3580	4.5356
1	0.0000	1.8108	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HADDOCK													
age 0	0.0000	0.0000	0.0000	0.0000	1.1147	0.0000	0.0000	0.9620	10.2406	0.0000	0.0000	4.5822	3.5955
1	0.0000	0.0000	0.0000	0.0000	0.0000	13.2774	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WHITING													
age 0	0.0000	0.0000	0.0000	1.3355	1.6181	0.8534	2.1690	2.6862	4.1949	0.0000	0.0000	4.2808	10.1862
1	0.0000	2.5496	16.9044	0.0000	0.0000	23.8565	0.0000	0.0000	8.8896	0.0000	0.0000	8.2790	0.0000
NORWAY POUT													
age 0	0.0000	0.0000	0.0000	1.2123	1.8683	0.5399	1.0651	3.1398	4.2988	0.0000	0.0000	0.0000	1.6430
1	0.0000	6.5320	7.3030	0.0000	0.0000	4.7418	0.0000	0.0000	20.5889	0.0000	0.0000	0.0000	0.0000
2	0.0000	1.9813	21.8173	0.0000	0.0000	6.4286	0.0000	0.0000	21.2028	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	13.3005	0.0000	0.0000	1.1821	0.0000	0.0000	21.2028	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	1.1821	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
HERRING													
age 0	0.0000	0.0000	0.0000	0.7388	0.5097	1.8515	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPRAT													
age 0	0.0000	0.0000	0.0000	0.0000	0.0000	1.0364	0.0000	0.2099	0.9251	0.0000	0.0000	2.1886	1.1443
1	0.0000	0.0000	0.0000	0.0000	0.0000	3.8157	0.0000	1.4746	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000	4.2329	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SANDEEL													
age 0	0.0000	0.0000	0.0000	0.2718	0.6226	1.0274	0.5299	1.4327	2.6487	0.0000	1.5169	2.7652	2.0166
1	4.5278	1.8500	2.1433	1.6859	3.6061	3.5784	4.8803	5.1619	5.1620	0.0000	0.0000	5.7636	9.0169
2	4.5278	1.7048	4.0184	0.0000	6.3303	7.9619	0.0000	5.2721	9.5751	0.0000	0.0000	4.2687	17.9195
3	0.0000	0.0000	4.3496	0.0000	8.4202	12.5033	0.0000	8.4310	9.2257	0.0000	0.0000	4.2687	11.0629
4	0.0000	0.0000	4.3496	0.0000	3.1712	13.0120	0.0000	5.2721	9.9187	0.0000	0.0000	4.2687	17.9195
5	0.0000	0.0000	1.4550	0.0000	3.1512	16.4126	0.0000	0.0000	5.7165	0.0000	0.0000	0.0000	10.5095
6	0.0000	0.0000	1.4550	0.0000	3.1762	16.0740	0.0000	0.0000	5.7165	0.0000	0.0000	0.0000	10.5095
OTHER PREY													
All size classes	0.1885	0.3940	3.4283	0.0197	0.0400	0.5810	0.0303	0.0600	0.2866	0.0200	0.0875	0.4966	3.6902

Table 2.2.2.2

Total North Sea stomach content data for starry ray in 1991 by predator size class, prey age class and quarter.

A. Average stomach content weight (g) per 1000 fish).

	Quarter: 1			Quarter: 2			Quarter: 3			Quarter: 4		
Size class	10-20 cm	20-30 cm	>300	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm
Nr of stomachs sampled	39	175	423	25	126	511	82	426	968	24	89	441
Nr of stomachs with food	28	97	194	22	85	314	81	372	703	24	70	326
Nr of regurgit. stomachs	11	46	76	2	20	46	0	21	108	0	3	31
Nr with skeletal remains	0	0	3	0	0	0	1	0	0	0	0	1
Nr of empty stomachs	0	32	150	1	21	151	0	33	157	0	16	83
% empty stomachs	0	27.83	146.87	4	33.64	122.37	0.00	15.31	83.17	0	35.57	71.39
ALL PREY	370	744	1771	255	439	1807	140	441	2108	345	893	2889
COD												
age 0	0	0	0	0	0	0	0	1	32	0	0	0
HADDOCK												
WHITING												
age 0	0	0	0	0	0	0	0	0	13	0	0	0
1	0	0	0	0	0	45	0	0	0	0	0	74
2	0	0	0	0	0	1	0	0	0	0	0	12
NORWAY POUT												
age 0	0	0	0	0	0	0	0	5	57	0	5	52
1	0	196	2	0	0	21	0	0	158	0	0	120
2	0	0	34	0	0	4	0	0	1	0	0	7
3	0	0	11	0	0	0	0	0	0	0	0	0
HERRING												
age 0	0	0	0	0	0	0	0	0	55	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	129
2	0	0	0	0	0	2	0	0	0	0	0	25
3	0	0	0	0	0	2	0	0	0	0	0	7
4	0	0	0	0	0	1	0	0	0	0	0	2
5	0	0	0	0	0	1	0	0	0	0	0	0
SPRAT												
age 1	0	0	1	0	0	0	0	0	0	0	0	0
SANDEEL												
age 0	0	0	0	0	64	60	0	101	698	0	27	133
1	0	250	683	0	35	398	0	4	118	0	3	27
2	0	0	14	0	11	390	0	0	6	0	0	5
3	0	0	5	0	2	210	0	0	5	0	0	4
4	0	0	1	0	0	42	0	0	0	0	0	1
5	0	0	1	0	0	31	0	0	0	0	0	0
6	0	0	0	0	0	31	0	0	0	0	0	0
OTHER PREY												
All size classes	370	2>.	1018	239	317	360	140	310	959	345	855	2195

Table 2.2.2.2 (continued)

B. Average prey weight (g) at time of ingestion.

	Quarter: 1			Quarter: 2			Quarter: 3			Quarter: 4		
Size class	10-20 cm	20-30 cm	>300	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm
ALL PREY	0.0700	0.3100	1.4213	0.0600	0.2052	2.5420	0.0895	0.3954	1.9006	0.1350	0.3929	1.4224
COD												
age 0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9048	10.2230	0.0000	0.0000	0.0000
HADDOCK												
WHITING												
age 0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	4.4061	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	24.0066	0.0000	0.0000	0.0000	0.0000	0.0000	18.2073
2	0.0000	0.0000	0.0000	0.0000	0.0000	24.0066	0.0000	0.0000	0.0000	0.0000	0.0000	18.2073
NORWAY POUT												
age 0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	3.1513	4.2839	0.0000	2.4067	3.0779
1	0.0000	1.2551	17.9498	0.0000	0.0000	5.0813	0.0000	0.0000	10.4034	0.0000	0.0000	15.1883
2	0.0000	0.0000	17.9498	0.0000	0.0000	6.9092	0.0000	0.0000	5.2615	0.0000	0.0000	15.1963
3	0.0000	0.0000	17.9498	0.0000	0.0000	7.3499	0.0000	0.0000	0.0000	0.0000	0.0000	16.0061
HERRING												
age 0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	8.5537	0.0000	0.0000	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.8210
2	0.0000	0.0000	0.0000	0.0000	0.0000	3.1749	0.0000	0.0000	0.0000	0.0000	0.0000	1.8210
3	0.0000	0.0000	0.0000	0.0000	0.0000	3.1749	0.0000	0.0000	0.0000	0.0000	0.0000	1.8210
4	0.0000	0.0000	0.0000	0.0000	0.0000	3.1749	0.0000	0.0000	0.0000	0.0000	0.0000	1.8210
5	0.0000	0.0000	0.0000	0.0000	0.0000	3.1749	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SPRAT												
age 1	0.0000	0.0000	0.2855	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SANDEEL												
age 0	0.0000	0.0000	0.0000	0.0000	0.2524	1.0309	0.0000	1.6051	2.4505	0.0000	2.5079	2.1773
1	0.0000	0.9200	2.8018	0.0000	1.9762	5.4951	0.0000	1.8096	5.1499	0.0000	2.5079	3.7450
2	0.0000	2.9243	4.4681	0.0000	1.9762	9.0306	0.0000	2.1026	8.3251	0.0000	0.0000	8.5220
3	0.0000	0.0000	5.6355	0.0000	1.9762	13.1650	0.0000	2.1026	3.7957	0.0000	0.0000	9.8325
4	0.0000	0.0000	4.8183	0.0000	1.9762	12.3873	0.0000	2.1026	8.3251	0.0000	0.0000	9.7585
5	0.0000	0.0000	7.2945	0.0000	0.0000	13.2848	0.0000	0.0000	0.0000	0.0000	0.0000	11.9223
6	0.0000	0.0000	7.2945	0.0000	0.0000	13.2872	0.0000	0.0000	0.0000	0.0000	0.0000	11.9223
OTHER PREY												
All size classes	0.0700	0.1326	1.0500	0.0600	0.1671	1.4658	0.0895	0.2982	1.2911	0.1350	0.3794	1.1588

Table 2.2.2.3

Total North Sea stomach content data for horse mackerel in 1991 by predator size class, prey age class and quarter.
A. Average stomach content weight (g) per 1000 fish).

	Quarter: 1		Quarter: 2			Quarter: 3			Quarter: 4		
Size class	20-30 cm	>300	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm
Nr of stomachs sampled	1	10	94	449	377	119	693	687	2	284	473
Nr of stomachs with food	0	0	57	191	153	89	407	373	0	71	119
Nr of regurgit. stomachs	0	0	0	0	0	0	61	72	0	4	0
Nr with skeletal remains	0	0	0	3	3	0	7	9	0	0	3
Nr of empty stomachs	1	10	37	255	221	30	218	233	2	209	351
% empty stomachs	100	200	119.97	112.26	192.73	25.21	60.20	132.94	100	161.92	254.13
ALL PREY	0	0	55	80	319	234	729	1487	0	142	592
COD											
HADDOCK											
age 0	0	0	0	0	0	0	0	68	0	0	0
WHITING											
age 0	0	0	0	0	1	0	0	58	0	0	0
NORWAY POUT											
age 0	0	0	0	0	0	0	9	30	0	0	14
HERRING											
age 0	0	0	0	0	15	0	0	298	0	0	231
SPRAT											
age 0	0	0	0	1	0	0	102	19	0	4	1
1	0	0	0	0	3	0	0	0	0	0	0
SANDEEL											
age 0	0	0	0	4	0	0	180	438	0	0	0
1	0	0	0	0	0	0	0	2	0	0	0
OTHER PREY											
All size classes	0	0	55	76	299	234	436	571	0	138	346

Table 2.2.2.3 (continued)

B. Average prey weight (g) at time of ingestion.

	Quarter: 1			Quarter: 2			Quarter: 3			Quarter: 4	
Size class	20-30 cm	>300	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm	10-20 cm	20-30 cm	>30 cm
ALL PREY	0.0000	0.0000	0.0037	0.0060	0.0046	0.0100	0.0127	0.0240	0.0000	0.0380	0.0260
COD											
HADDOCK											
age 0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	3.0711	0.0000	0.0000	0.0000
WHITING											
age 0	0.0000	0.0000	0.0000	0.0000	0.2400	0.0000	1.3991	2.0363	0.0000	0.0000	0.0000
NORWAY POUT											
age 0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	3.2063	2.1693	0.0000	0.0000	4.5892
HERRING											
age 0	0.0000	0.0000	0.0000	0.3355	1.7724	0.0000	0.0000	8.9970	0.0000	0.0000	8.3552
SPRAT											
age 0	0.0000	0.0000	0.0000	0.1198	0.0000	0.0000	0.0681	0.0656	0.0000	0.3919	0.1446
1	0.0000	0.0000	0.0000	0.0000	5.1639	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SANDEEL											
age 0	0.0000	0.0000	0.0000	0.1678	0.0000	0.0000	0.6704	0.9366	0.0000	0.0560	0.0000
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5103	0.0000	0.0000	0.0000
OTHER PREY											
All size classes	0.0000	0.0000	0.0037	0.0000	0.0024	0.0100	0.0073	0.0113	0.0000	0.0380	0.0179

Table 2.2.2.4

North Sea stomach data for western mackerel in 1991

Stomach contents

		Q1		Q2		Q3		Q4	
	Wma age	0	1	0	1	0	1	0	1
	Pey age								
Cod	0			0.018	0.017	0.005	0.032		
Whiting	0					0.001	0.08		
Haddock	0			0.008	0.001				
Herring	0			0.005		0.035	0.307	0.221	
Sprat	0					0.001	0.002	5.287	
	1			0.22	1.657	0.001		0.083	
	2			0.001				0.008	
	3							0.002	
Nor pout	0			0.131	0.08	0.459	4.298	1.055	5.323
	1						0.119		
Sandeel	0			2.198	9.652	4.791	19.066	0.579	
	1	0.03	0.48	0.424	7.729	0.034	1.346	0.017	
	2			0.005	0.945	0.002	0.359		
	3			0.002	0.215	0.001	0.333		
	4				0.038		0.059		
	5						0.018		
	6						0.008		
Other food		0.621	1.738	13.141	31.574	12.678	28.776	5.59	1.966
Number of stomachs		271	19	916	235	1254	778	382	86

North Sea stomach data for western mackerel in 1991

Weight in the stomach

		Q1		Q2		Q3		Q4	
	Wma age	0	1	0	1	0	1	0	1
	Pey age								
Cod	0			2.16	1.355	2.199	2.252		
Whiting	0					2.295	2.758		
Haddock	0			2.22	2.22				
Herring	0			14.43		4.14	4.051	7.014	
Sprat	0					0.73	0.73	2.679	
	1			2.51	3.84	12.13		13.578	
	2			16.64				16.621	
	3							18.43	
Nor pout	0			2.112	1.231	1.844	2.655	7.022	7.242
	1						17.992		
Sandeel	0			1.187	1.456	1.024	1.537	1.84	
	1	2.21	2.21	2.968	3.657	8.793	21.018	4.39	
	2			10.267	8.015	9.203	24.13		
	3			20.992	8.039	10.995	24.706		
	4				8.05		24.681		
	5						25.2		
	6						25.2		
Other food		0.621	1.738	13.141	31.574	12.678	28.776	5.59	1.966

Table 2.3.1 Overview of gastric evacuation studies which contributed to the consumption estimates used in this report.

MSVPA predator species	data applied from species	N of prey types	Author	N umber of datapoints	T - range [°C]	T - effect	Predator weight effect estimated	Weight - range [g]	Meal size variation	Evacuation constant refers to prey species
cod	cod	18	J. dos Santos & M.Jobling 1) A. Temming & J.P. Hermann 2)	2177	1 - 15	strong 4)	+	9 - 3700	+	smelt, whiting, Norway pout, haddock, herring
whiting	whiting	8	N.G. Andersen & J.R. Vestergaard 2 A. Temming & J.P. Hermann 2)	1467	6 - 15	weak	+	4 - 770	+	smelt, whiting, Norway pout, herring
haddock	haddock	5 2	R. Jones (1974) S. Robb, J. Hislop 2)	414	6 - 13	weak	+	11 - 1400	+	saithe (Jones) sandeel (S.Robb & J. Hislop)
saithe	**cod**	/	3)	/	/	/	/	/	/	/
mackerel	mackerel	2	B. Böhle, D. Skagen 2)	311	10 - 18	strong	- 5)	150 - 400	+	sprat , sandeel
grey gurnard	**haddock**	/	3)	/	/	/	/	/	/	/
horse mackerel	horse mackerel	3	A. Temming & J.P. Hermann 2)	303	11 - 16	strong	+	10 - 70 (270)	+	smelt
starry ray *raja radiata*	**little skate** *raja erinacea*	5	literature Nelson & Ross (1992)	104	10 - 16	strong	- 5)	218 - 737	-	sandlance

1) publication : dos Santos & Jobling 1995, raw data used in new model

2) unpublished results from ongoing project

3) data not yet available, ongoing project; N.G. Andersen & J.R. Vestergaard

4) strong : exp. coeff. > 0.1, weak : exp. coeff. < 0.1

5) fixed to (predator weight)^0.2

\+ analysed subject

Table 2.3.5.1 Length - weight relationships

parameter	cod	haddock	mackerel	saithe	whiting	grey gurnard	starry ray
a	0.0175	0.0155	0.003001	0.0175	0.0093	0.0062	0.005247518
b	2.8571	2.8268	3.29	2.8571	2.9456	3.1003	3.11
r	1.17	1.16	1	1.17	1.13	1	1

weight = (a * length ^ b) * r
(r : raising factor for slaughtered fish weights)

Table 3.1.1

RESIDUAL NATURAL MORTALITY (M1) AND PROPORTION MATURE

COD

AGE	M1	PROP. MATURE
0	.0500	.0000
1	.0500	.0100
2	.0500	.0500
3	.0500	.2300
4	.0500	.6200
5	.0500	.8600
6	.0500	1.0000
7	.0500	1.0000
8	.0500	1.0000
9	.0500	1.0000
10	.0500	1.0000
11	.0500	1.0000

WHITING

AGE	M1	PROP. MATURE
0	.0500	.0000
1	.0500	.1100
2	.0500	.9200
3	.0500	1.0000
4	.0500	1.0000
5	.0500	1.0000
6	.0500	1.0000
7	.0500	1.0000
8	.0500	1.0000
9	.0500	1.0000
10	.0500	1.0000

SAITHE

AGE	M1	PROP. MATURE
0	.0500	.0000
1	.0500	.0000
2	.0500	.0000
3	.0500	.0000
4	.0500	.1500
5	.0500	.7000
6	.0500	.9000
7	.0500	1.0000
8	.0500	1.0000
9	.0500	1.0000
10	.0500	1.0000
11	.0500	1.0000
12	.0500	1.0000
13	.0500	1.0000
14	.0500	1.0000
15	.0500	1.0000

MACKEREL

AGE	M1	PROP. MATURE
0	.0375	.0000
1	.0375	.0000
2	.0375	.0000
3	.0375	.0300
4	.0375	1.0000
5	.0375	1.0000
6	.0375	1.0000
7	.0375	1.0000
8	.0375	1.0000
9	.0375	1.0000
10	.0375	1.0000
11	.0375	1.0000
12	.0375	1.0000
13	.0375	1.0000
14	.0375	1.0000
15	.0375	1.0000

HADDOCK

AGE	M1	PROP. MATURE
0	.0500	.0000
1	.0500	.0100
2	.0500	.3200
3	.0500	.7100
4	.0500	.8700
5	.0500	.9500
6	.0500	1.0000
7	.0500	1.0000
8	.0500	1.0000
9	.0500	1.0000
10	.0500	1.0000
11	.0500	1.0000

Table 3.1.1 (continued)

RESIDUAL NATURAL MORTALITY (M1) AND PROPORTION MATURE

HERRING

AGE	M1	PROP. MATURE
0	.0250	.0000
1	.0250	.0000
2	.0250	.6300
3	.0250	1.0000
4	.0250	1.0000
5	.0250	1.0000
6	.0250	1.0000
7	.0250	1.0000
8	.0250	1.0000
9	.0250	1.0000

N. POUT

AGE	M1	PROP. MATURE
0	.0500	.0000
1	.0500	.1000
2	.0500	1.0000
3	.0500	1.0000

SANDEEL

AGE	M1	PROP. MATURE
0	.0500	.0000
1	.0500	.0000
2	.0500	1.0000
3	.0500	1.0000
4	.0500	1.0000
5	.0500	1.0000
6	.0500	1.0000

PLAICE

AGE	M1	PROP. MATURE
0	.0250	.0000
1	.0250	.0000
2	.0250	.5000
3	.0250	.5000
4	.0250	1.0000
5	.0250	1.0000
6	.0250	1.0000
7	.0250	1.0000
8	.0250	1.0000
9	.0250	1.0000
10	.0250	1.0000
11	.0250	1.0000
12	.0250	1.0000
13	.0250	1.0000
14	.0250	1.0000
15	.0250	1.0000

SOLE

AGE	M1	PROP. MATURE
0	.0250	.0000
1	.0250	.0000
2	.0250	.0000
3	.0250	1.0000
4	.0250	1.0000
5	.0250	1.0000
6	.0250	1.0000
7	.0250	1.0000
8	.0250	1.0000
9	.0250	1.0000
10	.0250	1.0000
11	.0250	1.0000
12	.0250	1.0000
13	.0250	1.0000
14	.0250	1.0000
15	.0250	1.0000

Table 3.1.2.1

Table Catch in numbers of age (1000) 1974 - 1995.

NUMBER CAUGHT COD

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	14677.	31222.	6061.	84278.	24738.	40344.	69351.	23240.	69774.	22022.
2	55430.	48470.	93193.	42050.	161152.	85776.	87459.	189784.	60296.	119265.
3	10716.	17106.	18630.	21608.	14859.	37349.	29367.	27017.	55842.	18436.
4	14870.	3748.	6052.	4714.	8977.	2965.	9973.	7561.	6941.	10128.
5	4393.	6567.	1504.	1768.	3041.	3021.	1503.	3755.	3170.	2565.
6	920.	1751.	2697.	533.	1004.	641.	1042.	763.	1802.	1185.
7	418.	398.	860.	630.	402.	350.	379.	542.	344.	564.
8	373.	156.	116.	229.	407.	118.	158.	139.	211.	144.
9	317.	183.	67.	60.	145.	127.	69.	63.	64.	72.
10	75.	78.	58.	30.	39.	35.	45.	33.	23.	21.
11	179.	52.	35.	24.	45.	21.	25.	21.	23.	19.
GRAND TOTAL NUMBER CAUGHT :	102368.	109731.	129273.	155924.	214809.	170747.	199371.	252918.	198490.	174421.
SOP	202009.	188770.	204400.	195295.	275889.	234721.	258737.	325926.	287894.	246875.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	1.	0.	0.	0.	0.
1	65578.	8448.	56886.	19108.	16530.	19850.	11258.	13572.	27287.	4107.
2	58124.	114816.	21896.	104054.	46872.	31671.	49412.	22324.	28878.	49461.
3	28270.	15710.	34649.	6980.	37321.	15238.	8436.	14992.	7109.	9175.
4	3461.	7612.	4936.	7908.	3148.	8221.	3775.	2357.	4602.	2[illegible]
5	3144.	1338.	2727.	1392.	2462.	911.	1957.	1180.	859.	14[illegible].
6	955.	1252.	651.	999.	637.	907.	251.	915.	446.	357.
7	441.	367.	612.	208.	304.	221.	243.	183.	294.	174.
8	249.	182.	174.	208.	64.	126.	38.	120.	49.	96.
9	64.	79.	58.	58.	51.	23.	43.	22.	38.	14.
10	45.	14.	48.	33.	12.	24.	7.	3.	17.	8.
11	23.	22.	13.	15.	12.	8.	3.	9.	9.	14.
GRAND TOTAL NUMBER CAUGHT :	160354.	149840.	122650.	140963.	107413.	77201.	75423.	55677.	69588.	67225.
SOP	211534.	211969.	189470.	185132.	175639.	128096.	109402.	90484.	94081.	104811.

AGE	1994	1995
0	0.	1.
1	12679.	14438.
2	20740.	54871.
3	18548.	10189.
4	2757.	4599.
5	823.	737.
6	522.	262.
7	138.	151.
8	58.	45.
9	31.	15.
10	7.	9.
11	16.	5.
GRAND TOTAL NUMBER CAUGHT :	56319.	85322.
SOP	94482.	120525.

Table 3.1.2.1 (continued)

Table Continued

NUMBER CAUGHT WHITING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	570112.	328979.	482203.	642759.	678772.	427967.	337481.	548997.	103143.	693908.
1	754672.	877896.	503853.	988002.	440089.	633035.	303220.	188624.	279191.	212233.
2	974691.	399818.	1187765.	483200.	292399.	500180.	389258.	352944.	124525.	168489.
3	228625.	292204.	170674.	272521.	225871.	219160.	258891.	263261.	237326.	107142.
4	32095.	56512.	74953.	30514.	76430.	82253.	79818.	95026.	83335.	132658.
5	4876.	9888.	12762.	15941.	6952.	25979.	39055.	22154.	25308.	36782.
6	1223.	1268.	3031.	5172.	6445.	3290.	9818.	10512.	6467.	8424.
7	5822.	100.	330.	540.	1795.	1381.	1000.	1791.	1710.	1615.
8	351.	1561.	21.	229.	280.	241.	685.	248.	364.	647.
9	53.	158.	271.	6.	11.	20.	57.	45.	57.	82.
10	19.	4.	36.	183.	10.	8.	22.	39.	32.	36.
GRAND TOTAL NUMBER CAUGHT :	2572539.	1968388.	2435899.	2439067.	1729054.	1893514.	1419305.	1483641.	861458.	1362016.
SOP	325299.	270350.	341950.	288723.	203973.	257505.	227373.	209240.	152632.	170142.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	199052.	208446.	215478.	85777.	413750.	89214.	287947.	1025454.	254141.	616775.
1	342148.	222945.	549458.	253473.	429274.	323960.	246974.	133162.	237839.	216583.
2	155749.	150835.	154928.	293361.	302478.	171787.	488362.	181520.	155897.	161501.
3	110829.	77975.	133146.	120697.	190874.	191132.	122933.	174415.	83762.	118631.
4	48000.	36780.	46490.	79744.	46023.	80379.	81712.	32817.	89590.	45212.
5	59679.	12603.	12410.	10830.	14979.	15216.	31356.	23530.	11051.	46456.
6	13770.	17728.	4259.	4138.	2240.	4625.	1932.	5060.	6343.	4025.
7	2707.	2969.	5011.	838.	389.	457.	638.	502.	2518.	1589.
8	384.	843.	675.	881.	72.	335.	88.	249.	103.	729.
9	160.	98.	58.	94.	82.	38.	16.	7.	9.	65.
10	23.	16.	4.	8.	45.	7.	1.	2.	1.	18.
GRAND TOTAL NUMBER CAUGHT :	932501.	731238.	1121917.	849841.	1400206.	877150.	1261959.	1576718.	841254.	1211584.
SOP	150244.	108796.	159171.	147898.	188375.	156734.	200626.	142339.	119939.	110893.

AGE	1994	1995
0	216083.	1614707.
1	159666.	138953.
2	140076.	134848.
3	84045.	104687.
4	42771.	33340.
5	16256.	14619.
6	17057.	5045.
7	895.	4547.
8	372.	313.
9	73.	103.
10	1.	59.
GRAND TOTAL NUMBER CAUGHT :	677295.	2051221.
SOP	85546.	98569.

Table 3.1.2.1 (continued)

Table Continued

NUMBER CAUGHT SAITHE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	3670.	68.	260.	8930.	390.	1026.	1443.	5565.	1544.	162.
2	14749.	50643.	23310.	12540.	11854.	18967.	23775.	17902.	24217.	33764.
3	60680.	58016.	127765.	15935.	14363.	11653.	13333.	19006.	24887.	24997.
4	31802.	46993.	56418.	40783.	27367.	13242.	10534.	9102.	35432.	18559.
5	12430.	19590.	19416.	22988.	20032.	12016.	9576.	7011.	10812.	25944.
6	20595.	9485.	7916.	5399.	4256.	6695.	7273.	4373.	6692.	4588.
7	14503.	8723.	4817.	2038.	1138.	2299.	5088.	3207.	1934.	4472.
8	5028.	5190.	4435.	1931.	936.	886.	1072.	3254.	1431.	1265.
9	1427.	1599.	1947.	1358.	646.	468.	558.	676.	1042.	893.
10	809.	544.	1335.	824.	609.	275.	448.	288.	315.	303.
11	413.	284.	500.	415.	494.	356.	339.	382.	116.	202.
12	223.	263.	403.	296.	331.	301.	236.	338.	133.	74.
13	132.	149.	172.	160.	167.	125.	209.	293.	102.	90.
14	30.	38.	117.	114.	96.	44.	129.	250.	150.	39.
15	27.	47.	42.	63.	77.	95.	78.	337.	161.	118.
GRAND TOTAL NUMBER CAUGHT :	166518.	201632.	248853.	113774.	82756.	68448.	74091.	71984.	108968.	115470.
SOP	297644.	296983.	351419.	193177.	141485.	110451.	120286.	116690.	159959.	171556.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	1.	0.	0.	0.	.
1	74.	346.	79.	2352.	14.	5340.	292.	353.	294.	143.
2	33018.	4285.	5862.	25521.	3341.	9529.	3385.	12725.	5477.	7026.
3	79206.	114882.	47752.	26683.	13114.	13721.	30474.	43178.	16348.	35495.
4	32121.	54661.	91388.	79485.	13468.	24283.	13714.	27405.	30435.	18775.
5	11754.	11684.	14795.	14439.	28616.	11313.	9181.	6598.	11867.	11323.
6	12297.	4610.	4706.	2335.	2966.	9800.	3754.	3072.	2833.	2928.
7	1289.	2436.	1610.	1282.	902.	1146.	2113.	1345.	1401.	1482.
8	1057.	422.	958.	883.	340.	474.	492.	758.	626.	1459.
9	260.	226.	255.	754.	241.	271.	147.	295.	459.	777.
10	190.	82.	127.	218.	174.	119.	68.	88.	130.	586.
11	102.	76.	100.	132.	61.	71.	45.	52.	49.	154.
12	71.	66.	78.	48.	33.	52.	26.	43.	58.	138.
13	27.	23.	36.	32.	25.	14.	20.	11.	11.	23.
14	41.	22.	32.	37.	16.	26.	6.	9.	10.	13.
15	55.	35.	45.	59.	60.	20.	21.	13.	53.	35.
GRAND TOTAL NUMBER CAUGHT :	171562.	193856.	167823.	154260.	63371.	76180.	63738.	95945.	70051.	80357.
SOP	216102.	238496.	248245.	207757.	113025.	119148.	92964.	120713.	108175.	105698.

AGE	1994	1995
0	0.	1.
1	101.	61.
2	6403.	2924.
3	15361.	26212.
4	36940.	24806.
5	11869.	13484.
6	3773.	3177.
7	807.	3175.
8	275.	582.
9	401.	478.
10	129.	214.
11	320.	147.
12	205.	200.
13	19.	27.
14	8.	27.
15	12.	42.
GRAND TOTAL NUMBER CAUGHT :	76623.	75557.
SOP	97196.	113672.

Table 3.1.2.1 (continued)

Table Continued

NUMBER CAUGHT MACKEREL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
1	2901.	11900.	2725.	1150.	0.	2300.	2700.	3900.	3000.	175.
2	18690.	10100.	73600.	19300.	8200.	550.	5600.	6000.	14300.	16900.
3	23590.	16200.	69700.	58900.	34700.	11300.	2400.	11500.	15500.	28400.
4	39880.	42400.	13900.	54300.	40800.	21200.	14300.	1125.	9700.	16600.
5	240820.	27800.	33800.	9825.	27900.	33300.	23500.	12500.	2000.	6800.
6	45800.	193200.	19500.	26600.	6000.	14300.	25900.	17400.	7700.	1050.
7	7510.	25600.	118600.	31600.	2500.	4200.	15300.	17900.	7600.	5500.
8	16100.	20400.	31300.	125900.	16100.	9200.	8400.	10500.	8300.	6500.
9	3189.	15800.	8000.	31200.	45700.	2000.	14000.	5400.	5300.	4900.
10	498.	5025.	9000.	8325.	14600.	27000.	3500.	7500.	3000.	4300.
11	313.	525.	4000.	8825.	1000.	5200.	19300.	2200.	3600.	1800.
12	932.	400.	550.	4525.	1000.	2000.	3800.	20400.	2200.	3200.
13	932.	500.	175.	850.	2900.	2000.	1325.	1800.	8600.	1150.
14	932.	500.	350.	150.	650.	1225.	1600.	2400.	1725.	7900.
15	21693.	21200.	3125.	2525.	3200.	2300.	2200.	1500.	1325.	1800.
GRAND TOTAL NUMBER CAUGHT :	423780.	391550.	388325.	383975.	205250.	138075.	143825.	122025.	93850.	106976.
SOP	197821.	189289.	177178.	191235.	101108.	70246.	73141.	63766.	45095.	49662.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.
1	25.	6633.	3380.	510.	2906.	2080.	1302.	490.	3774.	1891.
2	3025.	853.	28495.	510.	3118.	8156.	4323.	11811.	16176.	7553.
3	61900.	7118.	2521.	510.	3368.	8095.	21180.	13081.	12343.	13219.
4	37000.	39057.	5311.	200.	1905.	2346.	5640.	6395.	2955.	9467.
5	19600.	21838.	8260.	400.	388.	1323.	1640.	1421.	1812.	3210.
6	9700.	13085.	4251.	540.	1623.	282.	917.	552.	566.	755.
7	2700.	5822.	2550.	400.	952.	1129.	194.	1263.	228.	227.
8	5500.	1869.	1475.	310.	1076.	673.	794.	0.	112.	151.
9	5100.	6244.	1401.	740.	35.	741.	458.	474.	0.	114.
10	5200.	4132.	2711.	100.	547.	35.	529.	552.	0.	0.
11	3100.	3766.	1908.	200.	122.	388.	18.	395.	75.	0.
12	1825.	3381.	2803.	100.	18.	89.	265.	158.	188.	38.
13	1900.	2295.	1966.	200.	142.	153.	53.	158.	75.	150.
14	825.	2036.	1518.	100.	85.	60.	1.	79.	1.	75.
15	4200.	5263.	4216.	800.	567.	488.	388.	335.	415.	718.
GRAND TOTAL NUMBER CAUGHT :	161600.	123393.	72766.	5620.	16852.	26038.	37702.	37164.	38720.	37568.
SOP	71700.	58237.	31443.	2863.	6687.	9863.	14137.	13132.	12773.	9958.

AGE	1994	1995
0	1.	1.
1	1024.	1147.
2	4095.	4587.
3	7166.	8028.
4	5139.	5733.
5	1741.	1950.
6	409.	460.
7	123.	137.
8	81.	92.
9	61.	69.
10	0.	1.
11	20.	23.
12	41.	46.
13	103.	115.
14	61.	69.
15	409.	460.
GRAND TOTAL NUMBER CAUGHT :	20474.	22918.
SOP	5457.	6110.

Table 3.1.2.1 (continued)

Table Continued

NUMBER CAUGHT HADDOCK

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	601454.	66815.	148333.	163747.	348573.	861397.	294293.	642404.	276772.	661120.
1	1213969.	1822979.	142656.	228665.	446442.	300327.	635314.	134582.	276090.	158564.
2	174438.	678225.	1017986.	105357.	143783.	232334.	374652.	417372.	83625.	238007.
3	326842.	59119.	211990.	376531.	29374.	61005.	70495.	136602.	287619.	72474.
4	53159.	109516.	9687.	37690.	107375.	7649.	10193.	14479.	40592.	119968.
5	1834.	16129.	31836.	4147.	7965.	26054.	1837.	1890.	3131.	16573.
6	1321.	702.	5110.	5685.	1158.	2023.	7973.	379.	682.	1684.
7	10583.	501.	181.	1133.	1710.	229.	574.	2390.	276.	270.
8	237.	2795.	70.	113.	309.	416.	113.	128.	830.	64.
9	21.	104.	745.	24.	95.	111.	151.	64.	25.	181.
10	33.	52.	57.	162.	7.	26.	70.	21.	15.	44.
11	8.	11.	3.	2.	70.	19.	40.	37.	10.	14.
GRAND TOTAL NUMBER CAUGHT :	2383899.	2756948.	1568654.	923256.	1086861.	1491590.	1395705.	1350348.	969667.	1268963.
SOP	371972.	504337.	424403.	249533.	202970.	184880.	236571.	221724.	215955.	228053.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	76883.	198021.	34630.	10403.	10943.	12505.	55915.	125800.	282859.	141963.
1	452648.	208931.	166218.	288120.	30276.	56257.	79350.	221498.	195011.	344635.
2	161264.	575923.	207384.	238894.	553843.	39929.	99184.	76517.	243443.	255870.
3	114299.	78052.	356436.	46909.	93740.	215104.	16980.	22507.	31277.	108[illegible].
4	20551.	38490.	28802.	65905.	14177.	20724.	55469.	3493.	6443.	[illegible].
5	31393.	5326.	10108.	4884.	20372.	2949.	3571.	12295.	1156.	[illegible]6.
6	3577.	7302.	1329.	3042.	1668.	4435.	828.	919.	4739.	440.
7	574.	920.	2244.	576.	680.	590.	1278.	393.	440.	1140.
8	75.	193.	311.	779.	169.	198.	190.	609.	300.	145.
9	31.	53.	102.	116.	156.	92.	73.	139.	287.	103.
10	92.	21.	81.	42.	55.	32.	38.	48.	137.	144.
11	19.	83.	172.	114.	46.	25.	23.	11.	32.	65.
GRAND TOTAL NUMBER CAUGHT :	861406.	1113315.	807817.	659784.	726125.	352840.	312899.	464229.	766124.	862140.
SOP	192872.	268761.	257298.	169910.	217446.	126844.	84395.	79514.	122522.	169858.

AGE	1994	1995
0	93205.	203754.
1	95517.	295675.
2	294303.	83957.
3	100783.	165135.
4	29771.	25791.
5	1921.	7644.
6	568.	504.
7	191.	124.
8	518.	43.
9	116.	62.
10	31.	20.
11	59.	17.
GRAND TOTAL NUMBER CAUGHT :	616983.	782726.
SOP	150149.	140373.

Table 3.1.2.1 (continued)

Table Continued

NUMBER CAUGHT HERRING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	996100.	263800.	238200.	256800.	130100.	542000.	791700.	7888700.	9556700.	10029900.
1	846200.	2460500.	126600.	144400.	168700.	159300.	161200.	446900.	840400.	1146700.
2	772500.	541700.	901500.	44600.	4900.	34100.	108000.	264100.	268400.	544800.
3	362000.	259700.	117400.	186400.	5600.	10000.	91800.	56800.	230100.	216400.
4	126100.	140500.	52100.	10800.	5000.	10100.	32100.	39400.	33700.	105200.
5	56200.	57200.	34500.	7100.	300.	2100.	21700.	28600.	14400.	26200.
6	22300.	16200.	6100.	4000.	200.	200.	2200.	22600.	6800.	22800.
7	5100.	9100.	4400.	1500.	200.	800.	1400.	18700.	7800.	12800.
8	1900.	3500.	1100.	700.	200.	600.	400.	5400.	3600.	11400.
9	1000.	1401.	401.	1.	1.	100.	100.	1100.	1100.	12100.
GRAND TOTAL NUMBER CAUGHT :	3189400.	3753601.	1482301.	656301.	315201.	759300.	1210600.	8772300.	10963000.	12128300.
SOP	266032.	254005.	159323.	39260.	11177.	24542.	59654.	167251.	231049.	313688.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	2189400.	1292900.	703800.	1797500.	1293000.	1955800.	853900.	1594300.	7598200.	6981800.
1	561100.	1620100.	1763300.	3522400.	1970000.	1899500.	1477400.	1244400.	643400.	1284000.
2	976000.	1223100.	1155300.	2006500.	1955000.	927700.	593000.	771300.	960800.	760400.
3	421600.	1173400.	827100.	687200.	1185000.	1383600.	763300.	553500.	411700.	597800.
4	192600.	365700.	458300.	481600.	399000.	828100.	849200.	548900.	334500.	306100.
5	77700.	124000.	127900.	248900.	261000.	218400.	375900.	493900.	341500.	216200.
6	21700.	43500.	61000.	75600.	129000.	129500.	80100.	201500.	360100.	223800.
7	24200.	20000.	20300.	23900.	38000.	63400.	54400.	38800.	144700.	185900.
8	10600.	13200.	13500.	8000.	15000.	20800.	28500.	25000.	37700.	85800.
9	17800.	15900.	14600.	8100.	8000.	8600.	11700.	12600.	23300.	41200.
GRAND TOTAL NUMBER CAUGHT :	4492700.	5891800.	5145100.	8859700.	7253000.	7435400.	5087400.	5484200.	10855900.	10683000.
SOP	314023.	548537.	519746.	729051.	750630.	752559.	600368.	573165.	578204.	521990.

AGE	1994	1995
0	3717300.	6279700.
1	450500.	483100.
2	1391900.	1389500.
3	491300.	863600.
4	345400.	244700.
5	114200.	118900.
6	95500.	55500.
7	75600.	40800.
8	69500.	51300.
9	44800.	48000.
GRAND TOTAL NUMBER CAUGHT :	6796000.	9575100.
SOP	467813.	532572.

Table 3.1.2.1 (continued)

Table Continued

NUMBER CAUGHT N. POUT

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	6566000.	10857000.	6183000.	1716000.	1529000.	1832000.	665000.	36637000.	1209000.	2941000.
1	39098000.	20092000.	21036000.	19868000.	7897000.	14747000.	19261000.	5649000.	18111000.	15240000.
2	1236000.	2919000.	2144000.	2414000.	3123000.	2119000.	4236000.	3554000.	1167000.	4232000.
3	203000.	16000.	166000.	94000.	327000.	261000.	119000.	181000.	301001.	48000.
GRAND TOTAL NUMBER CAUGHT :	47103000.	33884000.	29529000.	24092000.	12876000.	18959000.	24281000.	46021000.	20788001.	22461000.
SOP	731148.	494281.	452929.	383034.	249229.	324564.	512408.	457527.	372716.	446256.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	2210000.	671000.	5436000.	229000.	2971000.	4732000.	1613000.	2683000.	490000.	938000.
1	13657000.	7365000.	3448000.	7461000.	1143000.	5730000.	5218000.	3944000.	9588000.	4752000.
2	4907000.	2427000.	1407000.	853000.	1425000.	478000.	1600000.	1984000.	1923000.	2495000.
3	416001.	221001.	83001.	18000.	20001.	25000.	65000.	136000.	143000.	94000.
GRAND TOTAL NUMBER CAUGHT :	21190001.	10684001.	10374001.	8561000.	5559001.	10965000.	8496000.	8747000.	12144000.	8279000.
SOP	457486.	225166.	157583.	156689.	91559.	155909.	139819.	144603.	235770.	173725.

AGE	1994	1995
0	3980000.	572000.
1	4451000.	10489000.
2	1411000.	615000.
3	157000.	45000.
GRAND TOTAL NUMBER CAUGHT :	9999000.	11721000.
SOP	171847.	169628.

Table 3.1.2.1 (continued)

Table Continued

NUMBER CAUGHT SANDEEL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	12120000.	9417000.	10939000.	26124000.	55420000.	47640700.	15710600.	66277000.	28751000.	22829000.
1	27289000.	23571000.	25120000.	50286000.	73565000.	26841100.	56385100.	22007000.	70443200.	12407900.
2	5425000.	8155000.	18523000.	9703000.	21167000.	27107500.	22866200.	19201000.	10087000.	40148500.
3	957000.	4555000.	2882000.	7020000.	2647000.	5023000.	5739700.	3896000.	4700300.	1782530.
4	2282000.	1044000.	1484000.	1267000.	1210000.	1415500.	1142000.	1053500.	2123000.	346110.
5	288000.	673000.	254000.	501000.	209000.	488000.	296000.	428000.	190000.	151004.
6	115001.	103001.	178001.	435001.	119001.	287001.	141101.	162801.	80001.	53001.
GRAND TOTAL NUMBER CAUGHT :	48476001.	47518001.	59380001.	95336001.	154337001.	108802801.	102280701.	113025301.	116374501.	77718045.
SOP	332568.	392601.	500327.	645834.	937507.	783928.	791922.	659963.	771605.	643415.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	6793000.	21009200.	9336000.	1272000.	17600000.	9045560.	12366000.	25731000.	7068000.	27798000.
1	87160000.	13747800.	31628000.	40434000.	13520000.	107110000.	24275000.	74190000.	74158000.	21390000.
2	5334100.	46201200.	7796000.	40648000.	36723000.	3083001.	22488000.	11938000.	14462000.	18359000.
3	14482030.	6043300.	2757000.	1750000.	21544000.	4597000.	3736000.	2347000.	1645000.	5030000.
4	460010.	854400.	353000.	339000.	2075000.	3258310.	491000.	682000.	647000.	816000.
5	156004.	236500.	60000.	86000.	647000.	48005.	2382000.	93000.	181000.	845000.
6	91001.	88901.	15001.	21001.	251001.	18001.	11001.	1.	132001.	196001.
GRAND TOTAL NUMBER CAUGHT :	114476145.	88181301.	51945001.	84550001.	92360001.	127159877.	65749001.	114981001.	98293001.	74434001.
SOP	899008.	803145.	388222.	809760.	933079.	845903.	555861.	763331.	687715.	578412.

AGE	1994	1995
0	854000.	4089001.
1	58109000.	82548001.
2	11352000.	13117001.
3	9202000.	2990001.
4	2154000.	1205001.
5	878000.	289001.
6	92001.	44001.
GRAND TOTAL NUMBER CAUGHT :	82641001.	104282007.
SOP	772128.	915716.

Table 3.1.2.1 (continued)

Table Continued

NUMBER CAUGHT PLAICE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	1618.	981.	2820.	3220.	1144.	1318.	979.	254.	3334.	1214.
2	20287.	28124.	33644.	56969.	60578.	58031.	64903.	100926.	47776.	119695.
3	60018.	61623.	77649.	43289.	62343.	118863.	133741.	122296.	209007.	115034.
4	60547.	31263.	96399.	66012.	54342.	48962.	77524.	57603.	69545.	99076.
5	40234.	25418.	13779.	83705.	50102.	47886.	24973.	35744.	28655.	29360.
6	18737.	21188.	9903.	9141.	35509.	39932.	17982.	12414.	16726.	12906.
7	7944.	11873.	9121.	5912.	5940.	24229.	13761.	9563.	7589.	8216.
8	6354.	5923.	6391.	5022.	3351.	4161.	8458.	8093.	5469.	4193.
9	5748.	4106.	2947.	4061.	2419.	2807.	1864.	4873.	4482.	3013.
10	4161.	3337.	2020.	1928.	2177.	2333.	1326.	1405.	3706.	2947.
11	12017.	1740.	2110.	1300.	1145.	1850.	953.	1098.	1135.	2144.
12	1901.	7935.	912.	1357.	603.	1113.	1173.	831.	712.	1219.
13	2051.	1080.	4478.	489.	689.	706.	433.	796.	574.	582.
14	1483.	1424.	388.	2290.	329.	706.	285.	467.	520.	344.
15	3747.	4177.	2644.	1828.	2524.	2579.	1210.	1305.	2007.	1051.
GRAND TOTAL NUMBER CAUGHT :	246847.	210192.	265205.	286523.	283195.	355476.	349565.	357668.	401237.	400994.
SOP	111246.	93779.	103013.	112203.	108561.	138293.	125432.	126138.	141330.	138035.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	
1	107.	121.	1674.	0.	4.	1260.	1549.	1460.	3097.	3 .
2	63253.	73552.	67125.	104586.	17446.	46168.	35459.	46134.	40793.	49490.
3	274208.	144316.	163717.	119980.	283622.	101733.	105320.	87563.	79760.	93464.
4	53549.	185204.	93801.	104128.	82089.	228268.	117052.	121415.	68464.	71097.
5	37468.	32520.	84479.	58551.	52985.	51556.	170573.	76487.	69406.	51113.
6	13661.	15543.	24049.	31687.	28065.	19013.	28513.	82686.	32396.	29708.
7	6466.	6870.	9299.	9971.	18589.	10407.	8904.	15965.	29403.	13717.
8	5544.	3650.	4490.	3832.	6064.	7479.	4635.	5724.	6978.	12648.
9	2719.	2697.	2734.	1947.	3560.	2082.	3851.	3390.	3354.	4108.
10	2088.	1543.	2025.	1468.	1882.	1672.	1239.	2631.	2394.	2227.
11	1308.	1029.	1178.	907.	1024.	916.	798.	1072.	1721.	1582.
12	1144.	1069.	1084.	588.	1010.	624.	511.	679.	972.	1171.
13	455.	727.	806.	483.	555.	433.	338.	401.	606.	864.
14	310.	370.	627.	268.	559.	326.	244.	339.	605.	308.
15	1262.	1057.	1229.	1157.	1744.	1552.	1231.	1297.	1604.	1321.
GRAND TOTAL NUMBER CAUGHT :	463542.	470268.	458317.	439553.	499198.	473489.	480217.	447243.	341553.	335960.
SOP	156432.	163817.	165971.	155755.	180330.	173657.	186012.	178581.	139185.	119730.

AGE	1994	1995
0	0.	1.
1	1289.	7004.
2	42074.	33584.
3	96504.	76525.
4	77713.	75987.
5	39430.	35892.
6	21216.	19020.
7	15714.	10655.
8	6625.	5029.
9	6121.	2676.
10	2722.	2164.
11	1129.	1317.
12	816.	633.
13	766.	373.
14	457.	405.
15	1019.	947.
GRAND TOTAL NUMBER CAUGHT :	313595.	272212.
SOP	112076.	98624.

Table 3.1.2.1 (continued)

Table Continued

NUMBER CAUGHT SOLE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	101.	264.	1041.	1748.	27.	9.	637.	423.	2660.	388.
2	15379.	22953.	3542.	22328.	25031.	8180.	1210.	29218.	26435.	34408.
3	21540.	28535.	27967.	12073.	29292.	41170.	12512.	3258.	45747.	41386.
4	5487.	11717.	14013.	15308.	6129.	16061.	17781.	6866.	1843.	21188.
5	7061.	2088.	4819.	7441.	6638.	2995.	7297.	8222.	3537.	624.
6	1923.	3830.	966.	1779.	4250.	3223.	1450.	3662.	4790.	1378.
7	1584.	791.	1909.	319.	1738.	1748.	2197.	948.	1678.	1950.
8	658.	908.	552.	1113.	611.	818.	1409.	886.	615.	979.
9	401.	508.	426.	257.	646.	242.	366.	766.	605.	386.
10	609.	235.	204.	210.	191.	392.	53.	197.	526.	302.
11	2364.	252.	195.	94.	235.	154.	414.	107.	149.	423.
12	104.	1905.	132.	122.	123.	116.	53.	160.	75.	31.
13	32.	26.	1320.	107.	106.	103.	53.	92.	201.	14.
14	306.	84.	38.	852.	68.	73.	32.	22.	12.	176.
15	1401.	944.	774.	729.	879.	687.	589.	331.	314.	230.
GRAND TOTAL NUMBER CAUGHT :	58950.	75040.	57898.	64480.	75964.	75971.	46053.	55158.	89187.	103863.
SOP	16663.	19141.	15905.	16786.	19022.	19414.	13841.	14188.	20718.	24107.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	191.	165.	373.	92.	10.	116.	824.	121.	906.	53.
2	30734.	16118.	9350.	29208.	13187.	46028.	11913.	14383.	6634.	49487.
3	43932.	43213.	18494.	21702.	47140.	18161.	103899.	28795.	43944.	16875.
4	22555.	20286.	17703.	9210.	15249.	22524.	9768.	89894.	16054.	31420.
5	8791.	9403.	7745.	6622.	4400.	4681.	9454.	7624.	37693.	13877.
6	741.	3556.	5522.	3133.	3890.	1687.	3885.	4320.	2494.	24038.
7	854.	209.	2273.	1527.	1554.	1449.	1188.	1979.	3081.	1496.
8	1043.	378.	110.	891.	897.	653.	1295.	824.	774.	1218.
9	524.	637.	281.	94.	526.	464.	613.	825.	435.	489.
10	243.	201.	620.	115.	38.	238.	270.	365.	482.	194.
11	209.	191.	355.	176.	34.	44.	329.	347.	182.	308.
12	147.	189.	173.	142.	85.	36.	60.	426.	242.	110.
13	31.	94.	126.	69.	41.	48.	29.	18.	146.	85.
14	24.	33.	105.	57.	9.	27.	63.	17.	7.	117.
15	243.	266.	306.	168.	111.	94.	218.	178.	249.	109.
GRAND TOTAL NUMBER CAUGHT :	110262.	94939.	63536.	73206.	87171.	96250.	143808.	150116.	113323.	139876.
SOP	26373.	23772.	17908.	17749.	21417.	22340.	34080.	40937.	32351.	31751.

AGE	1994	1995
0	0.	1.
1	698.	4638.
2	7453.	12471.
3	86319.	16684.
4	13696.	68245.
5	18552.	6297.
6	5664.	7883.
7	11047.	2023.
8	461.	6067.
9	906.	282.
10	274.	353.
11	86.	65.
12	214.	101.
13	82.	51.
14	44.	18.
15	247.	149.
GRAND TOTAL NUMBER CAUGHT :	145743.	125328.
SOP	33022.	30702.

Table 3.1.2.1 (continued)

Table Output from MSVPA KEYRUN for COD. Stock in numbers at age ('000). Biomass in tonnes.

FISHING MORTALITY COD

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0854	.1479	.0586	.2313	.1179	.1900	.1492	.1635	.2489	.1674
2	.8155	.7618	.9759	.8618	1.0489	.8304	.8921	.9807	.9336	1.0546
3	.7574	.8252	.8824	.7435	.9791	.9431	.9526	.9853	1.2433	1.1649
4	.7292	.6905	.8265	.6000	.8342	.5553	.7494	.7353	.7991	.8750
5	.7353	.8166	.6403	.5917	.9935	.7572	.5910	.6965	.7944	.7935
6	.7355	.7060	.9514	.4777	.7818	.5680	.6253	.6699	.8727	.8004
7	.7005	.7950	.9068	.5875	.7819	.6968	.7612	.7693	.7320	.7500
8	.7533	.5796	.5310	.6336	.9234	.5385	.7504	.6704	.7617	.7698
9	1.1684	.9906	.4930	.5645	1.0301	.8287	.6619	.7313	.7284	.6210
10	.7311	.9697	.9994	.4143	.8442	.7291	.7677	.7326	.6177	.5441
11	.5857	.6113	.6128	.6084	.8140	.6417	.7200	.2201	.9620	.5685
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8										
	.7467	.7392	.8163	.6423	.9061	.6985	.7603	.7868	.8767	.8869

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.2327	.1468	.2262	.1691	.2245	.1672	.1999	.1962	.2074	.0643
2	.9667	.9586	.8105	.8877	.9055	.9720	.8951	.8279	.8695	.7654
3	.9872	.9208	1.1364	.7359	1.1928	1.0493	.9271	.9157	.8324	.9312
4	.7439	.8496	.9258	.9254	.9559	1.0244	.8952	.7786	.9180	.8735
5	.7348	.7180	.8596	.7317	.8572	.8064	.7262	.7898	.7451	.
6	.7754	.7302	.9291	.9224	.9154	.9336	.5469	.9397	.8414	..
7	.7789	.7650	.9883	.9137	.8372	.9797	.7097	1.0317	.9697	1.0018
8	.8519	.8465	1.0036	1.1344	.7955	1.0036	.4095	.8973	.8707	.9881
9	.9009	.6879	.6793	1.1480	.9362	.6958	1.2515	.4432	.7612	.6463
10	.9665	.4732	1.2270	1.0809	.7483	1.9575	.4510	.2130	.6580	.3304
11	.9706	.9674	.2535	.7605	.5823	.8075	.8219	.7201	.6577	.7942
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8										
	.8341	.8270	.9505	.8930	.9228	.9670	.7300	.8830	.8638	.8904

AGE	1994	1995
0	.0000	.0000
1	.0780	.1083
2	.5898	.6001
3	.9287	.7617
4	.9514	.7016
5	.8825	.7518
6	.9234	.8490
7	1.0332	.8009
8	1.1076	1.1901
9	1.0263	.9786
10	.7238	.9693
11	.9999	.9676
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8		
	.9167	.8079

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table Continued

STOCK NUMBERS COD

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	320090.	475145.	230037.	932839.	570410.	561770.	1163349.	485361.	783720.	352078.
2	128119.	114223.	182457.	94560.	299136.	185353.	180175.	377738.	122592.	223918.
3	23318.	34457.	35189.	46486.	26339.	68560.	53268.	49043.	87358.	30530.
4	31264.	8130.	11575.	11232.	16941.	7544.	20353.	15603.	13580.	18816.
5	9132.	12534.	3402.	4224.	5140.	6124.	3606.	7999.	6195.	5065.
6	1925.	3682.	4663.	1508.	1965.	1598.	2409.	1673.	3333.	2341.
7	892.	765.	1510.	1491.	774.	742.	746.	1059.	700.	1140.
8	757.	377.	294.	519.	706.	302.	315.	297.	418.	287.
9	494.	304.	180.	148.	235.	239.	150.	127.	129.	166.
10	155.	131.	96.	94.	71.	71.	89.	66.	52.	53.
11	434.	119.	79.	56.	85.	47.	50.	111.	40.	46.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	324031.	284326.	284480.	267781.	360527.	324619.	363981.	441661.	361339.	317993.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	164193.	137588.	114796.	96751.	111741.	100482.	115407.	127333.	130661.	114418.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	677641.	151312.	631386.	256043.	191720.	278735.	140280.	162976.	300196.	142843.
2	114209.	228640.	50742.	208957.	96590.	61449.	100752.	47127.	58583.	108474.
3	50289.	29475.	58457.	15259.	60213.	26589.	16109.	28373.	14340.	17406.
4	7105.	14295.	8809.	14102.	5505.	13826.	6943.	4709.	8300.	4503.
5	6492.	2806.	5047.	2885.	4605.	1750.	4079.	2323.	1761.	2686.
6	1914.	2604.	1139.	1777.	1150.	1626.	646.	1626.	864.	681.
7	859.	722.	1017.	364.	567.	373.	511.	297.	498.	289.
8	459.	336.	286.	323.	124.	209.	119.	214.	90.	161.
9	113.	167.	123.	89.	88.	48.	65.	67.	74.	32.
10	76.	39.	71.	53.	24.	30.	20.	16.	37.	30.
11	39.	37.	61.	30.	29.	16.	6.	19.	20.	26.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	266251.	279966.	231273.	241748.	216979.	164627.	146840.	125567.	121814.	136478.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	96603.	92742.	88201.	76624.	73847.	67092.	53951.	50740.	45909.	41849.

AGE	1994	1995
0	0.	0.
1	382599.	299985.
2	57320.	144966.
3	35639.	22232.
4	4906.	10000.
5	1518.	1527.
6	951.	509.
7	225.	289.
8	90.	68.
9	51.	25.
10	14.	16.
11	26.	9.
TOTAL STOCK BIOMASS ON 1. JANUARY		
	142728.	181899.
SPAWNING STOCK BIOMASS ON 1. JANUARY		
	42956.	47606.

Table 3.1.2.1 (continued)

Table Continued

PREDATION MORTALITY COD

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	1.7807	2.5620	2.2299	1.0376	2.9033	.9761	1.4540	1.8984	3.4677	1.5039
1	.7852	.6493	.6704	.7461	.8464	.7873	.8158	1.0525	.8439	.7984
2	.3378	.2557	.2315	.2564	.2643	.2566	.2491	.3235	.2965	.2789
3	.1362	.1057	.0996	.1060	.1112	.1114	.1153	.1388	.1320	.1329
4	.0248	.0206	.0216	.0216	.0233	.0228	.0245	.0284	.0271	.0291
5	.0128	.0122	.0137	.0137	.0151	.0156	.0171	.0190	.0187	.0197
6	.0273	.0257	.0290	.0289	.0323	.0334	.0365	.0408	.0402	.0425
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	2.9811	1.8677	1.9450	1.7736	1.4500	2.0381	1.8505	1.9670	3.1297	2.5548
1	.6937	.7858	.7196	.6457	.7533	.6904	.7308	.6670	.6505	.6888
2	.2278	.2453	.2310	.1965	.2245	.2068	.2121	.2019	.1841	.1876
3	.1107	.1270	.1256	.1235	.1185	.1334	.1428	.1535	.1660	.1752
4	.0253	.0316	.0306	.0337	.0300	.0363	.0399	.0450	.0501	.0539
5	.0186	.0237	.0242	.0278	.0242	.0302	.0333	.0388	.0443	.0485
6	.0396	.0500	.0512	.0591	.0516	.0646	.0717	.0829	.0953	.1040
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1994	1995
0	1.8925	2.5030
1	.7324	.6874
2	.1973	.1810
3	.1821	.1883
4	.0559	.0581
5	.0503	.0527
6	.1068	.1117
7	.0000	.0000
8	.0000	.0000
9	.0000	.0000
10	.0000	.0000
11	.0000	.0000

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table Whiting

FISHING MORTALITY WHITING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0134	.0260	.0362	.0497	.0221	.0253	.0268	.0559	.0147	.1082
1	.4180	.2358	.2023	.4344	.1580	.2692	.1046	.1666	.2087	.2748
2	.8863	.7719	.9637	.5205	.4021	.4943	.4065	.2908	.3119	.4460
3	1.0185	1.0160	1.1851	.8567	.6576	.7559	.7469	.6779	.4659	.6789
4	.8802	.9673	1.0165	.9135	.7880	.6601	.9007	.8705	.6325	.6788
5	.9616	.9656	.7357	.7790	.6731	.8559	1.0635	.9274	.8333	.8456
6	1.9296	.9256	1.2101	.9862	1.1179	.9547	1.3685	1.3181	1.1434	.9574
7	1.1648	1.0853	.7455	.8360	1.6045	.9029	1.1571	1.3727	.9564	1.2792
8	.8874	1.2307	.6574	2.2173	1.7511	1.0046	1.9675	1.0598	1.3312	1.3788
9	2.3603	1.4816	.7125	.3927	.7077	.5364	.7599	.7375	.7571	1.2543
10	.9284	1.2013	1.2000	1.2000	1.3731	1.0093	1.3711	1.1593	.9852	1.0352
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6										
	1.1352	.9293	1.0222	.8112	.7277	.7442	.8972	.8169	.6774	.7213

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0247	.0201	.0309	.0153	.0433	.0156	.0593	.1150	.0261	.0628
1	.2933	.2470	.3417	.1468	.3911	.1476	.2755	.1507	.2477	.1770
2	.4846	.3106	.4033	.4154	.4559	.4666	.5378	.4618	.3664	.4286
3	.7831	.5861	.6180	.7754	.6520	.7047	.8790	.4322	.4814	.6258
4	.9650	.8084	1.1498	1.2093	.9611	.8114	.9110	.7271	.5081	.6648
5	.9625	.9108	.9652	1.2379	.9941	1.5141	1.1249	.9566	.7764	.7217
6	1.2792	1.1042	1.4273	1.5285	1.3188	1.4933	1.1020	.6829	1.0740	1.1424
7	1.2323	1.3219	1.6293	1.9008	.6176	1.5846	1.0459	1.1673	1.1543	1.1772
8	1.4108	2.4062	1.5693	2.2163	.8998	2.7695	2.1835	1.9597	.8175	1.6290
9	2.2000	2.9464	1.8968	1.0138	2.2352	3.3657	1.9391	1.5836	.3205	3.7944
10	1.1693	1.4022	1.1711	1.2521	2.7003	1.2402	1.6900	1.5202	.3870	1.2479
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6										
	.8949	.7440	.9127	1.0333	.8764	.9980	.9109	.6521	.6413	.7166

AGE	1994	1995
0	.0216	.1070
1	.1455	.0912
2	.2779	.2319
3	.5035	.4052
4	.6197	.4696
5	.7258	.5847
6	.9853	.7822
7	1.0775	.9785
8	1.0349	1.7252
9	.6606	.8991
10	1.0085	.8991
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6		
	.6224	.4947

Mortality of 0-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table Continued

STOCK NUMBERS WHITING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	4168007.	8679804.	6389777.	5557637.	7308329.	7056934.	7186487.	4095095.	2751914.	2267613.
2	2127530.	938704.	2307687.	1493150.	1171240.	1579308.	1533164.	1864560.	600657.	616807.
3	432916.	538373.	281116.	559043.	552969.	480055.	584250.	631466.	771245.	259352.
4	66982.	107117.	139011.	61187.	167360.	202686.	158319.	195475.	218454.	330336.
5	9415.	18619.	28609.	34987.	16832.	52177.	71654.	43586.	53832.	77097.
6	1681.	2462.	5003.	9538.	11143.	5929.	15262.	16859.	11392.	15623.
7	9253.	170.	688.	1043.	2455.	2532.	1570.	2643.	3001.	2439.
8	653.	2364.	47.	267.	370.	404.	840.	404.	548.	944.
9	64.	220.	565.	20.	24.	53.	121.	96.	115.	119.
10	34.	7.	54.	301.	14.	14.	32.	62.	54.	62.
TOTAL STOCK BIOMASS ON 1. JANUARY	549233.	611233.	652877.	557895.	611283.	659137.	678207.	610600.	438307.	358647.
SPAWNING STOCK BIOMASS ON 1. JANUARY	383286.	300570.	408011.	350058.	345898.	398398.	413433.	449814.	336782.	273770.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	3066847.	2889450.	4371783.	3825494.	3248270.	5456537.	2806499.	2254571.	2258573.	2934143.
2	529862.	775190.	623912.	1089485.	1130638.	601670.	1477882.	595146.	625964.	575680.
3	241158.	208420.	347270.	263409.	473325.	452034.	249384.	571994.	250063.	294083.
4	91900.	79023.	82192.	132561.	88372.	176805.	161679.	75154.	267514.	111[illegible].
5	113318.	24386.	23918.	17710.	27439.	23253.	53873.	44684.	24617.	10[illegible]
6	22247.	29803.	6521.	6072.	3422.	6815.	3376.	11363.	10839.	7[illegible].
7	4131.	4310.	6771.	1069.	912.	633.	1061.	772.	3881.	2483.
8	556.	986.	941.	1087.	131.	403.	106.	305.	197.	1002.
9	195.	111.	73.	160.	97.	44.	21.	10.	35.	71.
10	37.	22.	6.	12.	50.	11.	1.	3.	4.	27.
TOTAL STOCK BIOMASS ON 1. JANUARY	320061.	302764.	362433.	391715.	406893.	449167.	418350.	327941.	316475.	328621.
SPAWNING STOCK BIOMASS ON 1. JANUARY	208312.	194720.	204450.	248038.	282839.	253754.	306158.	243733.	231820.	221020.

AGE	1994	1995
0	0.	0.
1	2906926.	3432083.
2	737583.	817114.
3	249308.	366447.
4	113784.	107310.
5	38673.	40226.
6	32175.	11173.
7	1483.	7818.
8	626.	413.
9	161.	182.
10	2.	102.
TOTAL STOCK BIOMASS ON 1. JANUARY	322779.	370263.
SPAWNING STOCK BIOMASS ON 1. JANUARY	214504.	242964.

Table 3.1.2.1 (continued)

Table Continued

PREDATION MORTALITY WHITING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	1.4897	2.3610	2.3253	1.5801	2.2967	1.5563	2.2210	1.8569	2.3629	1.2356
1	.8728	.8891	1.0516	.9229	1.1743	1.0577	1.0448	1.5528	1.0867	.9790
2	.2879	.2339	.2541	.2729	.2899	.3002	.2806	.3920	.3279	.2931
3	.1781	.1381	.1398	.1494	.1461	.1534	.1480	.1836	.1819	.1586
4	.2000	.1529	.1631	.1772	.1775	.1797	.1893	.2191	.2090	.1911
5	.1799	.1486	.1627	.1652	.1704	.1735	.1835	.2144	.2039	.1972
6	.1630	.1492	.1573	.1709	.1638	.1741	.1850	.2078	.1980	.1729
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	2.1937	1.7430	1.7763	1.9063	1.5227	2.1532	1.7544	1.6801	2.0145	1.9104
1	.8819	1.0857	.8477	.8720	1.0950	.9585	1.0753	.9307	.9191	1.0037
2	.2484	.2924	.2590	.2182	.2608	.2142	.2114	.2053	.1891	.2083
3	.1327	.1444	.1450	.1168	.1327	.1235	.1204	.1278	.1224	.1238
4	.1617	.1867	.1851	.1658	.1740	.1770	.1750	.1890	.1920	.1981
5	.1731	.2082	.2058	.2061	.1987	.2155	.2314	.2599	.2810	.2961
6	.1620	.1777	.1808	.1670	.1693	.1667	.1736	.1914	.1997	.2094
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1994	1995
0	1.5112	2.2097
1	.9235	.9014
2	.2216	.2087
3	.1395	.1339
4	.2201	.2162
5	.3159	.3197
6	.2294	.2292
7	.0000	.0000
8	.0000	.0000
9	.0000	.0000
10	.0000	.0000

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table SAITHE

FISHING MORTALITY SAITHE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0084	.0004	.0025	.0854	.0039	.0046	.0104	.0297	.0051	.0004
2	.0624	.1560	.1832	.1545	.1460	.2443	.1351	.1648	.1908	.1410
3	.4463	.3791	.7308	.1800	.2620	.2050	.2719	.1516	.3666	.2977
4	.5026	.7652	.7948	.5460	.5356	.3996	.2926	.3009	.4638	.5123
5	.3596	.6878	.9025	.9403	.5585	.4725	.5641	.3258	.6937	.7443
6	.5892	.5252	.6833	.6816	.4200	.3693	.5786	.5597	.5711	.7367
7	.6644	.5244	.5654	.3583	.2777	.4355	.5189	.5667	.5110	1.0269
8	.4961	.5204	.5870	.4539	.2697	.3816	.3624	.8000	.5295	.8060
9	.4198	.2863	.3952	.3474	.2632	.2236	.4465	.4439	.6581	.8301
10	.3670	.2679	.4258	.2796	.2582	.1808	.3467	.4449	.3792	.4230
11	.3469	.2054	.4350	.2193	.2693	.2438	.3525	.5492	.3173	.4409
12	.3618	.3720	.5041	.4843	.2676	.2673	.2451	.7133	.3771	.3427
13	.6821	.4149	.4618	.3713	.5597	.1554	.2913	.5458	.4700	.4688
14	.3095	.4015	.6969	.6188	.3972	.2768	.2316	.6813	.6040	.3429
15	.2653	.3001	.3000	.3001	.3572	.2401	.3432	.6202	.4982	.5233
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6										
	.4744	.5893	.7779	.5870	.4440	.3616	.4268	.3345	.5238	.5728

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0002	.0027	.0006	.0273	.0001	.0275	.0022	.0019	.0023	.0
2	.1018	.0160	.0607	.2449	.0508	.0828	.0225	.1312	.0342	.
3	.5912	.5753	.2493	.4276	.1999	.2984	.3998	.4423	.2482	.3216
4	.7958	1.1130	1.4304	.8147	.3965	.6846	.5510	.7460	.6200	.4974
5	.7169	.7586	1.1416	.9473	.8119	.7027	.6036	.5610	.8916	.4980
6	1.0183	.6958	.8297	.5325	.4978	.7542	.5245	.4115	.5083	.5656
7	.4816	.5529	.5489	.5720	.3980	.3667	.3554	.3612	.3611	.5433
8	.7570	.2855	.4391	.7395	.2867	.3863	.2793	.2068	.3127	.7401
9	.3938	.3591	.2807	.8810	.4564	.4271	.2131	.2808	.2168	.7738
10	.4164	.2004	.3515	.4635	.4853	.4603	.1783	.1899	.1993	.4592
11	.2438	.2840	.3934	.8159	.2100	.3936	.3148	.2002	.1565	.3758
12	.2797	.2410	.5160	.3479	.4649	.2884	.2393	.5455	.3865	.8149
13	.2107	.1328	.1964	.4378	.2911	.3844	.1816	.1455	.2571	.2361
14	.4298	.2649	.2712	.3231	.3874	.5738	.2666	.1081	.1939	.5715
15	.3352	.1951	.3772	.3652	.4002	.4372	.5914	.6220	.7382	.9061
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6										
	.7805	.7857	.9127	.6805	.4765	.6100	.5197	.5402	.5670	.4707

AGE	1994	1995
0	.0000	.0000
1	.0009	.0003
2	.0387	.0360
3	.1963	.2186
4	.6214	.5556
5	.6843	.5144
6	.3173	.4056
7	.3164	.4940
8	.1996	.4066
9	.5482	.6502
10	.3112	.6797
11	.5114	.6797
12	1.4123	.6797
13	.2542	.6797
14	.1259	.6797
15	.6873	.6797
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6		
	.4548	.4235

Mortality of 0-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table Continued

STOCK NUMBERS SAITHE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	482815.	191784.	122122.	129669.	119240.	260174.	161591.	200026.	341888.	481597.
2	267796.	391996.	156954.	99734.	97478.	97245.	212028.	130924.	158975.	278488.
3	185071.	205993.	274573.	106994.	69968.	68966.	62358.	151659.	90903.	107554.
4	88474.	96936.	115399.	108201.	73136.	44062.	45974.	38880.	106643.	51555.
5	45265.	43586.	36743.	42425.	51040.	34842.	24042.	27912.	23376.	54491.
6	50923.	25729.	17848.	12130.	13491.	23765.	17673.	11124.	16371.	9491.
7	32858.	22964.	12374.	7321.	4986.	7199.	13335.	8040.	5150.	7494.
8	14214.	13805.	11098.	5739.	4176.	3082.	3800.	6473.	3720.	2519.
9	4660.	7017.	6653.	4999.	2952.	2580.	1702.	2136.	2347.	1768.
10	2891.	2441.	4203.	3565.	2808.	1798.	1634.	859.	1078.	956.
11	1547.	1640.	1529.	2248.	2207.	1775.	1229.	946.	451.	604.
12	807.	895.	1093.	810.	1478.	1380.	1139.	707.	447.	269.
13	293.	460.	505.	541.	409.	926.	865.	730.	284.	251.
14	124.	121.	249.	261.	305.	191.	649.	529.	346.	145.
15	127.	189.	169.	258.	269.	472.	283.	753.	436.	301.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	806265.	754124.	709883.	500416.	416990.	373978.	369985.	392729.	416343.	420468.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	452271.	364534.	299849.	240983.	222193.	216074.	202711.	177490.	164000.	173914.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	371554.	135131.	153520.	95079.	167389.	214750.	141307.	223760.	154074.	233475.
2	394145.	304136.	110334.	125615.	75751.	137033.	171058.	115441.	182856.	125859.
3	198023.	291466.	245051.	85011.	80504.	58948.	103276.	136938.	82894.	144681.
4	65344.	89715.	134138.	156237.	45344.	53927.	35776.	56631.	71952.	52879.
5	25078.	23956.	23898.	26013.	56020.	24718.	22002.	16650.	21641.	31124.
6	21023.	9950.	9097.	6187.	8169.	20166.	9904.	9720.	7659.	7137.
7	3679.	6154.	4009.	3206.	2930.	4011.	7642.	4713.	5162.	3682.
8	2188.	1854.	2883.	1886.	1472.	1603.	2261.	4354.	2666.	2918.
9	907.	828.	1120.	1494.	721.	888.	871.	1365.	2813.	1543.
10	605.	482.	450.	658.	477.	356.	445.	537.	777.	1688.
11	513.	327.	323.	260.	339.	241.	184.	305.	364.	521.
12	318.	329.	201.	178.	94.	225.	133.	110.	204.	255.
13	156.	197.	212.	98.	103.	48.	138.	86.	52.	114.
14	129.	104.	141.	142.	52.	63.	27.	94.	61.	33.
15	204.	210.	148.	204.	187.	61.	53.	30.	114.	61.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	481490.	536733.	515794.	410975.	305317.	288934.	287011.	324329.	322229.	349188.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	141164.	122397.	126217.	121172.	135478.	127844.	110950.	109965.	119262.	122908.

AGE	1994	1995
0	0.	0.
1	113328.	221000.
2	191018.	92697.
3	96537.	150458.
4	85747.	64848.
5	25827.	36974.
6	15195.	10457.
7	3234.	8815.
8	1733.	1908.
9	1097.	1117.
10	525.	466.
11	873.	315.
12	293.	429.
13	92.	58.
14	73.	59.
15	26.	91.
TOTAL STOCK BIOMASS ON 1. JANUARY		
	362984.	387579.
SPAWNING STOCK BIOMASS ON 1. JANUARY		
	128404.	145724.

Table 3.1.2.1 (continued)

Table Continued

PREDATION MORTALITY SAITHE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	.0004	.0004	.0004	.0004	.0005	.0005	.0005	.0006	.0006	.0006
4	.0054	.0049	.0058	.0054	.0059	.0062	.0064	.0078	.0077	.0083
5	.0053	.0050	.0057	.0055	.0059	.0063	.0066	.0077	.0076	.0081
6	.0072	.0068	.0078	.0075	.0081	.0085	.0091	.0105	.0103	.0110
7	.0028	.0027	.0030	.0031	.0033	.0034	.0038	.0041	.0040	.0042
8	.0098	.0095	.0105	.0108	.0119	.0122	.0135	.0146	.0144	.0150
9	.0270	.0261	.0288	.0295	.0326	.0335	.0371	.0402	.0397	.0413
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	.0006	.0007	.0008	.0009	.0008	.0009	.0010	.0012	.0014	.0015
4	.0076	.0099	.0099	.0109	.0102	.0119	.0138	.0160	.0180	.0192
5	.0075	.0096	.0097	.0109	.0099	.0118	.0134	.0156	.0177	[illegible]
6	.0103	.0131	.0133	.0150	.0134	.0162	.0182	.0213	.0241	[illegible]0
7	.0041	.0051	.0053	.0061	.0052	.0065	.0071	.0083	.0095	.0105
8	.0144	.0183	.0187	.0218	.0185	.0235	.0256	.0299	.0342	.0378
9	.0395	.0500	.0514	.0599	.0508	.0647	.0704	.0822	.0941	.1039
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1994	1995
0	.0000	.0000
1	.0000	.0000
2	.0000	.0000
3	.0016	.0017
4	.0198	.0200
5	.0198	.0203
6	.0271	.0279
7	.0111	.0117
8	.0394	.0417
9	.1081	.1144
10	.0000	.0000
11	.0000	.0000
12	.0000	.0000
13	.0000	.0000
14	.0000	.0000
15	.0000	.0000

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table MACKEREL

FISHING MORTALITY MACKEREL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001
1	.0064	.0244	.0101	.0074	.0000	.0209	.0202	.0210	.0153	.0046
2	.1097	.0264	.1931	.0873	.0637	.0171	.0622	.0533	.0955	.1066
3	.0773	.1253	.2388	.2195	.2108	.1116	.0922	.1638	.1807	.2638
4	.1822	.1855	.1414	.2783	.2194	.1826	.1929	.0535	.1928	.2839
5	.2353	.1784	.2069	.1326	.2120	.2652	.3019	.2395	.1208	.1909
6	.2200	.2870	.1715	.2347	.1056	.1518	.3248	.3552	.2166	.0822
7	.1028	.1759	.2677	.4314	.0290	.0951	.2306	.3621	.2454	.2249
8	.2421	.4229	.3154	.4726	.3831	.1357	.2670	.2281	.2697	.3247
9	.0901	.3785	.2713	.5571	.2931	.0699	.3009	.2555	.1638	.2398
10	.0457	.1914	.3590	.4699	.5174	.2668	.1614	.2426	.2091	.1844
11	.0395	.0593	.2143	.6721	.0867	.3302	.2967	.1346	.1670	.1771
12	.1426	.0620	.0764	.3752	.1338	.2380	.4097	.5412	.1839	.2091
13	.1280	.1005	.0324	.1536	.4120	.4075	.2347	.3196	.4367	.1318
14	.0280	.0890	.0895	.0337	.1582	.2897	.6391	.7945	.5504	.8826
15	.6790	.3602	.2535	.4059	.5713	.2927	.2914	1.4402	.4108	.7472
MEAN F (UNWEIGHTED) FOR AGES 4 TO 8										
	.1965	.2499	.2206	.3099	.1898	.1661	.2634	.2477	.2091	.2213

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0031	.1343	.2153	.0169	.0521	.0564	.0235	.0042	.0369	.0188
2	.0973	.1274	1.2957	.0421	.1321	.1901	.1503	.2812	.1777	.0917
3	.6578	.3325	.6266	.0559	.4109	.5494	.9910	.8176	.5121	.2048
4	.6149	1.1422	.4210	.0835	.2942	.5248	.8925	.8746	.4117	.9081
5	.6043	.8710	.7434	.0464	.2235	.3202	.8172	.5344	.6298	1.0311
6	.4304	1.0240	.3800	.0873	.2597	.2358	.3609	.6636	.4034	.5546
7	.2981	.4703	.5224	.0513	.2104	.2717	.2380	1.1436	.6139	.2641
8	.3493	.3257	.1954	.1008	.1837	.2119	.2934	.0000	.2536	1.0590
9	.4342	.7913	.4117	.1331	.0143	.1746	.2059	.2638	.0000	.4182
10	.4075	.7073	.9595	.0428	.1333	.0168	.1717	.3766	.0000	.0000
11	.1876	.5485	.8202	.1465	.0651	.1240	.0101	.1735	.0762	.0000
12	.2605	.3004	1.0233	.0798	.0169	.0582	.1103	.1072	.1125	.0478
13	.1753	.5666	.2747	.1573	.1500	.1849	.0423	.0826	.0655	.1173
14	.1255	.2706	.9047	.0186	.0899	.0823	.0016	.0761	.0007	.0821
15	.6811	2.0661	.3660	.7412	.0198	.2066	.2227	.1792	.1255	.1500
MEAN F (UNWEIGHTED) FOR AGES 4 TO 8										
	.4594	.7666	.4524	.0738	.2343	.3129	.5204	.6433	.4624	.7634

AGE	1994	1995
0	.0000	.0000
1	.0091	.0098
2	.0486	.0484
3	.1109	.1193
4	.1074	.1143
5	.3769	.0508
6	.3082	.1500
7	.1500	.1500
8	.1328	.1500
9	2.0864	.1500
10	.0000	.1500
11	.0513	.1500
12	.0422	.1500
13	.1659	.1500
14	.0601	.1500
15	.1500	.1500
MEAN F (UNWEIGHTED) FOR AGES 4 TO 8		
	.2151	.1230

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table Continued

STOCK NUMBERS MACKEREL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	505680.	551393.	297859.	170363.	41411.	122229.	149923.	205103.	217781.	41662.
2	198957.	432482.	463158.	253781.	145545.	35643.	103029.	126462.	172864.	184605.
3	350778.	153458.	362541.	328640.	200162.	117535.	30158.	83333.	103192.	135239.
4	264678.	279468.	116525.	245757.	227109.	139539.	90478.	23670.	60888.	74139.
5	1269717.	189865.	199822.	87071.	160132.	156974.	100060.	64216.	19311.	43217.
6	256380.	863747.	136722.	139840.	65638.	111499.	103637.	63680.	43501.	14731.
7	84956.	177094.	557940.	99131.	95183.	50836.	82452.	64462.	38423.	30149.
8	82761.	65976.	127838.	367441.	55427.	79582.	39785.	56353.	38628.	25874.
9	40921.	55917.	37202.	80265.	197154.	32523.	59803.	26221.	38612.	25389.
10	12335.	32186.	32961.	24411.	39576.	126584.	26103.	38096.	17479.	28213.
11	8908.	10143.	22876.	19814.	13133.	20305.	83439.	19119.	25727.	12206.
12	7752.	7371.	8228.	15892.	8708.	10365.	12561.	53380.	14383.	18737.
13	8578.	5786.	5962.	6561.	9399.	6557.	7032.	7178.	26741.	10300.
14	37346.	6496.	4503.	4968.	4843.	5358.	3755.	4786.	4488.	14873.
15	48613.	78213.	15406.	8312.	8045.	9948.	9672.	2142.	4336.	3761.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	985228.	892661.	751527.	617458.	454499.	365719.	311368.	259181.	233413.	212772.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	810129.	715375.	533170.	463196.	367472.	317495.	269324.	193758.	151799.	134330.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	.
1	9203.	58285.	19636.	33511.	64433.	42410.	62476.	128429.	115567.	11[illegible].
2	35695.	7897.	43863.	13626.	28359.	52642.	34502.	52526.	110080.	95867.
3	142826.	27874.	5984.	10333.	11244.	21388.	37465.	25551.	34129.	79318.
4	89411.	63675.	17204.	2752.	8410.	6417.	10628.	11970.	9710.	17602.
5	48038.	41610.	17489.	9719.	2179.	5394.	3268.	3747.	4296.	5537.
6	30734.	22594.	14990.	7158.	7986.	1500.	3370.	1242.	1890.	1970.
7	11678.	17201.	6984.	8824.	5646.	5302.	1020.	2022.	551.	1087.
8	20723.	7460.	9251.	3565.	7215.	3937.	3477.	692.	555.	257.
9	16095.	12577.	4636.	6549.	2775.	5168.	2742.	2232.	595.	370.
10	17193.	8974.	4907.	2644.	4934.	2354.	3735.	1921.	1476.	513.
11	20194.	9845.	3808.	1618.	2180.	3717.	1993.	2708.	1134.	1270.
12	8800.	14408.	4896.	1443.	1203.	1758.	2826.	1698.	1959.	905.
13	13085.	5837.	9183.	1515.	1147.	1018.	1428.	2178.	1313.	1507.
14	7770.	9451.	2851.	6005.	1114.	850.	728.	1178.	1726.	1058.
15	9383.	6621.	15397.	1683.	32479.	2922.	2165.	2231.	3903.	5729.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	171770.	107536.	65192.	33293.	55844.	39174.	39328.	43496.	55370.	67086.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	125953.	93875.	52623.	24976.	41647.	18861.	17100.	15[illegible].	13519.	16690.

AGE	1994	1995
0	0.	0.
1	124284.	129000.
2	95138.	106000.
3	75287.	78000.
4	55625.	58000.
5	6110.	43000.
6	1700.	3607.
7	974.	1075.
8	718.	721.
9	77.	541.
10	210.	8.
11	441.	181.
12	1093.	361.
13	742.	902.
14	1153.	541.
15	3237.	3607.
TOTAL STOCK BIOMASS ON 1. JANUARY		
	76258.	93835.
SPAWNING STOCK BIOMASS ON 1. JANUARY		
	26143.	40297.

Table 3.1.2.1 (continued)

Table Continued

PREDATION MORTALITY MACKEREL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
5	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
5	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1994	1995
0	.0000	.0000
1	.0000	.0000
2	.0000	.0000
3	.0000	.0000
4	.0000	.0000
5	.0000	.0000
6	.0000	.0000
7	.0000	.0000
8	.0000	.0000
9	.0000	.0000
10	.0000	.0000
11	.0000	.0000
12	.0000	.0000
13	.0000	.0000
14	.0000	.0000
15	.0000	.0000

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table HADDOCK

FISHING MORTALITY HADDOCK

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0054	.0129	.0181	.0183	.0221	.0401	.0457	.0656	.0353	.0549
1	.3363	.3478	.3057	.3101	.5554	.1684	.2204	.1884	.2274	.2130
2	.9266	1.0425	.8478	.9900	.8331	1.0115	.8008	.4608	.4526	.6602
3	.9063	1.2544	1.3853	1.0139	1.0224	1.4076	1.1660	.8857	.7956	1.0104
4	.9478	1.0913	.7661	1.2359	1.0668	.9457	1.0395	.9286	.8349	1.0963
5	.6776	1.0014	1.3469	1.0275	1.0828	.9464	.6813	.6053	.5733	1.1889
6	.9372	.6677	1.1492	1.0483	1.0352	1.0447	.9465	.3025	.4895	.7812
7	1.1369	1.3393	.3565	.9248	1.1366	.5698	1.0123	.8919	.3858	.3685
8	.7418	1.1622	.6443	.4003	.6845	1.0224	.6238	.6712	.9329	.1402
9	.2643	.8873	1.2244	.4800	.6746	.5594	1.5070	.9143	.2543	.5377
10	1.1766	2.5651	3.0570	1.0046	.2421	.3850	.8787	.9086	.5853	.9710
11	1.0439	.9000	.9000	.9000	1.0643	.9522	1.0033	.8952	.8874	.9354
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6	.8791	1.0114	1.0991	1.0631	1.0081	1.0712	.9268	.6366	.6292	.9474

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0139	.0311	.0043	.0079	.0071	.0077	.0110	.0321	.0402	.0328
1	.1821	.3518	.2266	.1575	.2279	.1861	.2752	.2366	.2022	.2434
2	.6580	.6492	1.1259	.8708	.8325	.7885	1.1209	.8223	.7198	.8110
3	.9031	.9107	1.2811	.9845	1.2620	1.0779	1.0942	.9881	1.1233	.9934
4	1.0305	1.0437	1.2014	.9738	1.0687	1.2531	1.0631	.7621	.9820	.9698
5	1.1161	.9442	.9960	.7450	1.0917	.7213	.8563	.8292	.7058	.0
6	1.0075	.9810	.7226	1.1194	.6562	.8119	.5071	.6255	1.0705	.2
7	.6849	.8272	.9890	.8418	.8352	.5232	.6000	.4897	.7083	.8742
8	.1700	.5408	.7635	1.3360	.6354	.6321	.3232	.6429	.8844	.5446
9	.0945	.1727	.5822	.7311	1.0850	.8768	.4988	.4136	.7186	.9233
10	.6036	.0849	.4241	.5476	.9110	.6759	1.1792	.7686	.9491	1.0567
11	.9522	.9343	.9713	1.0653	1.6004	.7002	.6135	.6297	1.0942	1.0350
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6	.9430	.9058	1.0654	.9387	.9822	.9305	.9283	.8054	.9203	.8837

AGE	1994	1995
0	.0069	.0405
1	.2296	.1086
2	.5658	.5374
3	1.0291	.7733
4	.9208	.8855
5	.9026	.7282
6	1.0800	.7424
7	.9850	.7340
8	1.5089	.6170
9	1.2328	.7020
10	.8238	.7020
11	1.3890	.7020
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6	.8997	.7334

Mortality of 0-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table Continued

STOCK NUMBERS HADDOCK

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	11991782.	16829497.	2011446.	2356154.	4327751.	5471921.	8783998.	2808091.	3449982.	2261192.
2	345436.	1247024.	2152539.	195737.	303246.	442717.	821148.	1402537.	291839.	594119.
3	618363.	93250.	311570.	656125.	51129.	91955.	112877.	260332.	593203.	128277.
4	98097.	186862.	20194.	59336.	180549.	13957.	17134.	26874.	80357.	202727.
5	4139.	28609.	47620.	7156.	13107.	47167.	4129.	4646.	7961.	26445.
6	2411.	1631.	8194.	9632.	1993.	3442.	14179.	1613.	1941.	3438.
7	16911.	745.	662.	2067.	2687.	562.	962.	4380.	941.	940.
8	491.	4442.	160.	380.	671.	706.	260.	286.	1470.	524.
9	98.	192.	1138.	69.	208.	277.	208.	114.	120.	473.
10	52.	62.	65.	274.	35.	87.	130.	38.	37.	76.
11	13.	20.	6.	4.	114.	33.	69.	66.	19.	25.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	1032840.	1331463.	694239.	458748.	430350.	468263.	710004.	543729.	518719.	422231.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	262065.	228818.	268750.	230705.	136520.	100257.	111675.	178871.	223804.	192853.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	6012481.	2251378.	2142546.	4857251.	536549.	910184.	1066210.	2804942.	2431951.	3897429.
2	398568.	1493579.	359385.	480260.	1165787.	86145.	170418.	159633.	539783.	541681.
3	214358.	148608.	551391.	83448.	146420.	359072.	28145.	39723.	50650.	192817.
4	35338.	66621.	45429.	117696.	24075.	31728.	93856.	7197.	11328.	12689.
5	51284.	9650.	17819.	10490.	34305.	6310.	6955.	24695.	2568.	3270.
6	6151.	12916.	2848.	4992.	3748.	8745.	2294.	2188.	7867.	911.
7	1243.	1782.	3836.	1095.	1292.	1544.	3075.	1090.	921.	2118.
8	533.	513.	638.	1168.	387.	459.	749.	1382.	547.	371.
9	373.	368.	245.	243.	251.	168.	200.	444.	595.	185.
10	226.	278.	253.	112.	96.	70.	57.	99.	240.	237.
11	34.	149.	303.	189.	63.	53.	52.	26.	52.	107.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	552948.	524410.	437063.	470863.	351502.	232017.	165769.	228388.	274789.	402992.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	146537.	186910.	211132.	126348.	152282.	130555.	75636.	49255.	65968.	98874.

AGE	1994	1995
0	0.	0.
1	1248264.	6909367.
2	823572.	241317.
3	175969.	339976.
4	54835.	48291.
5	3689.	16767.
6	968.	1060.
7	331.	257.
8	723.	101.
9	176.	131.
10	60.	42.
11	85.	36.
TOTAL STOCK BIOMASS ON 1. JANUARY		
	326386.	591867.
SPAWNING STOCK BIOMASS ON 1. JANUARY		
	128679.	144054.

Table 3.1.2.1 (continued)

Table Continued

PREDATION MORTALITY HADDOCK

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	1.7425	2.2569	2.4590	2.2275	2.2293	1.8849	2.3229	2.2554	2.0792	1.5783
1	1.7277	1.5091	1.8242	1.5406	1.5249	1.5287	1.4145	1.8755	1.3316	1.3227
2	.1830	.1444	.1402	.1525	.1602	.1552	.1479	.1997	.1694	.1592
3	.0904	.0755	.0731	.0765	.0760	.0726	.0692	.0897	.0781	.0788
4	.0844	.0758	.0714	.0742	.0755	.0722	.0655	.0879	.0765	.0782
5	.0539	.0489	.0513	.0506	.0543	.0555	.0587	.0675	.0665	.0696
6	.0370	.0334	.0281	.0283	.0305	.0298	.0283	.0362	.0353	.0357
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	1.9306	2.1756	1.9485	2.2261	1.9714	1.9316	1.7735	1.6932	1.6808	1.9174
1	1.0106	1.2831	1.0687	1.0695	1.4012	1.2892	1.4237	1.2114	1.0995	1.1110
2	.1286	.1472	.1343	.1171	.1452	.1302	.1354	.1256	.1096	.1133
3	.0655	.0744	.0632	.0586	.0672	.0639	.0695	.0665	.0610	.0640
4	.0675	.0750	.0643	.0590	.0704	.0646	.0721	.0685	.0606	.0655
5	.0628	.0761	.0764	.0841	.0752	.0905	.1002	.1148	.1300	.1398
6	.0316	.0330	.0329	.0321	.0307	.0332	.0375	.0396	.0416	.0447
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1994	1995
0	1.5277	2.2288
1	1.2137	1.0996
2	.1190	.1036
3	.0640	.0566
4	.0641	.0534
5	.1446	.1496
6	.0449	.0456
7	.0000	.0000
8	.0000	.0000
9	.0000	.0000
10	.0000	.0000
11	.0000	.0000

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table HERRING

FISHING MORTALITY HERRING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0694	.0861	.0900	.0699	.0363	.0635	.0735	.4514	.3758	.4161
1	.4821	.5773	.1948	.1717	.1242	.1104	.0468	.1444	.1975	.1499
2	.9381	1.2086	1.2149	.1335	.0172	.0771	.2527	.2718	.1981	.2670
3	.9002	1.4383	1.4280	.9653	.0318	.0553	.3491	.2503	.4503	.3099
4	.9477	1.2456	1.5948	.4108	.0683	.0740	.2423	.2544	.2217	.4086
5	1.1448	1.8171	1.2766	.9320	.0189	.0355	.2153	.3500	.1279	.2593
6	1.0360	1.2658	1.0822	.4127	.0563	.0142	.0466	.3521	.1200	.2917
7	.7642	2.0489	1.5734	.7310	.0300	.3154	.1250	.6210	.1802	.3191
8	.7802	2.0003	2.3972	1.0526	.1731	.1151	.2301	.8495	.1946	.3796
9	1.0001	1.0003	.3602	.0010	.0003	.0120	.0022	.3000	.0387	.3302
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6										
	1.0072	1.4417	1.3454	.6802	.0438	.0448	.2133	.3017	.2300	.3174

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.1144	.0323	.0113	.0842	.0667	.1274	.0633	.1545	.3594	.4551
1	.0683	.1954	.1342	.1960	.2263	.3104	.3159	.2485	.1610	.1608
2	.2413	.3258	.3506	.3288	.2897	.2293	.2473	.4094	.4150	.4190
3	.3783	.6083	.4525	.4435	.3970	.3898	.3539	.4427	.4652	.6068
4	.4792	.6718	.5303	.5385	.5138	.5366	.4370	.4505	.5151	.7568
5	.5557	.6162	.5034	.5938	.6083	.5802	.4711	.4607	.5309	.7129
6	.3293	.6628	.6824	.6150	.6813	.6860	.4050	.4680	.6829	.7651
7	.5300	.5187	.7064	.5828	.6567	.8101	.6382	.3187	.6613	.8458
8	.4217	.5396	.7030	.5924	.7857	.8539	.9646	.6027	.5174	.9531
9	.3146	.4608	.4702	.1864	.5794	.2729	.3970	.3113	.4581	.3686
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6										
	.4356	.6398	.5421	.5477	.5501	.5482	.4168	.4554	.5485	.7104

AGE	1994	1995
0	.6445	.3353
1	.0883	.3555
2	.4973	.7185
3	.6706	.8139
4	.8707	.8621
5	.6869	.8218
6	.7692	.8222
7	.5711	.8143
8	.7965	.8718
9	.7224	.8718
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6		
	.7493	.8300

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table Continued

STOCK NUMBERS HERRING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	3391715.	7322007.	1287810.	1284358.	2072301.	2117792.	6007510.	6181720.	8311934.	12888669.
2	1796666.	1051365.	1857739.	467219.	455000.	751137.	781888.	2046973.	2113812.	3337019.
3	786740.	423261.	195205.	322293.	239060.	252803.	399358.	358174.	795315.	1049246.
4	230204.	218504.	72121.	33406.	86026.	162618.	170045.	207059.	191966.	353746.
5	90074.	73239.	52066.	12074.	18220.	66504.	125926.	112036.	132103.	126570.
6	36738.	23965.	9986.	12122.	3970.	15036.	54147.	85628.	65656.	97038.
7	10024.	10928.	5861.	2924.	6858.	3216.	12824.	44038.	50670.	49502.
8	3687.	4224.	1274.	1099.	1274.	6022.	2123.	10241.	21415.	38290.
9	1678.	2291.	1402.	1092.	3639.	9150.	50000.	4629.	30599.	45626.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	323276.	265986.	199351.	97783.	104941.	151062.	243920.	341874.	430378.	640216.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	232718.	148947.	132345.	69405.	67447.	104805.	150132.	210889.	271977.	392949.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	12803345.	11788482.	22264155.	28996990.	15830066.	11991250.	8749564.	8769794.	6497240.	10756821.
2	5948531.	6320590.	5240542.	10132812.	11725633.	6139512.	3917910.	3057107.	3672582.	2947091.
3	1585335.	3102303.	2815526.	2329912.	4507796.	5140723.	3081416.	1856603.	1312827.	1598461.
4	551798.	815219.	1222927.	1266435.	1085885.	2200210.	2640951.	1657561.	909222.	633217.
5	196261.	287775.	345039.	594969.	611762.	543125.	1090636.	1449998.	896954.	461[illegible].
6	82521.	95135.	129825.	175229.	274878.	280268.	257502.	576388.	775556.	44[illegible].
7	61925.	51601.	41946.	57007.	82158.	121071.	122234.	150240.	318240.	345[illegible].
8	32554.	32981.	27795.	18727.	28800.	38549.	48731.	58427.	98840.	148644.
9	69834.	45010.	40033.	50004.	19005.	38165.	37921.	49834.	67650.	142497.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	940744.	1180577.	1260171.	1707553.	1917436.	1686769.	1387930.	1161040.	998465.	897201.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	622032.	863718.	847576.	1078403.	1402089.	1372502.	1174213.	970968.	818584.	686337.

AGE	1994	1995
0	0.	0.
1	7688920.	2562721.
2	4857572.	3759585.
3	1244110.	1864024.
4	663060.	469823.
5	251173.	233387.
6	190847.	106526.
7	184084.	78124.
8	134110.	94095.
9	92499.	88028.
TOTAL STOCK BIOMASS ON 1. JANUARY		
	847376.	703675.
SPAWNING STOCK BIOMASS ON 1. JANUARY		
	620311.	568593.

Table 3.1.2.1 (continued)

Table Continued

PREDATION MORTALITY HERRING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	1.0099	1.2265	.9163	.8392	.8062	.7519	.9075	.6340	.6571	.5428
1	.5893	.6943	.7192	.7662	.7907	.7862	.9300	.8287	.6151	.5232
2	.4077	.3753	.4368	.4367	.4706	.4547	.4281	.5736	.4023	.3773
3	.2810	.2314	.2374	.2556	.2536	.2413	.2078	.2734	.2598	.2328
4	.0975	.0887	.0926	.0954	.0892	.0817	.0750	.0950	.0948	.0805
5	.0793	.0754	.0809	.0804	.0733	.0701	.0704	.0844	.0806	.0685
6	.0765	.0425	.0460	.0569	.0542	.0449	.0601	.0726	.0624	.0574
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.6164	.5661	.6102	.6883	.6475	.7083	.6411	.5798	.5994	.6395
1	.5375	.5153	.5529	.6094	.6208	.7082	.6356	.5219	.5295	.5342
2	.3097	.3828	.3600	.3811	.4349	.3601	.3995	.3359	.3168	.3434
3	.1868	.2226	.2465	.2199	.2203	.1763	.1661	.1712	.1640	.1731
4	.0718	.0880	.0902	.0891	.0791	.0652	.0626	.0636	.0626	.0678
5	.0685	.0798	.0742	.0784	.0723	.0661	.0667	.0651	.0653	.0705
6	.0402	.0561	.0406	.0424	.0387	.0438	.0338	.0260	.0262	.0222
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1994	1995
0	.5880	.7425
1	.5272	.5966
2	.3605	.3351
3	.2033	.1741
4	.0735	.0724
5	.0709	.0787
6	.0239	.0333
7	.0000	.0000
8	.0000	.0000
9	.0000	.0000

Mortality of 0-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table NORWAY POUT

FISHING MORTALITY N. POUT

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0369	.0422	.0356	.0200	.0108	.0087	.0076	.1743	.0069	.0201
1	1.0574	.6909	.5350	.5285	.4683	.4557	.4845	.4822	.4861	.4758
2	2.9623	1.2868	1.6991	.7609	1.1398	1.6722	1.6980	1.0095	1.6167	1.2128
3	2.2995	1.0731	.9001	1.7669	.7999	.9210	1.4644	.8795	.8990	1.1321
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2										
	2.0098	.9888	1.1171	.6447	.8040	1.0639	1.0912	.7458	1.0514	.8443

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0184	.0082	.0439	.0033	.0262	.0459	.0142	.0177	.0050	.0092
1	.6216	.6724	.5932	.5094	.2969	.4020	.3687	.3015	.3946	.3672
2	1.9736	1.5939	1.6868	2.6996	1.7537	1.1142	.7846	1.2432	1.2916	1.3351
3	1.2324	1.6581	.8183	.3146	2.0382	.2958	1.4558	.4182	1.1755	.6690
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2										
	1.2976	1.1332	1.1400	1.6045	1.0253	.7581	.5767	.7723	.8431	.8512

AGE	1994	1995
0	.0228	.0046
1	.4031	.3733
2	1.4901	.3477
3	.9621	.4680
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2		
	.9466	.3605

Mortality of 0-group is for 3rd and 4th quarter only

STOCK NUMBERS N. POUT

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	154882920.	112501883.	160849816.	117171610.	56471959.	92422382.	121470265.	48206307.	128457564.	104661989.
2	3453575.	9341528.	8254585.	11769327.	11228004.	5731768.	11547480.	15297626.	3405767.	13683502.
3	466231.	34246.	460705.	201735.	984357.	629178.	216699.	508399.	729588.	124783.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	1278887.	1078781.	1438267.	1179087.	737756.	865252.	1207105.	751804.	1087977.	1126339.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	219488.	309268.	338055.	377633.	351488.	233083.	376249.	422073.	209328.	410451.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	82538979.	62421137.	39605497.	54970442.	17247329.	47115705.	43246451.	42948268.	73712156.	41085370.
2	14000475.	8699244.	3785296.	2768149.	5302997.	2040294.	6151377.	5251099.	5453366.	10167719.
3	878490.	389750.	217856.	108845.	26612.	178372.	126854.	577095.	258647.	339
TOTAL STOCK BIOMASS ON 1. JANUARY										
	997404.	697812.	400242.	488229.	258409.	414130.	480404.	475621.	700866.	568495.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	432838.	270852.	129340.	112231.	140437.	91859.	184598.	181855.	196675.	287471.

AGE	1994	1995
0	0.	0.
1	36733547.	88584592.
2	4638012.	4277068.
3	449292.	204091.
TOTAL STOCK BIOMASS ON 1. JANUARY		
	408430.	783609.
SPAWNING STOCK BIOMASS ON 1. JANUARY		
	157172.	177690.

Table 3.1.2.1 (continued)

Table Continued

PREDATION MORTALITY N. POUT

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.9732	1.1058	.9152	.9031	.8387	.8064	1.2761	.9167	1.0659	1.0918
1	1.5512	1.7217	1.8802	1.6172	1.6199	1.4247	1.3878	1.9680	1.5534	1.3360
2	1.5880	1.6763	1.8803	1.7056	1.7206	1.5141	1.3757	2.0052	1.6355	1.4667
3	.7853	.7871	.8519	.7611	.7799	.6922	.5930	.8890	.7473	.6664

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	1.4225	1.4925	1.5973	2.5197	1.6911	1.6509	1.8739	1.4041	1.6366	1.9632
1	1.4285	1.9305	1.8676	1.6292	1.6378	1.4340	1.5398	1.5624	1.3864	1.6143
2	1.4723	2.0384	1.9776	1.7945	1.8269	1.5672	1.6867	1.7152	1.5105	1.7454
3	.6451	.9131	.9827	.7924	.7903	.6375	.6626	.7181	.6097	.7317

AGE	1994	1995
0	1.3315	1.7557
1	1.5474	1.4913
2	1.7288	1.5470
3	.7422	.6951

Mortality of O-group is for 3rd and 4th quarter only

Table SANDEEL

FISHING MORTALITY SANDEEL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0083	.0063	.0126	.0263	.0731	.0719	.0386	.0728	.0575	.0219
1	.1277	.1205	.1816	.3027	.4072	.2025	.4268	.3285	.3118	.1770
2	.0851	.1348	.3606	.2614	.5349	.7288	.5867	.7385	.7083	.6964
3	.0231	.1955	.1598	.4683	.1998	.4595	.7141	.4025	.9123	.5469
4	.2022	.0913	.3027	.2292	.3378	.3616	.4067	.7239	1.1319	.3098
5	.2602	.2596	.0911	.5064	.1415	.5856	.2744	.7955	.6632	.4440
6	.7264	.4746	.6435	.8757	.8937	.8516	1.0373	.8553	.9100	.8869
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2										
	.1064	.1277	.2711	.2821	.4710	.4656	.5067	.5335	.5100	.4367

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0107	.0138	.0131	.0036	.0231	.0082	.0184	.0358	.0151	.0342
1	.4556	.2335	.1127	.3038	.2310	.7340	.3011	.6209	.4494	.2641
2	.2050	1.2568	.4211	.3935	1.1260	.1639	.8516	.5405	.4566	.4047
3	1.1927	.9191	.3450	.2492	.6902	.7566	.5626	.3446	.2174	.5162
4	.4869	.4188	.1832	.1115	1.2578	.3741	.3180	.3638	.2676	.2980
5	.4318	1.5082	.0724	.0999	.5916	.1241	1.0634	.1496	.2482	1.3967
6	1.0841	1.2846	.3167	.0272	.7276	.0249	.0355	.0000	.3333	.6069
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2										
	.3303	.7452	.2669	.3486	.6785	.4489	.5763	.5807	.4530	.3344

AGE	1994	1995
0	.0004	.0094
1	.4368	.3703
2	.4948	.3579
3	.6813	.3867
4	1.0108	.3118
5	1.2403	.6049
6	.7837	.1709
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2		
	.4658	.3641

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table SANDEEL

STOCK NUMBERS SANDEEL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	838180186.	573583802.	431522812.	461404857.	518913048.	386331480.	371049390.	193771156.	484040808.	191401783.
2	87952356.	93578897.	88382017.	59207680.	68561674.	70977295.	68728505.	51883096.	25769485.	104017162.
3	58083671.	38650310.	33535263.	26724155.	20517671.	18437110.	15681068.	16157819.	10298912.	6103082.
4	17817158.	20557267.	8704024.	9308264.	5875927.	6374470.	4478968.	2718128.	3909317.	1653534.
5	1945846.	4794997.	5314777.	2049881.	2525350.	1610201.	1762060.	1091487.	517292.	558982.
6	327929.	414283.	742969.	1107521.	315702.	671006.	286025.	383323.	171782.	114186.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	5423426.	4276164.	3369713.	3042177.	3191806.	2663963.	2498325.	1598381.	2391721.	1915981.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	2154523.	2039188.	1686775.	1242698.	1168045.	1157270.	1051232.	842673.	503962.	1169514.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	474957596.	159156991.	536966604.	296145262.	124320802.	359152565.	178251723.	280432426.	346043754.	192521762.
2	36627071.	84039821.	28813735.	162135541.	66437625.	27148679.	50087034.	35663457.	49837694.	71863862.
3	25957979.	14756517.	11544544.	9840799.	54949202.	10447371.	10961878.	9929335.	10724900.	15875936.
4	1513031.	3234337.	2530936.	3896789.	3449636.	12479898.	2145634.	2597974.	3264927.	3855946.
5	580366.	439714.	1072650.	1136671.	1784030.	510063.	4410840.	800915.	1005590.	1371826.
6	169514.	175047.	66883.	931759.	585531.	865474.	377174.	1576114.	554852.	520117.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	2651140.	1752991.	2629168.	3029573.	2087454.	2108051.	1503700.	1695552.	2102930.	1819027.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	798806.	1132279.	534998.	1874606.	1602602.	707356.	808518.	601865.	753359.	1068192.

AGE	1994	1995
0	0.	0.
1	317152638.	492323385.
2	38228058.	58538605.
3	23219517.	11793209.
4	4029113.	5423286.
5	1491278.	802298.
6	201272.	368306.
TOTAL STOCK BIOMASS ON 1. JANUARY		
	2082521.	2811671.
SPAWNING STOCK BIOMASS ON 1. JANUARY		
	845625.	891610.

PREDATION MORTALITY SANDEEL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	1.2721	1.8601	.9919	.6302	.9204	.9572	1.2482	.9430	1.3906	1.1144
1	1.8649	1.5502	1.6048	1.4043	1.3827	1.3245	1.3407	1.4891	1.0259	1.2756
2	.5372	.6915	.6356	.5984	.5785	.5812	.6612	.6786	.5322	.[illegible]
3	.8157	1.0954	.9219	.8464	.7694	.7556	.8385	.8166	.7169	.6[illegible]
4	.9105	1.0616	.9434	.8754	.7569	.7244	.8053	.7351	.6131	.5372
5	1.2476	1.5493	1.4002	1.3067	1.1468	1.0669	1.2177	1.0387	.8608	.7284
6	1.0562	1.2331	1.1659	1.0823	.9271	.8447	.9103	.8194	.6681	.5631

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	1.6017	1.2051	1.3398	1.6256	1.1342	1.2771	1.3502	1.1070	1.2975	1.4045
1	1.0764	1.2755	.8848	.9908	1.0906	1.0360	1.1080	.9067	.9224	1.1525
2	.5041	.5284	.4533	.4886	.5239	.5431	.5667	.4611	.4874	.5251
3	.6899	.6440	.5411	.5990	.5921	.6264	.6771	.5677	.6056	.6551
4	.5488	.4848	.4172	.4698	.4537	.4659	.4674	.3853	.3995	.4519
5	.7207	.6815	.6067	.6570	.6369	.7199	.6252	.5457	.5676	.6226
6	.5234	.4622	.4060	.4227	.4413	.4563	.4109	.3506	.3575	.3975

AGE	1994	1995
0	1.1767	1.4855
1	1.0529	1.0025
2	.4812	.4910
3	.5730	.6053
4	.4030	.4678
5	.5430	.6533
6	.3664	.4436

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table PLAICE

FISHING MORTALITY PLAICE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0037	.0030	.0090	.0071	.0027	.0031	.0015	.0006	.0034	.0021
2	.0443	.0737	.1214	.2254	.1601	.1678	.1828	.1930	.1372	.1445
3	.4706	.1650	.2659	.2030	.3653	.4732	.6268	.5416	.6690	.4972
4	.6139	.4252	.3717	.3377	.3750	.4834	.5743	.5372	.6025	.6929
5	.5147	.5016	.2997	.5681	.4127	.5881	.4336	.5059	.4988	.4901
6	.3731	.5033	.3331	.2996	.4503	.6073	.4101	.3599	.4235	.3952
7	.2892	.3856	.3777	.3061	.2927	.5693	.3892	.3598	.3524	.3433
8	.3594	.3258	.3308	.3300	.2561	.3081	.3543	.3738	.3232	.3016
9	.3624	.3723	.2398	.3247	.2354	.3179	.1986	.3191	.3285	.2673
10	.3719	.3305	.2828	.2192	.2591	.3343	.2186	.2034	.3825	.3345
11	.4330	.2335	.3197	.2645	.1754	.3255	.1975	.2531	.2249	.3537
12	.3367	.5033	.1653	.3117	.1687	.2306	.3141	.2363	.2312	.3557
13	.3167	.2896	.5242	.1126	.2297	.2715	.1183	.3240	.2275	.2678
14	.2441	.3367	.1431	.4934	.0928	.3459	.1499	.1621	.3233	.1854
15	.4641	.4624	.3633	.3244	.2865	.4113	.2950	.3561	.3945	.4387
MEAN F (UNWEIGHTED) FOR AGES 3 TO 8										
	.4368	.3844	.3298	.3408	.3587	.5049	.4647	.4464	.4782	.4534

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0002	.0002	.0013	.0000	.0000	.0031	.0042	.0040	.0077	.0100
2	.1323	.1490	.1501	.0938	.0365	.0941	.1059	.1493	.1287	.1472
3	.5013	.4418	.5040	.3864	.3499	.2742	.2909	.3574	.3608	.4253
4	.4035	.6670	.5106	.6195	.4423	.4677	.5220	.5609	.4620	.5558
5	.5440	.4085	.6553	.6208	.6639	.4921	.6836	.6799	.6430	.6668
6	.4001	.4109	.5441	.4966	.6236	.4806	.5056	.7676	.6253	.5797
7	.3182	.3258	.4191	.4126	.5538	.4499	.3949	.5376	.6281	.5476
8	.3685	.2694	.3304	.2746	.4268	.4055	.3327	.4257	.4317	.5559
9	.2939	.2774	.2997	.2109	.3980	.2293	.3397	.3880	.4328	.4431
10	.2694	.2427	.3109	.2344	.2916	.2952	.1872	.3686	.4703	.5171
11	.2168	.1844	.2637	.1991	.2277	.2010	.2003	.2195	.3861	.5806
12	.2880	.2467	.2689	.1820	.3162	.1890	.1475	.2317	.2790	.4408
13	.1939	.2671	.2655	.1648	.2336	.1939	.1328	.1478	.2975	.3861
14	.1994	.2136	.3451	.1185	.2602	.1873	.1443	.1727	.3078	.2157
15	.3723	.3852	.5062	.4065	.6427	.6842	.4772	.6247	1.7937	.5032
MEAN F (UNWEIGHTED) FOR AGES 3 TO 8										
	.4226	.4205	.4939	.4684	.5101	.4283	.4550	.5548	.5251	.5552

AGE	1994	1995
0	.0000	.0000
1	.0049	.0143
2	.1596	.1484
3	.4132	.4208
4	.6586	.5782
5	.6092	.6503
6	.5864	.6261
7	.6403	.6251
8	.5033	.3969
9	.5190	.3597
10	.5379	.3177
11	.4774	.4804
12	.5934	.4785
13	.5109	.5289
14	.3203	.4979
15	.5256	.4979
MEAN F (UNWEIGHTED) FOR AGES 3 TO 8		
	.5685	.5496

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table Continued

STOCK NUMBERS PLAICE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	459895.	341589.	329662.	477120.	436075.	451036.	666648.	431732.	1033148.	592363.
2	490238.	414293.	307934.	295386.	428332.	393160.	406507.	601704.	389990.	930691.
3	167302.	424045.	347978.	246570.	213171.	329923.	300521.	306060.	448374.	307294.
4	138095.	94444.	324953.	241019.	181880.	133665.	185705.	145055.	160839.	207434.
5	104807.	67539.	55782.	202448.	155350.	112932.	74456.	94448.	76544.	79515.
6	63382.	56424.	36845.	37220.	103297.	92547.	56442.	43407.	51190.	41785.
7	33240.	38997.	30485.	23571.	24625.	58711.	44932.	33326.	26906.	29780.
8	22088.	22356.	23823.	18758.	15578.	16485.	29795.	27279.	20817.	16933.
9	19872.	13881.	14531.	15400.	12134.	10846.	10894.	18788.	16859.	13534.
10	14009.	12401.	8577.	10243.	9973.	8585.	7062.	7983.	12192.	10839.
11	35755.	8739.	8063.	5850.	7443.	6964.	5560.	5135.	5894.	7525.
12	6953.	20982.	6261.	5299.	4063.	5652.	4551.	4129.	3608.	4259.
13	7902.	4493.	11478.	4802.	3511.	3105.	4061.	3008.	2950.	2591.
14	7160.	5209.	3043.	6149.	3882.	2525.	2142.	3264.	1968.	2126.
15	10553.	11798.	9077.	6901.	10595.	7998.	4954.	4555.	6438.	3095.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	465398.	445130.	442085.	455928.	457940.	458708.	463324.	454224.	534018.	545572.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	326310.	299033.	317997.	323754.	322836.	310166.	284810.	290730.	283552.	324929.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	[illegible]
1	615299.	557970.	1354918.	564407.	595205.	422252.	398465.	401352.	435048.	342 [illegible]
2	534253.	556060.	504082.	1222722.	509904.	537831.	380242.	358359.	360945.	389660.
3	727926.	423054.	432895.	391991.	1005699.	444230.	442156.	308882.	278664.	286406.
4	168802.	398304.	245571.	236106.	240415.	639928.	304732.	298205.	194809.	175073.
5	93674.	101824.	184530.	133012.	114661.	139426.	361619.	163048.	153383.	110556.
6	43776.	48882.	60752.	86002.	64093.	52985.	76357.	163386.	73800.	71892.
7	24988.	26075.	28668.	31170.	46120.	30380.	28815.	40396.	66151.	34271.
8	18907.	16274.	16805.	16825.	18375.	23662.	17236.	17248.	20895.	31165.
9	11247.	11747.	11143.	10823.	11441.	10748.	14106.	11039.	10043.	12069.
10	9246.	7488.	7925.	7348.	7783.	6841.	7578.	8891.	6603.	5723.
11	7019.	6391.	5315.	5255.	5260.	5261.	4608.	5686.	5564.	3733.
12	4781.	5113.	4809.	3695.	3896.	3790.	3894.	3413.	4131.	3422.
13	2700.	3243.	3615.	3325.	2787.	2570.	2839.	3040.	2449.	2828.
14	1793.	2012.	2247.	2508.	2552.	1996.	1916.	2249.	2373.	1646.
15	4246.	3458.	3235.	3622.	3846.	3275.	3416.	2910.	2016.	3484.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	566514.	563536.	667140.	669777.	680117.	644610.	602801.	529300.	459014.	414972.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	329075.	370929.	358949.	413453.	413128.	471516.	449296.	394342.	322550.	288522.

AGE	1994	1995
0	0.	0.
1	289481.	536544.
2	306127.	259929.
3	303464.	235445.
4	168640.	180823.
5	90423.	78567.
6	50536.	43745.
7	34807.	24242.
8	17457.	16133.
9	15870.	9359.
10	6788.	8257.
11	3087.	3587.
12	1890.	1733.
13	1993.	945.
14	1739.	1082.
15	2581.	2538.
TOTAL STOCK BIOMASS ON 1. JANUARY		
	363705.	357211.
SPAWNING STOCK BIOMASS ON 1. JANUARY		
	251434.	221070.

Table 3.1.2.1 (continued)

Table Continued

PREDATION MORTALITY PLAICE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0007	.0007	.0008	.0008	.0008	.0009	.0010	.0011	.0011	.0011
2	.0008	.0008	.0009	.0008	.0009	.0009	.0010	.0011	.0011	.0012
3	.0012	.0012	.0013	.0013	.0014	.0015	.0016	.0018	.0018	.0019
4	.0014	.0013	.0015	.0015	.0016	.0017	.0018	.0020	.0020	.0021
5	.0045	.0044	.0049	.0048	.0052	.0055	.0060	.0066	.0065	.0068
6	.0126	.0123	.0136	.0135	.0147	.0153	.0168	.0184	.0182	.0189
7	.0074	.0073	.0080	.0080	.0087	.0090	.0099	.0107	.0106	.0110
8	.0051	.0050	.0055	.0056	.0060	.0062	.0069	.0074	.0074	.0076
9	.0092	.0090	.0099	.0098	.0106	.0112	.0123	.0133	.0132	.0137
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0011	.0013	.0014	.0016	.0014	.0017	.0018	.0022	.0024	.0027
2	.0011	.0014	.0014	.0016	.0014	.0017	.0019	.0022	.0026	.0028
3	.0017	.0022	.0022	.0025	.0022	.0027	.0030	.0035	.0040	.0044
4	.0020	.0024	.0025	.0028	.0025	.0031	.0034	.0040	.0045	.0049
5	.0064	.0079	.0082	.0093	.0081	.0100	.0109	.0128	.0147	.0160
6	.0180	.0227	.0233	.0266	.0229	.0285	.0311	.0366	.0417	.0456
7	.0106	.0135	.0138	.0158	.0135	.0169	.0183	.0217	.0246	.0270
8	.0074	.0094	.0096	.0111	.0094	.0118	.0128	.0152	.0172	.0189
9	.0129	.0161	.0166	.0189	.0163	.0203	.0219	.0259	.0297	.0324
10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1994	1995
0	.0000	.0000
1	.0028	.0029
2	.0029	.0030
3	.0046	.0048
4	.0052	.0054
5	.0169	.0176
6	.0482	.0504
7	.0287	.0301
8	.0201	.0212
9	.0344	.0359
10	.0000	.0000
11	.0000	.0000
12	.0000	.0000
13	.0000	.0000
14	.0000	.0000
15	.0000	.0000

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table SOLE

FISHING MORTALITY SOLE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0010	.0066	.0095	.0131	.0006	.0008	.0043	.0030	.0183	.0028
2	.1839	.2741	.1028	.2579	.2333	.2195	.1204	.2461	.2289	.3073
3	.5697	.5344	.5530	.5238	.5563	.6495	.5360	.4796	.6596	.5892
4	.5916	.6198	.4842	.5926	.4888	.6005	.5747	.5633	.4866	.6516
5	.4468	.4150	.4953	.4555	.4910	.4168	.5340	.5064	.5643	.2677
6	.4409	.4127	.3058	.3038	.4539	.4167	.3247	.4981	.5540	.3964
7	.3881	.2908	.3312	.1402	.4844	.3034	.4948	.3255	.3972	.4064
8	.2691	.3579	.3021	.2923	.3843	.3929	.3805	.3370	.3238	.3787
9	.1645	.3076	.2540	.2014	.2472	.2311	.2738	.3287	.3632	.3108
10	.2679	.1240	.1756	.1730	.2044	.2104	.0657	.2099	.3544	.2799
11	.3142	.1516	.1293	.1031	.2664	.2261	.3198	.1644	.2176	.4759
12	.0777	.3987	.0996	.1002	.1707	.1821	.1015	.1755	.1490	.0575
13	.0247	.0226	.4702	.0985	.1068	.1891	.1063	.2293	.3097	.0338
14	.2130	.0754	.0376	.5589	.0755	.0897	.0742	.0528	.0378	.4328
15	.4137	.3394	.3176	.3441	.4422	.5104	.3961	.5282	.4478	.3547
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8										
	.4129	.4150	.3678	.3666	.4417	.4285	.4236	.4223	.4592	.4282

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0028	.0021	.0024	.0013	.0000	.0011	.0049	.0020	.0025	.0008
2	.2838	.3016	.1412	.2348	.2316	.1189	.1315	.0982	.1277	.1612
3	.7088	.7135	.5916	.4929	.6392	.5055	.3810	.4576	.4175	.4782
4	.6617	.7492	.6390	.5888	.6842	.6417	.4964	.5815	.4426	.5275
5	.5479	.5670	.6374	.4628	.5519	.4063	.5407	.8067	.4590	.7619
6	.5170	.3961	.6864	.5107	.4831	.3757	.6152	.4481	.6015	.5309
7	.4065	.2378	.4222	.3604	.4565	.2966	.4353	.6586	.6004	.7952
8	.3526	.2824	.1704	.2593	.3322	.3143	.4167	.5524	.5216	.4542
9	.3207	.3396	.3155	.1952	.2168	.2586	.4852	.4594	.5818	.6636
10	.2962	.1772	.5816	.1870	.1028	.1314	.2132	.5497	.4989	.4978
11	.2842	.3565	.4768	.2852	.0697	.1494	.2399	.4150	.5154	.6070
12	.2667	.3984	.5600	.3149	.1937	.0883	.2753	.4951	.4995	.6031
13	.0677	.2434	.4473	.4018	.1257	.1432	.0848	.1093	.2804	.2960
14	.0672	.0859	.4158	.3314	.0741	.1025	.2515	.0601	.0526	.3393
15	.3740	.4340	.7377	.6829	.4190	.5536	1.0673	.5785	3.5533	.7823
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8										
	.4969	.4639	.4698	.4157	.4827	.3799	.4310	.5147	.4529	.5299

AGE	1994	1995
0	.0000	.0000
1	.0084	.0150
2	.1267	.1812
3	.4004	.3940
4	.7949	.5612
5	.6029	.9653
6	.7276	.5023
7	.4401	.5539
8	.5369	.4174
9	.6404	.6801
10	.9026	.5229
11	.3850	.4965
12	1.0383	.9713
13	1.1561	.6440
14	.2173	.7762
15	.8277	.7762
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8		
	.5185	.5108

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table Continued

STOCK NUMBERS SOLE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	111098.	42332.	114992.	141358.	48190.	12382.	156124.	150454.	153791.	144847.
2	95773.	100126.	37940.	102727.	125828.	43423.	11155.	140094.	135140.	136039.
3	51865.	72079.	68853.	30966.	71794.	90128.	31536.	8944.	99058.	97211.
4	12858.	26542.	38212.	35830.	16592.	37236.	42585.	16691.	5008.	46331.
5	20496.	6429.	12903.	21270.	17895.	9191.	18445.	21644.	8578.	2779.
6	5648.	11861.	3840.	7113.	12201.	9907.	5480.	9781.	11799.	4413.
7	5156.	3282.	7090.	2554.	4740.	6996.	5895.	3574.	5363.	6117.
8	2918.	3158.	2216.	4596.	2004.	2635.	4661.	3243.	2328.	3251.
9	2777.	2015.	1995.	1480.	3100.	1233.	1607.	2877.	2090.	1521.
10	2727.	2120.	1333.	1392.	1089.	2177.	880.	1098.	1860.	1306.
11	9168.	1874.	1682.	1004.	1051.	796.	1582.	738.	797.	1168.
12	1455.	6059.	1457.	1338.	820.	729.	574.	1039.	567.	580.
13	1371.	1218.	3680.	1193.	1095.	625.	549.	470.	789.	442.
14	1668.	1210.	1078.	2081.	979.	890.	468.	447.	338.	524.
15	4324.	3430.	2975.	2619.	2572.	1797.	1883.	843.	910.	805.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	60725.	58333.	53615.	57678.	58908.	50496.	44834.	52062.	62356.	68068.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	41762.	42199.	42554.	36228.	38883.	43798.	35466.	24926.	35747.	41781.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	72081.	82737.	162687.	74342.	477414.	115800.	184973.	66216.	401431.	75767.
2	130111.	64755.	74285.	146004.	66734.	429546.	103932.	165285.	59256.	358647.
3	90480.	88598.	43310.	58329.	104387.	47871.	344827.	82385.	135430.	47134.
4	48783.	40290.	39263.	21680.	32227.	49828.	26117.	213051.	47144.	80662.
5	21797.	22724.	17186.	18697.	10850.	14667.	23645.	14326.	107266.	27251.
6	1923.	11399.	11657.	8217.	10644.	5651.	8835.	12450.	5781.	61277.
7	2678.	1035.	6916.	5290.	4443.	5920.	3496.	4300.	7155.	2847.
8	3675.	1609.	735.	4086.	3323.	2537.	3962.	2035.	2001.	3525.
9	2010.	2332.	1095.	560.	2844.	2151.	1671.	2354.	1056.	1069.
10	1001.	1310.	1488.	715.	412.	2052.	1485.	918.	1325.	524.
11	883.	666.	979.	742.	528.	332.	1600.	1065.	469.	710.
12	657.	601.	422.	550.	505.	446.	258.	1139.	636.	253.
13	495.	455.	365.	218.	363.	376.	369.	178.	628.	349.
14	386.	419.	323.	211.	132.	290.	295.	307.	144.	429.
15	815.	790.	613.	355.	339.	231.	344.	421.	268.	211.
TOTAL STOCK BIOMASS ON 1. JANUARY										
	66995.	58299.	54407.	57133.	76129.	102638.	115532.	115384.	112595.	123569.
SPAWNING STOCK BIOMASS ON 1. JANUARY										
	45175.	45096.	35873.	32976.	42916.	36712.	91733.	88933.	84227.	69570.

AGE	1994	1995
0	0.	0.
1	91354.	342915.
2	67735.	80983.
3	275861.	53929.
4	26418.	167121.
5	42811.	10730.
6	11498.	21176.
7	32369.	4987.
8	1154.	18705.
9	2015.	607.
10	489.	941.
11	281.	174.
12	350.	173.
13	125.	112.
14	235.	36.
15	458.	293.
TOTAL STOCK BIOMASS ON 1. JANUARY		
	110271.	107797.
SPAWNING STOCK BIOMASS ON 1. JANUARY		
	96221.	79314.

Table 3.1.2.1 (continued)

Table Continued

PREDATION MORTALITY SOLE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0030	.0030	.0033	.0033	.0036	.0037	.0040	.0044	.0043	.0045
2	.0003	.0003	.0004	.0003	.0004	.0004	.0004	.0005	.0005	.0005
3	.0002	.0002	.0002	.0002	.0002	.0002	.0003	.0003	.0003	.0003
4	.0016	.0015	.0016	.0017	.0019	.0019	.0021	.0023	.0023	.0024
5	.0003	.0002	.0003	.0003	.0003	.0003	.0004	.0004	.0004	.0004
6	.0019	.0019	.0021	.0021	.0023	.0024	.0026	.0028	.0028	.0029
7	.0021	.0020	.0022	.0023	.0026	.0027	.0030	.0032	.0032	.0034
8	.0014	.0013	.0014	.0015	.0017	.0017	.0019	.0021	.0021	.0022
9	.0052	.0052	.0056	.0058	.0062	.0064	.0071	.0076	.0075	.0077
10	.0075	.0074	.0080	.0083	.0088	.0090	.0100	.0108	.0106	.0109
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0044	.0057	.0058	.0067	.0056	.0071	.0077	.0091	.0102	.0113
2	.0005	.0006	.0006	.0007	.0006	.0008	.0009	.0010	.0011	.0012
3	.0003	.0004	.0004	.0004	.0004	.0005	.0005	.0006	.0007	.0007
4	.0023	.0028	.0029	.0034	.0029	.0037	.0041	.0047	.0055	.0060
5	.0004	.0005	.0005	.0006	.0005	.0006	.0007	.0008	.0009	.0
6	.0028	.0036	.0037	.0042	.0036	.0046	.0049	.0058	.0066	.73
7	.0031	.0038	.0039	.0046	.0040	.0051	.0055	.0064	.0075	.0082
8	.0020	.0025	.0026	.0030	.0026	.0033	.0036	.0042	.0049	.0054
9	.0076	.0098	.0101	.0116	.0098	.0123	.0133	.0158	.0177	.0197
10	.0109	.0140	.0143	.0165	.0139	.0175	.0188	.0223	.0250	.0278
11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
13	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1994	1995
0	.0000	.0000
1	.0121	.0127
2	.0013	.0013
3	.0008	.0008
4	.0061	.0064
5	.0010	.0011
6	.0077	.0081
7	.0083	.0088
8	.0054	.0057
9	.0211	.0223
10	.0300	.0317
11	.0000	.0000
12	.0000	.0000
13	.0000	.0000
14	.0000	.0000
15	.0000	.0000

Mortality of O-group is for 3rd and 4th quarter only

Table 3.1.2.1 (continued)

Table

COD MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1987 - 1994

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.00000	2269957.	1965284.	2.08202
1	.16334	231924.	110300.	.69486
2	.83913	92406.	11747.	.20136
3	.93915	26741.	2300.	.14937
4	.91529	7849.	204.	.04310
5	.79615	2701.	64.	.03717
6	.85813	1165.	52.	.07949
7	.93458	390.	0.	.00000
8	.90083	166.	0.	.00000
9	.86356	65.	0.	.00000
10	.77036	28.	0.	.00000
11	.76802	21.	0.	.00000

*) STOCK NUMBER ON 1. JANUARY (Except for the 0-group which is on 1. July)

WHITING MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1987 - 1994

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.04487	22060140.	17603255.	1.80660
1	.21024	3211377.	1820078.	.97224
2	.42629	854256.	135718.	.21612
3	.63173	350450.	30235.	.12585
4	.80157	140976.	16481.	.18636
5	1.00644	42375.	5713.	.25058
6	1.16590	10133.	960.	.18833
7	1.21565	1537.	0.	.00000
8	1.68878	482.	0.	.00000
9	1.86411	75.	0.	.00000
10	1.38078	14.	0.	.00000

*) STOCK NUMBER ON 1. JANUARY (Except for the 0-group which is on 1. July)

SAITHE MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1987 - 1994

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.00000	202949.	0.	.00000
1	.00785	167895.	0.	.00000
2	.08379	140579.	0.	.00000
3	.31678	98599.	105.	.00117
4	.61646	69812.	548.	.01499
5	.71254	27999.	234.	.01476
6	.51395	10517.	142.	.02016
7	.40928	4323.	29.	.00804
8	.39387	2362.	57.	.02885
9	.47464	1349.	89.	.07926
10	.34338	683.	0.	.00000
11	.37228	386.	0.	.00000
12	.56247	186.	0.	.00000
13	.27349	91.	0.	.00000
14	.31879	68.	0.	.00000
15	.59346	92.	0.	.00000

*) STOCK NUMBER ON 1. JANUARY (Except for the 0-group which is on 1. July)

MACKEREL MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1987 - 1994

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.00000	104991.	0.	.00000
1	.02724	85468.	0.	.00000
2	.13923	60342.	0.	.00000
3	.45658	36840.	0.	.00000
4	.51210	15389.	0.	.00000
5	.49746	5031.	0.	.00000
6	.35918	3352.	0.	.00000
7	.36787	3178.	0.	.00000
8	.27941	2552.	0.	.00000
9	.41203	2563.	0.	.00000
10	.09263	2223.	0.	.00000
11	.08085	1883.	0.	.00000
12	.07187	1611.	0.	.00000
13	.12071	1356.	0.	.00000
14	.05141	1727.	0.	.00000
15	.22437	6794.	0.	.00000

*) STOCK NUMBER ON 1. JANUARY (Except for the 0-group which is on 1. July)

Table 3.1.2.1 (continued)

Table Continued

HADDOCK MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1987 - 1994

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.01820	15465569.	12246621.	1.84021
1	.21982	2219097.	1380488.	1.22739
2	.81644	495910.	41936.	.12443
3	1.06905	134531.	4564.	.06434
4	.99917	44176.	1585.	.06560
5	.84111	11535.	628.	.10989
6	.82972	3964.	97.	.03805
7	.73218	1433.	0.	.00000
8	.81343	723.	0.	.00000
9	.81002	283.	0.	.00000
10	.86397	121.	0.	.00000
11	1.01592	78.	0.	.00000

*) STOCK NUMBER ON 1. JANUARY (Except for the 0-group which is on 1. July)

HERRING MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1987 - 1994

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.24439	22347305.	9331303.	.63649
1	.21340	12410081.	5008668.	.58585
2	.35446	5806277.	1668246.	.36653
3	.47118	2633981.	398586.	.18677
4	.57737	1382068.	72846.	.07044
5	.58060	737538.	34030.	.06941
6	.63406	372218.	6702.	.03214
7	.63557	172544.	0.	.00000
8	.75826	71854.	0.	.00000
9	.41201	62197.	0.	.00000

*) STOCK NUMBER ON 1. JANUARY (Except for the 0-group which is on 1. July)

N. POUT MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1987 - 1994

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.01803	293206730.	223640475.	1.75887
1	.38043	44632408.	30114489.	1.54390
2	1.46403	5221627.	3127631.	1.69692
3	.91615	258137.	101554.	.71056

*) STOCK NUMBER ON 1. JANUARY (Except for the 0-group which is on 1. July)

SANDEEL MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1987 - 1994

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.01734	1140905428.	794389552.	1.29662
1	.41763	261752616.	137280018.	1.03251
2	.55396	62675244.	17267934.	.50965
3	.50225	18243617.	5324888.	.61200
4	.50019	4464989.	1079932.	.43707
5	.61422	1563902.	406793.	.61475
6	.31740	701537.	184059.	.40038

*) STOCK NUMBER ON 1. JANUARY (Except for the 0-group which is on 1. July)

PLAICE MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1987 - 1994

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.00000	449549.	0.	.00000
1	.00425	431107.	813.	.00206
2	.11440	508224.	917.	.00215
3	.35725	432687.	1091.	.00336
4	.53609	282238.	765.	.00380
5	.63241	158266.	1375.	.01235
6	.58317	79881.	2102.	.03516
7	.52059	39014.	659.	.02081
8	.41952	20358.	256.	.01457
9	.37009	12017.	242.	.02497
10	.36277	7194.	0.	.00000
11	.31146	4807.	0.	.00000
12	.29745	3516.	0.	.00000
13	.25840	2729.	0.	.00000
14	.21584	2122.	0.	.00000
15	.70721	3144.	0.	.00000

*) STOCK NUMBER ON 1. JANUARY (Except for the 0-group which is on 1. July)

Table 3.1.2.1 (continued)

Table Continued

SOLE MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1987 - 1994

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.00000	230743.	6.	.00003
1	.00261	185912.	1475.	.00871
2	.15382	174643.	152.	.00096
3	.47154	137028.	65.	.00056
4	.59471	62141.	228.	.00456
5	.57403	32439.	22.	.00076
6	.53660	15544.	84.	.00559
7	.50539	8228.	45.	.00619
8	.42344	2828.	9.	.00406
9	.43763	1715.	23.	.01516
10	.38540	990.	19.	.02147
11	.33332	716.	0.	.00000
12	.43854	517.	0.	.00000
13	.32468	326.	0.	.00000
14	.17858	255.	0.	.00000
15	1.05807	328.	0.	.00000

*) STOCK NUMBER ON 1. JANUARY (Except for the 0-group which is on 1. July)

Table 3.1.2.1 (continued)

Table BIOMASSES CONSUMED BY PREDATORS, COMPARED TO STOCK BIOMASS AND YIELD OF PREDATOR

PREDATOR COD

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	10841.	67381.	0.	0.	149854.	24064.	99041.	82650.
1975	10417.	72557.	0.	0.	96622.	15930.	78363.	86477.
1976	9452.	71708.	0.	0.	45577.	9826.	103289.	66455.
1977	14595.	69082.	0.	0.	49956.	6331.	99456.	82915.
1978	16828.	86107.	0.	0.	76673.	8739.	71145.	93126.
1979	14608.	84509.	0.	0.	93247.	12271.	105429.	74317.
1980	19445.	88974.	0.	0.	88138.	19904.	132691.	77633.
1981	22125.	83980.	0.	0.	81599.	35016.	102643.	69358.
1982	16884.	49195.	0.	0.	48702.	39588.	128542.	67285.
1983	11845.	35700.	0.	0.	54739.	51585.	113077.	51899.
1984	10461.	33266.	0.	0.	50937.	58075.	79057.	59821.
1985	8144.	39618.	0.	0.	45173.	71480.	55826.	47862.
1986	8228.	40061.	0.	0.	37409.	71610.	33133.	64376.
1987	5941.	39969.	0.	0.	31619.	78160.	39156.	67565.
1988	4389.	38238.	0.	0.	14122.	89924.	26750.	34478.
1989	3196.	33726.	0.	0.	8799.	55873.	29126.	28944.
1990	2999.	26674.	0.	0.	14851.	39671.	29475.	24093.
1991	2160.	17994.	0.	0.	16127.	28637.	27137.	22165.
1992	2640.	16195.	0.	0.	20186.	22012.	32753.	27822.
1993	2920.	19601.	0.	0.	19698.	23749.	29870.	29057.
1994	3613.	23056.	0.	0.	29715.	24635.	30202.	38215.
1995	4393.	32387.	0.	0.	44927.	23246.	62147.	58086.

PREDATOR COD

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	ST.BIOM.	YIELD
1974	0.	0.	433832.	437895.	324031.	202009.
1975	0.	0.	360366.	474567.	284326.	188770.
1976	0.	0.	306308.	549063.	284480.	204400.
1977	0.	0.	322335.	676717.	267781.	195295.
1978	0.	0.	352617.	712951.	360527.	275889.
1979	0.	0.	384381.	652037.	324619.	234721.
1980	0.	0.	426784.	809164.	363981.	258737.
1981	0.	0.	394722.	802261.	441661.	325926.
1982	0.	0.	350197.	708318.	361339.	287894.
1983	0.	0.	318846.	538057.	317993.	246875.
1984	0.	0.	291617.	548600.	266251.	211534.
1985	0.	0.	268103.	503194.	279966.	211969.
1986	0.	0.	254817.	478427.	231273.	189470.
1987	0.	0.	262410.	412462.	241748.	185132.
1988	0.	0.	207901.	347214.	216979.	175639.
1989	0.	0.	159665.	295173.	164627.	128096.
1990	0.	0.	137763.	268141.	146840.	109402.
1991	0.	0.	114220.	254348.	125567.	90484.
1992	0.	0.	121610.	290889.	121814.	94081.
1993	0.	0.	124896.	323137.	136478.	104811.
1994	0.	0.	149436.	361100.	142728.	94482.
1995	0.	0.	225186.	387462.	181899.	120525.

PREDATOR WHITING

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	1810.	84064.	0.	0.	246690.	49512.	442415.	916407.
1975	1704.	162585.	0.	0.	71232.	26327.	616523.	1200180.
1976	6463.	140769.	0.	0.	63233.	15183.	550846.	867010.
1977	2640.	124051.	0.	0.	117059.	19535.	388551.	799080.
1978	6675.	183901.	0.	0.	161668.	22968.	409373.	860959.
1979	4746.	129800.	0.	0.	204603.	46118.	518507.	765843.
1980	3906.	150691.	0.	0.	130366.	79102.	542186.	691434.
1981	5658.	62615.	0.	0.	105720.	78268.	473940.	530900.
1982	5295.	52086.	0.	0.	56031.	100617.	490235.	425813.
1983	2250.	29621.	0.	0.	74321.	87673.	339105.	365254.
1984	1306.	49488.	0.	0.	40855.	84558.	265863.	366135.
1985	2339.	50232.	0.	0.	38089.	110447.	184872.	434602.
1986	1146.	56260.	0.	0.	68821.	162441.	210703.	603358.
1987	1074.	64739.	0.	0.	21195.	177434.	208840.	523678.
1988	1293.	76526.	0.	0.	19566.	141415.	239133.	454368.
1989	1018.	83566.	0.	0.	24438.	105436.	294523.	491166.
1990	1036.	43509.	0.	0.	51571.	79155.	274864.	405952.
1991	1486.	34893.	0.	0.	43206.	61885.	282960.	368638.
1992	1517.	46168.	0.	0.	63833.	73287.	267105.	354344.
1993	2632.	47967.	0.	0.	28551.	73570.	224277.	387811.
1994	1376.	41290.	0.	0.	81298.	42397.	264045.	476918.
1995	1203.	70370.	0.	0.	59688.	66721.	341678.	523874.

Table 3.1.2.1 (continued)

Table Continued

PREDATOR WHITING

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	ST.BIOM.	YIELD
1974	0.	0.	1740897.	1999765.	549233.	325299.
1975	0.	0.	2078551.	2778821.	611233.	270350.
1976	0.	0.	1643505.	2595664.	652877.	341950.
1977	0.	0.	1450915.	2361766.	557895.	288723.
1978	0.	0.	1645545.	2959303.	611283.	203973.
1979	0.	0.	1669617.	2430308.	659137.	257505.
1980	0.	0.	1597686.	2649991.	678207.	227373.
1981	0.	0.	1257101.	1770465.	610600.	209240.
1982	0.	0.	1130078.	1455013.	438307.	152632.
1983	0.	0.	898223.	1134380.	358647.	170142.
1984	0.	0.	808205.	1451656.	320061.	150244.
1985	0.	0.	820582.	1510677.	302764.	108796.
1986	0.	0.	1102729.	1549158.	362433.	159171.
1987	0.	0.	996960.	1697680.	391715.	147898.
1988	0.	0.	932302.	1863518.	406893.	188375.
1989	0.	0.	1000147.	1975336.	449167.	156734.
1990	0.	0.	856087.	1507206.	418350.	200626.
1991	0.	0.	793068.	1226576.	327941.	142339.
1992	0.	0.	806252.	1403349.	316475.	119939.
1993	0.	0.	764807.	1434076.	328621.	110893.
1994	0.	0.	907324.	1331177.	322779.	85546.
1995	0.	0.	1063534.	1708943.	370263.	98569.

PREDATOR SAITHE

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	44.	28417.	0.	0.	516847.	35093.	488564.	173277.
1975	34.	55721.	0.	0.	229424.	17279.	568006.	178952.
1976	147.	55034.	0.	0.	175090.	12727.	614437.	133744.
1977	22.	26773.	0.	0.	188699.	7287.	394283.	111279.
1978	63.	25800.	0.	0.	172635.	7138.	247066.	102796.
1979	32.	14745.	0.	0.	183594.	10613.	253455.	74473.
1980	21.	15554.	0.	0.	127515.	15731.	268019.	48839.
1981	52.	13973.	0.	0.	154096.	19729.	316010.	58619.
1982	58.	12572.	0.	0.	90143.	19896.	331692.	79296.
1983	19.	7439.	0.	0.	124387.	22786.	301387.	67455.
1984	10.	20470.	0.	0.	101862.	25850.	337570.	62191.
1985	25.	33464.	0.	0.	138187.	44166.	322652.	78295.
1986	8.	24706.	0.	0.	221061.	48504.	300113.	103003.
1987	4.	14617.	0.	0.	37606.	61972.	199210.	80660.
1988	7.	16894.	0.	0.	28286.	66337.	138571.	63484.
1989	8.	11768.	0.	0.	29428.	45131.	137028.	50223.
1990	10.	8942.	0.	0.	69430.	36103.	167267.	39030.
1991	15.	10175.	0.	0.	76920.	27546.	213556.	53625.
1992	17.	11263.	0.	0.	92195.	25327.	203780.	49506.
1993	18.	17078.	0.	0.	56377.	21980.	241902.	62676.
1994	11.	9042.	0.	0.	125484.	25558.	192742.	78622.
1995	8.	21281.	0.	0.	118667.	27942.	312264.	71050.

PREDATOR SAITHE

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	ST.BIOM.	YIELD
1974	0.	0.	1242242.	709761.	806265.	297644.
1975	0.	0.	1049416.	745326.	754124.	296983.
1976	0.	0.	991179.	801281.	709883.	351419.
1977	0.	0.	728344.	598553.	500416.	193177.
1978	0.	0.	555498.	506574.	416990.	141485.
1979	0.	0.	536912.	424482.	373978.	110451.
1980	0.	0.	475680.	369263.	369985.	120286.
1981	0.	0.	562480.	531439.	392729.	116690.
1982	0.	0.	533657.	503055.	416343.	159959.
1983	0.	0.	523473.	431240.	420468.	171556.
1984	0.	0.	547952.	538318.	481490.	216102.
1985	0.	0.	616789.	711736.	536733.	238496.
1986	0.	0.	697394.	737596.	515794.	248245.
1987	0.	0.	394069.	591251.	410975.	207757.
1988	0.	0.	313579.	478919.	305317.	113025.
1989	0.	0.	273584.	398367.	288934.	119148.
1990	0.	0.	320782.	398473.	287011.	92964.
1991	0.	0.	381836.	472600.	324329.	120713.
1992	0.	0.	382089.	393771.	322229.	108175.
1993	0.	0.	400029.	525782.	349188.	105698.
1994	0.	0.	431459.	469083.	362984.	97196.
1995	0.	0.	551212.	556006.	387579.	113672.

Table 3.1.2.1 (continued)

Table Continued

PREDATOR MACKEREL

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	358.	1208.	0.	0.	0.	48294.	280234.	1950948.
1975	308.	543.	0.	0.	0.	13260.	279743.	1219783.
1976	1283.	503.	0.	0.	0.	6660.	187570.	939116.
1977	273.	338.	0.	0.	0.	8052.	81909.	758143.
1978	762.	552.	0.	0.	0.	6415.	87917.	592635.
1979	178.	222.	0.	0.	0.	12775.	81956.	431921.
1980	84.	132.	0.	0.	0.	14630.	42669.	268313.
1981	210.	43.	0.	0.	0.	12283.	67564.	207524.
1982	490.	59.	0.	0.	0.	18368.	61937.	189215.
1983	210.	44.	0.	0.	0.	15860.	49126.	223721.
1984	105.	96.	0.	0.	0.	11749.	32165.	212953.
1985	47.	45.	0.	0.	0.	10487.	10190.	115433.
1986	16.	14.	0.	0.	0.	8957.	8739.	57933.
1987	6.	8.	0.	0.	0.	4242.	4423.	31968.
1988	11.	8.	0.	0.	0.	4406.	9106.	46160.
1989	15.	11.	0.	0.	0.	2261.	8446.	32330.
1990	15.	8.	0.	0.	0.	1986.	9119.	37237.
1991	29.	6.	0.	0.	0.	1699.	13095.	33358.
1992	69.	14.	0.	0.	0.	3517.	13694.	41298.
1993	149.	26.	0.	0.	0.	3533.	19353.	73604.
1994	73.	30.	0.	0.	0.	1540.	32413.	106067.
1995	65.	77.	0.	0.	0.	6246.	29476.	125139.

PREDATOR MACKEREL

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	ST.BIOM.	YIELD
1974	0.	0.	2281044.	3997701.	985228.	197821.
1975	0.	0.	1513638.	4201382.	892661.	189289.
1976	0.	0.	1135133.	3535927.	751527.	177178.
1977	0.	0.	848716.	2789017.	617458.	191235.
1978	0.	0.	688282.	1961305.	454499.	101108.
1979	0.	0.	527052.	1636001.	365719.	70246.
1980	0.	0.	325827.	1546254.	311368.	73141.
1981	0.	0.	287624.	1327367.	259181.	63766.
1982	0.	0.	270069.	1257736.	233413.	45095.
1983	0.	0.	288960.	1009196.	212772.	49662.
1984	0.	0.	257068.	714222.	171770.	71700.
1985	0.	0.	136203.	457005.	107536.	58237.
1986	0.	0.	75659.	287907.	65192.	31443.
1987	0.	0.	40648.	183943.	33293.	2863.
1988	0.	0.	59691.	300922.	55844.	6687.
1989	0.	0.	43063.	237651.	39174.	9863.
1990	0.	0.	48365.	248334.	39328.	14137.
1991	0.	0.	48187.	314627.	43496.	13132.
1992	0.	0.	58591.	399732.	55370.	12773.
1993	0.	0.	96665.	440752.	67086.	9958.
1994	0.	0.	140123.	477350.	76258.	5457.
1995	0.	0.	161002.	569663.	93835.	6110.

PREDATOR HADDOCK

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	1.	419.	0.	0.	7386.	379.	119479.	434595.
1975	0.	209.	0.	0.	1543.	149.	148903.	410484.
1976	2.	373.	0.	0.	1472.	298.	118682.	281766.
1977	1.	353.	0.	0.	1527.	115.	61533.	187726.
1978	2.	133.	0.	0.	1886.	38.	42589.	130536.
1979	1.	78.	0.	0.	2813.	146.	52494.	136413.
1980	1.	128.	0.	0.	1749.	75.	59542.	133363.
1981	1.	139.	0.	0.	1661.	250.	83689.	194468.
1982	2.	202.	0.	0.	1133.	610.	104928.	170698.
1983	1.	71.	0.	0.	1854.	434.	71042.	148622.
1984	1.	115.	0.	0.	1288.	1258.	68749.	130846.
1985	2.	231.	0.	0.	1137.	675.	51462.	223489.
1986	1.	175.	0.	0.	1580.	1535.	51004.	181533.
1987	0.	85.	0.	0.	322.	719.	41155.	94902.
1988	0.	170.	0.	0.	295.	1899.	31956.	103225.
1989	0.	107.	0.	0.	204.	798.	29033.	63495.
1990	0.	23.	0.	0.	376.	184.	20247.	41080.
1991	1.	19.	0.	0.	453.	356.	23436.	58583.
1992	1.	62.	0.	0.	860.	138.	29108.	69886.
1993	1.	90.	0.	0.	391.	257.	36938.	111611.
1994	0.	100.	0.	0.	1530.	294.	50654.	166487.
1995	0.	153.	0.	0.	1304.	546.	74631.	150783.

Table 3.1.2.1 (continued)

Table Continued

PREDATOR HADDOCK

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	ST.BIOM.	YIELD
1974	0.	0.	562260.	3074858.	1032840.	371972.
1975	0.	0.	561288.	2195351.	1331463.	504337.
1976	0.	0.	402592.	1298347.	694239.	424403.
1977	0.	0.	251254.	1128329.	458748.	249533.
1978	0.	0.	175185.	1383575.	430350.	202970.
1979	0.	0.	191943.	1743277.	468263.	184880.
1980	0.	0.	194858.	1699421.	710004.	236571.
1981	0.	0.	280209.	1331089.	543729.	221724.
1982	0.	0.	277573.	1028732.	518719.	215955.
1983	0.	0.	222024.	1175541.	422231.	228053.
1984	0.	0.	202256.	1306556.	552948.	192872.
1985	0.	0.	276997.	1174109.	524410.	268761.
1986	0.	0.	235827.	1121520.	437063.	257298.
1987	0.	0.	137183.	952175.	470863.	169910.
1988	0.	0.	137545.	624622.	351502.	217446.
1989	0.	0.	93636.	408817.	232017.	126844.
1990	0.	0.	61910.	532537.	165769.	84395.
1991	0.	0.	82848.	670137.	228388.	79514.
1992	0.	0.	100054.	933361.	274789.	122522.
1993	0.	0.	149287.	860712.	402992.	169858.
1994	0.	0.	219066.	1161421.	326386.	150149.
1995	0.	0.	227417.	1403437.	59185	140373.

PREDATOR W_MACKEREL

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	1333.	7377.	0.	0.	0.	14891.	280405.	1270362.
1975	2223.	20781.	0.	0.	0.	5731.	644467.	2441262.
1976	1829.	4639.	0.	0.	0.	1195.	176153.	415390.
1977	157.	1135.	0.	0.	0.	626.	98496.	130141.
1978	1381.	3981.	0.	0.	0.	1237.	134439.	250938.
1979	1447.	5034.	0.	0.	0.	7763.	294194.	554409.
1980	1237.	6839.	0.	0.	0.	12608.	389096.	611735.
1981	2110.	2723.	0.	0.	0.	12594.	608398.	757341.
1982	5024.	4938.	0.	0.	0.	35870.	697759.	822699.
1983	1845.	2639.	0.	0.	0.	31525.	695964.	1180138.
1984	1859.	7594.	0.	0.	0.	31077.	837264.	993639.
1985	2210.	4785.	0.	0.	0.	55883.	543519.	1376485.
1986	1033.	4093.	0.	0.	0.	105144.	969349.	1179878.
1987	950.	6373.	0.	0.	0.	55744.	1011878.	899471.
1988	675.	4423.	0.	0.	0.	33652.	985457.	903422.
1989	570.	3982.	0.	0.	0.	27709.	869746.	642861.
1990	763.	3555.	0.	0.	0.	26306.	1235680.	1068692.
1991	1093.	2253.	0.	0.	0.	18327.	1093221.	913335.
1992	1324.	3764.	0.	0.	0.	34545.	837883.	698604.
1993	2802.	4665.	0.	0.	0.	29866.	1104895.	1202341.
1994	1075.	2945.	0.	0.	0.	9729.	1150153.	1328694.
1995	945.	5542.	0.	0.	0.	37848.	918294.	823506.

PREDATOR W_MACKEREL

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	AV.BIOM.
1974	0.	0.	1574368.	932275.	442769.
1975	0.	0.	3114465.	1677269.	841922.
1976	0.	0.	599206.	465883.	195792.
1977	0.	0.	230555.	205778.	89983.
1978	0.	0.	391974.	349970.	141257.
1979	0.	0.	862847.	778150.	305261.
1980	0.	0.	1021515.	1582416.	491198.
1981	0.	0.	1383167.	1276513.	513514.
1982	0.	0.	1566290.	2229315.	697052.
1983	0.	0.	1912111.	2296078.	778934.
1984	0.	0.	1871432.	2522147.	837532.
1985	0.	0.	1982882.	2799100.	849438.
1986	0.	0.	2259498.	3249163.	1033217.
1987	0.	0.	1974415.	3452763.	1072346.
1988	0.	0.	1927629.	2859137.	921879.
1989	0.	0.	1544868.	2889000.	854968.
1990	0.	0.	2334996.	3092182.	1072346.
1991	0.	0.	2028229.	2758536.	921879.
1992	0.	0.	1576121.	2857747.	854968.
1993	0.	0.	2344569.	3235875.	1080369.
1994	0.	0.	2492596.	2862494.	1013776.
1995	0.	0.	1786134.	3046285.	923795.

Table 3.1.2.1 (continued)

Table Continued

PREDATOR RAJA RADIATA

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	170.	1910.	0.	0.	0.	910.	6062.	27569.
1975	33.	351.	0.	0.	0.	81.	3519.	8997.
1976	35.	98.	0.	0.	0.	12.	1121.	1882.
1977	15.	198.	0.	0.	0.	28.	1027.	2587.
1978	264.	1013.	0.	0.	0.	155.	2587.	10734.
1979	38.	227.	0.	0.	0.	52.	1861.	3785.
1980	122.	1935.	0.	0.	0.	692.	6607.	11758.
1981	589.	2233.	0.	0.	0.	2054.	7511.	26905.
1982	304.	605.	0.	0.	0.	1058.	3931.	9700.
1983	436.	2019.	0.	0.	0.	5869.	15739.	35108.
1984	541.	4193.	0.	0.	0.	9706.	17429.	52829.
1985	1331.	6786.	0.	0.	0.	16655.	16936.	88316.
1986	470.	7412.	0.	0.	0.	19296.	8656.	82541.
1987	387.	6679.	0.	0.	0.	21447.	13914.	68573.
1988	238.	2811.	0.	0.	0.	8567.	4940.	36391.
1989	351.	9325.	0.	0.	0.	10162.	14255.	61276.
1990	196.	3103.	0.	0.	0.	4833.	8610.	34594.
1991	415.	2930.	0.	0.	0.	4991.	9612.	43895.
1992	1309.	7648.	0.	0.	0.	13147.	38313.	114088.
1993	2069.	8857.	0.	0.	0.	16165.	24120.	107611.
1994	326.	3422.	0.	0.	0.	4316.	7913.	48152.
1995	431.	6933.	0.	0.	0.	4538.	22765.	71049.

PREDATOR RAJA RADIATA

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	AV.BIOM.
1974	0.	0.	36621.	37831.	49326.
1975	0.	0.	12981.	36895.	15769.
1976	0.	0.	3148.	6295.	3777.
1977	0.	0.	3854.	9621.	5505.
1978	0.	0.	14753.	30613.	20865.
1979	0.	0.	5963.	14969.	8043.
1980	0.	0.	21113.	35100.	30183.
1981	0.	0.	39291.	78643.	66236.
1982	0.	0.	15598.	23526.	22408.
1983	0.	0.	59171.	85612.	87036.
1984	0.	0.	84698.	121873.	122202.
1985	0.	0.	130024.	216668.	210747.
1986	0.	0.	118374.	148329.	160212.
1987	0.	0.	111001.	171879.	162221.
1988	0.	0.	52947.	103245.	91444.
1989	0.	0.	95369.	162273.	154085.
1990	0.	0.	51336.	103411.	92975.
1991	0.	0.	61843.	111847.	102637.
1992	0.	0.	174505.	294125.	275256.
1993	0.	0.	158823.	281425.	265329.
1994	0.	0.	64129.	106034.	98059.
1995	0.	0.	105717.	153017.	155621.

PREDATOR GURNARDS

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	14830.	109797.	0.	0.	46939.	0.	19826.	215057.
1975	17651.	260464.	0.	0.	12956.	0.	34558.	301222.
1976	47235.	200907.	0.	0.	14083.	0.	35923.	195715.
1977	1662.	13350.	0.	0.	1909.	0.	1859.	16783.
1978	63788.	242839.	0.	0.	34316.	0.	17994.	235879.
1979	867.	5382.	0.	0.	1285.	0.	852.	5290.
1980	2752.	16912.	0.	0.	2184.	0.	2813.	14737.
1981	20825.	39074.	0.	0.	10004.	0.	10795.	99426.
1982	67232.	123554.	0.	0.	17526.	0.	35898.	187780.
1983	10780.	28217.	0.	0.	10544.	0.	10815.	77246.
1984	16923.	123501.	0.	0.	13898.	0.	26799.	138836.
1985	18079.	90080.	0.	0.	8799.	0.	14008.	135356.
1986	8633.	69620.	0.	0.	15126.	0.	9664.	116436.
1987	3424.	44778.	0.	0.	1378.	0.	6720.	39736.
1988	2942.	39986.	0.	0.	1392.	0.	3804.	42827.
1989	3910.	59315.	0.	0.	3058.	0.	8564.	53168.
1990	3229.	31813.	0.	0.	6094.	0.	7745.	57526.
1991	9116.	41787.	0.	0.	7052.	0.	11108.	97499.
1992	17308.	104362.	0.	0.	20963.	0.	21727.	153696.
1993	23089.	79522.	0.	0.	5466.	0.	14544.	143384.
1994	8426.	50513.	0.	0.	16656.	0.	10463.	123254.
1995	7359.	89173.	0.	0.	9640.	0.	18493.	95145.

Table 3.1.2.1 (continued)

Table Continued

PREDATOR GURNARDS

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	AV.BIOM.
1974	0.	0.	406450.	729964.	285611.
1975	0.	0.	626852.	969725.	415275.
1976	0.	0.	493863.	789001.	333439.
1977	0.	0.	35563.	63729.	26239.
1978	0.	0.	594817.	1139870.	448155.
1979	0.	0.	13677.	33830.	11333.
1980	0.	0.	39398.	108364.	37875.
1981	0.	0.	180124.	445224.	161247.
1982	0.	0.	431990.	1074823.	399267.
1983	0.	0.	137602.	305422.	115901.
1984	0.	0.	319958.	845723.	308652.
1985	0.	0.	266322.	428581.	187507.
1986	0.	0.	219479.	454337.	179043.
1987	0.	0.	96037.	255189.	92940.
1988	0.	0.	90951.	183294.	73529.
1989	0.	0.	128016.	376700.	131275.
1990	0.	0.	106406.	341047.	113767.
1991	0.	0.	166563.	519178.	173157.
1992	0.	0.	318056.	1180838.	371116.
1993	0.	0.	266004.	772303.	263856.
1994	0.	0.	209312.	467693.	174570.
1995	0.	0.	219810.	573741.	205800.

PREDATOR SEAL

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	4212.	3487.	3100.	0.	1126.	28.	0.	0.
1975	4341.	4602.	2652.	0.	1317.	17.	0.	0.
1976	4277.	4700.	2662.	0.	1372.	16.	0.	0.
1977	5531.	4470.	2057.	0.	934.	7.	0.	0.
1978	4900.	5700.	1782.	0.	649.	14.	0.	0.
1979	6832.	6656.	1737.	0.	1375.	30.	0.	0.
1980	8159.	7663.	1516.	0.	856.	45.	0.	0.
1981	7956.	7391.	1842.	0.	877.	59.	0.	0.
1982	9134.	7768.	2058.	0.	1474.	69.	0.	0.
1983	6061.	7713.	1772.	0.	1331.	97.	0.	0.
1984	6828.	5781.	1458.	0.	1977.	133.	0.	0.
1985	6395.	5205.	1705.	0.	1244.	209.	0.	0.
1986	8554.	6223.	1969.	0.	1705.	246.	0.	0.
1987	6176.	7154.	2598.	0.	1420.	382.	0.	0.
1988	7026.	6547.	1768.	0.	1549.	383.	0.	0.
1989	6100.	10088.	2090.	0.	1191.	515.	0.	0.
1990	5019.	9559.	2023.	0.	729.	689.	0.	0.
1991	6669.	11150.	2797.	0.	1813.	749.	0.	0.
1992	6651.	13705.	3852.	0.	1017.	546.	0.	0.
1993	6982.	15514.	3288.	0.	1670.	363.	0.	0.
1994	11268.	13717.	4136.	0.	1600.	317.	0.	0.
1995	11105.	15995.	4309.	0.	4029.	294.	0.	0.

PREDATOR SEAL

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	AV.BIOM.
1974	1012.	53.	13018.	18042.	1350.
1975	915.	44.	13888.	17171.	1350.
1976	922.	56.	14004.	19356.	1450.
1977	1048.	62.	14109.	18791.	1430.
1978	1415.	53.	14512.	20689.	1530.
1979	1427.	53.	18108.	21694.	1730.
1980	1328.	77.	19644.	23379.	1870.
1981	1373.	83.	19581.	26433.	2000.
1982	1388.	83.	21976.	26109.	2090.
1983	1374.	93.	18442.	27572.	2000.
1984	1366.	70.	17612.	25641.	1880.
1985	1791.	93.	16642.	32363.	2130.
1986	2189.	118.	21004.	33062.	2350.
1987	2665.	93.	20487.	37490.	2520.
1988	2245.	200.	19718.	33198.	2300.
1989	2671.	177.	22832.	40667.	2760.
1990	3533.	184.	21737.	45213.	2910.
1991	4312.	324.	27814.	52710.	3500.
1992	3739.	364.	29875.	60313.	3920.
1993	3598.	399.	31813.	65276.	4220.
1994	3092.	288.	34418.	67964.	4450.
1995	2838.	599.	39168.	70346.	4760.

Table 3.1.2.1 (continued)

Table Continued

PREDATOR BIRDS

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	3652.	3763.	0.	0.	10272.	441.	0.	125233.
1975	3796.	5671.	0.	0.	7889.	289.	0.	120735.
1976	8887.	5064.	0.	0.	2310.	303.	0.	112419.
1977	7340.	4901.	0.	0.	3729.	149.	0.	109336.
1978	10278.	6618.	0.	0.	5501.	258.	0.	110978.
1979	9457.	5314.	0.	0.	7670.	516.	0.	108050.
1980	9449.	5100.	0.	0.	7286.	819.	0.	100076.
1981	10395.	2936.	0.	0.	4363.	1040.	0.	97241.
1982	13184.	3257.	0.	0.	3995.	1293.	0.	107950.
1983	7541.	2434.	0.	0.	4803.	1798.	0.	119290.
1984	6683.	3979.	0.	0.	6035.	2804.	0.	122296.
1985	7593.	4329.	0.	0.	3508.	3971.	0.	120211.
1986	6673.	4504.	0.	0.	5085.	3718.	0.	146325.
1987	3362.	3756.	0.	0.	3771.	5089.	0.	165412.
1988	4219.	5387.	0.	0.	1154.	7286.	0.	141034.
1989	4198.	5491.	0.	0.	1801.	8645.	0.	119520.
1990	3390.	3389.	0.	0.	3390.	9781.	0.	119883.
1991	5729.	3194.	0.	0.	4863.	8604.	0.	138668.
1992	6196.	4535.	0.	0.	5861.	5705.	0.	151709.
1993	8616.	4527.	0.	0.	5206.	3845.	0.	158729.
1994	7496.	4420.	0.	0.	6482.	3282.	0.	175250.
1995	5212.	5702.	0.	0.	9089.	3153.	0.	187384.

PREDATOR BIRDS

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	AV.BIOM.
1974	0.	0.	143361.	98235.	1510.
1975	0.	0.	138379.	111005.	1559.
1976	0.	0.	128982.	128426.	1609.
1977	0.	0.	125454.	140254.	1661.
1978	0.	0.	133633.	140627.	1714.
1979	0.	0.	131006.	152090.	1769.
1980	0.	0.	122730.	169482.	1826.
1981	0.	0.	115975.	185645.	1885.
1982	0.	0.	129679.	181661.	1946.
1983	0.	0.	135867.	185497.	2009.
1984	0.	0.	141798.	189918.	2073.
1985	0.	0.	139612.	202788.	2140.
1986	0.	0.	166305.	187123.	2209.
1987	0.	0.	181389.	183427.	2280.
1988	0.	0.	159079.	217481.	2354.
1989	0.	0.	139655.	249037.	2429.
1990	0.	0.	139833.	261375.	2508.
1991	0.	0.	161058.	253070.	2588.
1992	0.	0.	174005.	253467.	2672.
1993	0.	0.	180924.	260316.	2758.
1994	0.	0.	196929.	258523.	2847.
1995	0.	0.	210540.	259576.	2938.

PREDATOR OTHERS

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	N. POUT	SANDEEL
1974	6131.	30387.	0.	0.	116477.	13826.	256803.	312825.
1975	8277.	51463.	0.	0.	134055.	12924.	224041.	292164.
1976	8085.	47127.	0.	0.	43125.	9791.	318928.	239385.
1977	14832.	40971.	0.	0.	41756.	5333.	307729.	243831.
1978	14977.	54224.	0.	0.	65131.	7715.	195523.	279301.
1979	12490.	47752.	0.	0.	76408.	9770.	258190.	236272.
1980	17107.	44569.	0.	0.	89170.	15259.	344743.	177644.
1981	18819.	35390.	0.	0.	62446.	29885.	217212.	153852.
1982	12129.	20524.	0.	0.	44992.	30113.	291267.	269505.
1983	10035.	19422.	0.	0.	44432.	49611.	355110.	155095.
1984	11220.	23392.	0.	0.	74696.	61056.	253223.	249676.
1985	10419.	31065.	0.	0.	56813.	86397.	192196.	160464.
1986	9942.	32104.	0.	0.	42810.	81896.	90348.	392105.
1987	9171.	31527.	0.	0.	60891.	116541.	138617.	283176.
1988	7440.	35776.	0.	0.	22924.	144147.	101616.	190644.
1989	6708.	45197.	0.	0.	18454.	93112.	168563.	227100.
1990	6334.	31913.	0.	0.	27109.	70032.	188343.	178319.
1991	4848.	24128.	0.	0.	47762.	53944.	169433.	229282.
1992	6311.	23067.	0.	0.	45273.	42537.	243958.	246981.
1993	6515.	28792.	0.	0.	62151.	53139.	190850.	199365.
1994	8975.	30219.	0.	0.	47203.	54378.	143737.	255824.
1995	8089.	27578.	0.	0.	82758.	29863.	235420.	290793.

Table 3.1.2.1 (continued)

Table Continued

PREDATOR	OTHERS				
PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	AV.BIOM.
1974	0.	0.	736449.	503551.	310000.
1975	0.	0.	722924.	517076.	310000.
1976	0.	0.	666441.	573559.	310000.
1977	0.	0.	654452.	585548.	310000.
1978	0.	0.	616872.	623128.	310000.
1979	0.	0.	640881.	599119.	310000.
1980	0.	0.	688492.	551508.	310000.
1981	0.	0.	517603.	722397.	310000.
1982	0.	0.	668530.	571470.	310000.
1983	0.	0.	633703.	606297.	310000.
1984	0.	0.	673263.	566737.	310000.
1985	0.	0.	537354.	702646.	310000.
1986	0.	0.	649205.	590795.	310000.
1987	0.	0.	639923.	600077.	310000.
1988	0.	0.	502547.	737453.	310000.
1989	0.	0.	559134.	680866.	310000.
1990	0.	0.	502050.	737950.	310000.
1991	0.	0.	529397.	710603.	310000.
1992	0.	0.	608127.	631873.	310000.
1993	0.	0.	540813.	699187.	310000.
1994	0.	0.	540335.	699665.	310000.
1995	0.	0.	674501.	565499.	310000.

Table 3.1.2.2

Table TOTAL BIOMASSES CONSUMED BY ALL PREDATORS, COMPARED TO TOTAL STOCK BIOMASS AND TOTAL YIELD

	MSVPA SPECIES						OTHER PREDATORS		
YEAR	TOTAL BIOMASS	AVERAGE BIOMASS	TOTAL YIELD	TOTAL FISH EATEN	TOT. OTH. MORTALITY	TOT. OTH. FOOD EATEN	AVERAGE BIOMASS	TOTAL FISH EATEN	TOT. OTH. FOOD EATEN
1974	11249308.	10267920.	2852403.	6260275.	1907505.	10219979.	1090566.	2910268.	2319897.
1975	9998202.	9645671.	2703535.	5563258.	1799311.	10395447.	1585874.	4629490.	3329141.
1976	8596037.	7789987.	2730847.	4478717.	1448747.	8780282.	846067.	1905644.	1982520.
1977	7234952.	6609187.	2315078.	3601563.	1226409.	7554383.	434817.	1063986.	1023722.
1978	6825000.	6311734.	2250920.	3417127.	1169606.	7523707.	923521.	1766561.	2304897.
1979	6381197.	6353629.	2148544.	3309905.	1175796.	6886105.	638137.	1672483.	1599852.
1980	6891053.	6125257.	2419364.	3020834.	1115705.	7074093.	872952.	1912893.	2470248.
1981	5446245.	5732222.	2362413.	2782135.	1029296.	5762621.	1054882.	2255741.	2734855.
1982	6474573.	6459363.	2398952.	2561574.	1151199.	4952853.	1432762.	2834063.	4106904.
1983	6028287.	6512244.	2431788.	2251525.	1133631.	4288413.	1295880.	2896896.	3506478.
1984	7015316.	6812891.	2695773.	2107097.	1165237.	4559353.	1582340.	3108761.	4272040.
1985	6004623.	6219225.	2650695.	2118674.	1033528.	4356722.	1561962.	3072837.	4382145.
1986	6622883.	7699825.	2135056.	2366426.	1291914.	4174608.	1687031.	3433866.	4662809.
1987	7500859.	7789427.	2582563.	1831270.	1264908.	3837510.	1642306.	3023251.	4700826.
1988	6356079.	6600306.	2678187.	1651018.	1030710.	3615195.	1401505.	2752871.	4133807.
1989	6130117.	6117632.	2491052.	1570096.	963089.	3315344.	1455517.	2489874.	4398543.
1990	5147666.	5501330.	2017664.	1424907.	876408.	2954692.	1594506.	3156358.	4581178.
1991	5026619.	5611476.	2146799.	1420159.	930604.	2938289.	1513762.	2974904.	4405945.
1992	5464546.	5704821.	2130714.	1468596.	969979.	3421103.	1817931.	2880689.	5278362.
1993	5107629.	5507159.	1926826.	1535684.	939572.	3584460.	1926532.	3522946.	5314383.
1994	5043438.	5874686.	1989715.	1847409.	1031807.	3800130.	1603702.	3537719.	4462372.
1995	6389406.	6375280.	2226491.	2228351.	1146961.	4625512.	1602914.	3035869.	4668464.

Table 3.1.2.3 Mean values of multi and single species natuaral mortality (M) over the years 1974-94

	Multi species M						Single species M					
	Age group						Age group					
	0	1	2	3	4	5	0	1	2	3	4	5
Species												
Cod	2.21	0.91	0.40	0.29	0.19	0.18	2.70	0.80	0.35	0.25	0.20	0.20
Haddock	2.19	1.57	0.34	0.27	0.27	0.28	2.05	1.65	0.40	0.25	0.25	0.20
Herring	0.82	0.74	0.50	0.32	0.18	0.17	2.00	1.00	0.30	0.20	0.10	0.10
Norway pout	1.56	1.80	1.89	0.95	_	_	1.60	1.60	1.60	1.60	_	_
Sandeel	1.43	1.43	0.75	0.91	0.82	1.08	1.60	1.20	0.60	0.60	0.60	0.60
Whiting	2.08	1.21	0.46	0.34	0.38	0.41	2.55	0.95	0.45	0.35	0.30	0.25

Table 3.1.2.4 Mean values of Predatation mortality (M2) over the years 1974-84 and residual natuaral mortality (M1)

	Predation mortality (M2)						
	Age group						
	0	1	2	3	4	5	M1
Species							
Cod	2.07	0.79	0.27	0.12	0.02	0.02	0.16
Haddock	2.09	1.51	0.16	0.08	0.08	0.06	0.20
Herring	0.81	0.71	0.42	0.24	0.09	0.08	0.10
Norway pout	1.03	1.59	1.64	0.74	_	_	0.20
Sandeel	1.18	1.39	0.59	0.81	0.78	1.12	0.20
Whiting	1.95	1.05	0.29	0.16	0.18	0.18	0.20

Mean values of Predatation mortality (M2) over the years 1985-94 and residual natuaral mortality (M1)

	Predation mortality (M2)						
	Age group						
	0	1	2	3	4	5	M1
Species							
Cod	2.04	0.71	0.21	0.14	0.04	0.03	0.16
Haddock	1.88	1.22	0.13	0.07	0.07	0.10	0.20
Herring	0.63	0.57	0.37	0.20	0.07	0.07	0.10
Norway pout	1.72	1.61	1.76	0.76	_	_	0.20
Sandeel	1.29	1.04	0.50	0.61	0.44	0.62	0.20
Whiting	1.80	0.97	0.23	0.13	0.19	0.24	0.20

Mean values of Predatation mortality (M2) over the years 1974-94 and residual natuaral mortality (M1)

	Predation mortality (M2)						
	Age group						
	0	1	2	3	4	5	M1
Species							
Cod	2.05	0.75	0.24	0.13	0.03	0.02	0.16
Haddock	1.99	1.37	0.14	0.07	0.07	0.08	0.20
Herring	0.72	0.64	0.40	0.22	0.08	0.07	0.10
Norway pout	1.36	1.60	1.69	0.75	_	_	0.20
Sandeel	1.23	1.23	0.55	0.71	0.62	0.88	0.20
Whiting	1.88	1.01	0.26	0.14	0.18	0.21	0.20

Table 3.2.1.1 Frequencies of occurrence of various magnitudes of differences in suitabilities and M2 between KEYRUN and run with censored weights. All predators combined.

MAGNITUDE OF CHANGE IN SUITABILITY	FREQUENCY OF OCCURRENCE	MAGNITUDE OF CHANGE IN M2	FREQUENCY OF OCCURRENCE
> -0.1	5	> -.005	1
-.005 to -.1	2	-.001 to -.005	0
-.002 to -.005	34	-.0005 to -.001	6
-.001 to -.002	39	-.0001 to -.0005	49
-.0005 to -.001	45	-.00005 to -.0001	36
0 to -.0005	620	0 to -.00005	757
0.0 to +.0005	594	+.00005 to 0.0	312
+.0005 to .001	4	+.0001 to .00005	37
+.001 to .002	4	+.0005 to .0001	77
+.002 to .005	11	+.001 to .0005	7
+.005 to .01	9	+.005 to .001	2
>0.1	0	>.005	0

Table 3.2.1.2 Keyrun vs. censored weights. Linear models fitting the change in suitability and M2 to the change in predator biomass. Models with both overall slope and with separate slopes for each predator are fit. Where significant fits were found, table entries are percent of variance explained, and, for separate slopes model, the species with significant parameter estimates. Changes are expressed as both absolute value (tonnes) and percent of mean biomass of the two runs.

Change in:	suit	M2
Predator biomass	**NO**	**.026 (+)**
Prey biomass	**NO**	**.014 (+)**
% Predator biomass	**NO**	**.023 (+)**
% Prey Biomass	**NO**	**NO**

Separate slopes:

Predator biomass	**NO**	**.050 (+ Cod)**
Prey biomass	**.033 (Norway pout Sandeel)**	**.037 (+ Cod)**
% Predator biomass	**NO**	**.053 (+ Cod)**
% Prey biomass	**.024 (Cod)**	**.079 (+ Cod)**

Fixed effects model:	**NO**	**.031**
Predator species	**NO**	**.019**
Prey species	**NO**	**.016**
Predator * Prey	**NO**	**.0098**

Translation of the predator code in the M2 bar charts
1 = cod
2 = whiting
3 = saithe
4 = mackerel
5 = haddock
6 = w. mackerel
7 = starry ray
8 = horse mackerel
9 = grey gurnards
10 = seals
11 = birds
12 = other

Table 3.2.2.2.1 ANOVA of 1981 and 1991 estimates of suitability

SSq				
Cause	cod	whiting	saithe	haddock
mean	3329.6 100.0%	993.55 100.0%	960.31 100.0%	548.93 100.0%
+basic model	1240 37.2%	437.4 44.0%	375.4 39.1%	234.2 42.7%
+predator size	54.2 1.6%	64.17 6.5%	8.247 0.9%	33.49 6.1%
+skewness of Size Pref.	9.753 0.3%	0.07211 0.0%	20.62 2.1%	0.8957 0.2%
+scalings.yr	305.1 9.2%	56.26 5.7%	253.8 26.4%	60.56 11.0%
+size suit.year	4.204 0.1%	0.9772 0.1%	22.97 2.4%	1.883 0.3%
residual	1716.5 51.6%	434.65 43.7%	279.33 29.1%	217.87 39.7%

D.F.				
Cause	cod	whiting	saithe	haddock
mean	866	473	182	226
+basic model	25	24	20	15
+predator size	1	1	1	1
+skewness of Size Pref.	1	1	1	1
+scalings.yr	24	21	13	11
+size suit.year	2	2	2	2
residual	813	424	145	196

M.Sq				
Cause	cod	whiting	saithe	haddock
mean	3.84	2.10	5.28	2.43
+basic model	49.60	18.23	18.77	15.61
+predator size	54.20	64.17	8.25	33.49
+skewness of Size Pref.	9.75	0.07	20.62	0.90
+scalings.yr	12.71	2.68	19.52	5.51
+size suit.year	2.10	0.49	11.49	0.94
residual	2.11	1.03	1.93	1.11

Fratio and P level				
Cause	cod	whiting	saithe	haddock
mean				
+basic model	23.49 0.0000	17.78 0.0000	9.74 0.0000	14.05 0.0000
+predator size	25.67 0.0000	62.60 0.0000	4.28 0.0403	30.13 0.0000
+skewness of Size Pref.	4.62 0.0319	0.07 0.7910	10.70 0.0013	0.81 0.3705
+scalings.yr	6.02 0.0000	2.61 0.0001	10.13 0.0000	4.95 0.0000
+size suit.year	1.00 0.3700	0.48 0.6212	5.96 0.0032	0.85 0.4303
residual	1.00 0.5000	1.00 0.5000	1.00 0.5000	1.00 0.5000

Table 3.2.2.2.2 Canonical Suitablity estimates when size \selection is nested under year.

	cod		whiting		saithe		haddock	
	1981	1991	1981	1991	1981	1991	1981	1991
μ	3.773	3.860	3.582	3.600	4.902	7.206	-0.510	1.968
σ2	2.391	3.008	1.518	1.804	0.642	-2.989	-4.634	-2.367
prefered ratio	43.524	47.456	35.940	36.590	134.528	1346.978	0.601	7.157
d (power)	-0.301	47.456	-0.781	36.590	0.532	1346.978	-0.838	7.157
e	0.120	0.000	0.026	0.000	-20.220	0.000	3.398	0.000
correction	76	52	211	122	2.69E+08			
cod.1	0.429	0.348	0.449					
cod.2	1.446	1.158						
cod.3	0.768	1.347	0.018	0.200				
cod.4	0.236	0.741	0.298	0.167				
total	2.879	3.593	0.766	0.367				
whiting.1	0.456	0.667	0.164	0.539				
whiting.2	0.125	0.349	0.869	1.191				
whiting.3	0.043	0.164	0.351	0.081	0.264			
whiting.4	0.103	0.421	0.241	0.240				
total	0.726	1.601	1.624	2.051	0.264			
haddock.1	0.316	0.100	0.556	0.365	25.277			
haddock.2	0.167	0.158	1.156		0.071			
haddock.3	0.128	0.092	0.249	0.258	2.773			
haddock.4	0.232	0.158	0.582	0.426	0.387			
total	0.843	0.508	2.542	1.049	28.508			
herring.1	0.104	0.084	0.075	0.021				
herring.2	0.100	0.057	0.423	0.062				
herring.3	0.037	0.136	0.220	0.129	0.139			
herring.4	0.040	0.022	0.053	0.033	0.145			
total	0.281	0.300	0.772	0.245	0.285			
n.pout.1	0.117	0.082	0.216	0.079	0.032			
n.pout.2	0.042	0.134	0.102	0.068	0.001			
n.pout.3	0.120	0.083	0.027	0.023	0.118			
n.pout.4	0.179	0.064	0.070	0.094	0.861			
total	0.458	0.363	0.415	0.264	1.011			
sandeel.1	0.034	0.004	0.013	0.014	0.212			
sandeel.2	0.179	0.068	0.058	0.133	0.638			
sandeel.3	0.007	0.024	0.026	0.036	16.279			
sandeel.4	0.094	0.007	0.028	0.049				
total	0.314	0.104	0.126	0.232	17.129			
sum 1	1.455	1.285	1.473	1.018	25.521			
sum 2	2.059	1.925	2.608	1.454	0.710			
sum 3	1.102	1.846	0.892	0.727	19.573			
sum 4	0.885	1.413	1.271	1.010	1.392			

Table 3.2.2.2.3 Canonical Suitablity estimates when size \selection is not nested under year.

	cod		whiting		saithe		haddock	
	1981	1991	1981	1991	1981	1991	1981	1991
μ	3.810		3.588		7.665		0.856	
σ2	2.674		1.640		-4.125		-3.351	
prefered ratio	45.158		36.147		2132.428		2.353	
d (power)	1.425		2.187		-1.858		-0.255	
e	-0.187		-0.305		0.121		0.149	
correction	62	62	162	162				
cod.1	0.427	0.347	0.399					
cod.2	1.433	1.167						
cod.3	0.744	1.415	0.018	0.190				
cod.4	0.234	0.708	0.295	0.164				
total	2.837	3.637	0.713	0.354				
whiting.1	0.454	0.656	0.149	0.567				
whiting.2	0.128	0.345	0.799	1.265				
whiting.3	0.043	0.163	0.358	0.082				
whiting.4	0.106	0.416	0.240	0.234				
total	0.731	1.580	1.546	2.148				
haddock.1	0.320	0.097	0.495	0.386				
haddock.2	0.169	0.156	1.000					
haddock.3	0.128	0.092	0.235	0.247				
haddock.4	0.238	0.153	0.538	0.426				
total	0.855	0.497	2.269	1.059				
herring.1	0.105	0.082	0.073	0.020				
herring.2	0.102	0.055	0.396	0.064				
herring.3	0.037	0.132	0.225	0.129				
herring.4	0.042	0.022	0.051	0.034				
total	0.286	0.291	0.744	0.247				
n.pout.1	0.117	0.082	0.213	0.077				
n.pout.2	0.042	0.133	0.102	0.066				
n.pout.3	0.117	0.083	0.028	0.022				
n.pout.4	0.177	0.064	0.070	0.092				
total	0.452	0.362	0.413	0.258				
sandeel.1	0.034	0.004	0.014	0.014				
sandeel.2	0.176	0.069	0.059	0.130				
sandeel.3	0.007	0.025	0.026	0.035				
sandeel.4	0.093	0.007	0.027	0.049				
total	0.310	0.105	0.125	0.228				
sum 1	1.457	1.268	1.344	1.064				
sum 2	2.049	1.924	2.355	1.526				
sum 3	1.075	1.911	0.889	0.704				
sum 4	0.889	1.370	1.221	0.999				