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REPORT OF THE MULTISPECIES ASSESSMENT WORKING GROUP

Copenhagen, 23 November - 2 December 1993

Ask not what your MSVPA can do for you but what you can do for your MSVPA

J.G.P after J.F.K.

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1 INTRODUCTION

The Multispecies Assessment Working Group met at ICES Headquarters, from 23 November-2 December 1993.

1.1 Participants

N. Bax	Australia
N. Daan	Netherlands
W. Dekker	Netherlands
H. Gislason	Denmark
J. Hislop	UK (Scotland)
T. Ling	China (with UK-Scotland delegation)
S. Mehl	Norway
S. Pedersen	Denmark (Greenland) - Part-time
J. Pope	UK (England)
J. Rice (Chairman)	Canada
P. Shelton	Canada
D. Skagen	Norway
A. Temming	Germany

H. Sparholt, the ICES Fisheries Assessment Scientist, also participated in substantial portions of the meeting.

1.2 Terms of Reference

The Terms of Reference (C.Res.1992/2:8:19) for the meeting were:

a) continue the development of multispecies methods of assessment, and report on progress in development, testing, and distribution of updated software for multispecies, multi-fleet assessments;

b) integrate the results of the 1991 Stomach Sampling Programme and produce an updated MSVPA for the North Sea, including further testing of the assumption of constant suitability;

c) evaluate the statistical properties of stomach sampling schemes, and continue the statistical analysis of feeding data;

d) initiate data preparation and model construction to apply retrospective multispecies assessment techniques to boreal systems, including variable growth and spatial overlap of predators and prey.

1.3 Overview

At this meeting, the Working Group gave preeminence to its second Term of Reference: to fully integrate the data from the 1991 Stomach Sampling Programme into the North Sea MSVPA and test the MSVPA assumption of constant suitability. Although initially these charges may seem straightforward, they are not.

First of all, there are several approaches to the second task which could render it meaningless. On one hand, useful tests must have sufficient power so that if the assumption of constant suitability is wrong, the Working Group should have a chance to actually reject the hypothesis of constant suitability. Because of the large number of suitability parameters, sampling variance in the stomach data, and lack of within-year replication, it is hard to achieve high statistical power in our tests. Lack of replication means entire classes of statistical tests are not available to test the stability of suitabilities.

On the other hand, nothing in the sea is unchanging. Were powerful tests available, we would be almost certain to reject a hypothesis that all suitabilities were constant. Does rejecting the Null Hypothesis of constant suitability mean abandoning MSVPA approaches to assessment? Scientific tests involve discriminating among alternative hypotheses. Alternatives to the MSVPA assumption of constant suitability have rarely been worked out explicitly. Important time was spent deliberating what alternatives to the MSVPA assumption would look like, and what they would mean for both the functioning of the North Sea fish predators and prey, and for the assessment of those stocks.

The inclusion of the 1991 stomach data in the North Sea MSVPA, and the examination of the effects of those data on outputs, covers the bulk of the Report. Section 3 is devoted to a description of the 1991 sampling programme, and summaries of the stomach data. It reflects an outstanding example of coordinated and complementary work among the various national laboratories and by the 10 coordinators of the sampling programme. The demanding sampling objectives were met in almost every case. Both the laboratory and computer processing of all required samples was completed in time for a meeting in 1993. Those accomplishments are remarkable. They are more noteworthy because not only do the 1991 data now exist, but they are directly comparable to another data set collected a decade earlier. The Working Group feels that fisheries would benefit if all key individuals who coordinated or processed the stomachs and stomach data would be kept healthy and on staff of their respective laboratories forever to ensure that the standards of the 1981 and 1991 stomach sampling programmes can be upheld in any future programmes.

The Working Group made substantial use of the stomach data. Those analyses are just a beginning, however. The Working Group is sure it will devote hundreds more hours to analyses of these data. Moreover, there are many other uses to be made of them, aside from Working Group activities. The potential value of the data raises a potential problem for ICES. Individual national laboratories have significant investments in portions of the data set, and plans for those portions. ICES needs a clear and consistent policy on access to the overall data base, to ensure that the interests of the contributors, of ICES, and of the scientific community in general are all protected.

Section 4 documents the three core MSVPA runs from the meeting. All used the same catch-at-age data; one used only the 1981 stomach data (81-RUN), one only the 1991 stomach data (91-RUN), and one all the stomach data, including the partial data sets from 1985-1987 (KEYRUN). The first two runs allow tests of the stability of suitabilities with independent data sets. The third set reflects the best estimates possible, using all data, and would be the basis for any new advice from multispecies assessments of the North Sea.

The figures in Section 4 illustrate that 81-RUN and 91-RUN are not identical in biomass levels, yield/biomass, biomass of prey consumed, and other summary indicators of the complex interactions within the North Sea. The differences are small, however, and the trends over 20 years are very similar. How small should the differences be, though, and how similar the trends, before one can conclude that they are biologically "the same"? That question led to the 10 subsections of chapter 6.

Section 6 first explains the rationale for the approach taken by the Working Group. It presents 9 possible models for including predation effects in assessments, from simple constant M at age to complex variants of MSVPA with changing predator/prey relationships in space and/or in time. It explains why the simplest alternatives can be (and have been) rejected without needing MSVPA results, and why rejection of constant suitabilities would not justify a return to single species assessments with constant M2 at age. Rather, it becomes clear that assumptions about ration as well as suitability are keys to selecting an appropriate model for predation in multispecies assessments (or an appropriate value for M in single species assessments).

Section 6 then presents the estimates of consumption and suitabilities in graphical form, from each of the core runs. Overall more similarities than differences are present. The most unstable suitability estimates occur when data are weak; either a rare combination of predator (age) and prey (age) or when the input catch at age data are suspect. Moreover, little of the variability in suitability estimates gets translated into variability in M2 estimates.

At the 1990 meeting of the Working Group, *a priori* predictions were made of what the 1991 diets should be, given all stomach data available in 1990. At this meeting, those predictions were updated with the new catch at age data and compared to observed diets. There are differences in detail between observed and expected consumption patterns, particularly for cod. Overall, however, observed and predicted values are close. The best estimates now, using all stomach data, are generally quite close to the observed diets in 1991.

The Working Group also considered the complementary question of stability of rations between 1981 and 1991. Such tests would be done more appropriately with the actual stomach data rather than the MSVPA calculations of amounts eaten, but some progress was made on this issue. Although the biomass of MSVPA prey was generally lower for all predators in 1991 than in 1981, only for saithe was there evidence that ration might have changed systematically with the amount of food available. These results, and the importance of assumptions about constancy of ration to selecting among predation models, led the Working Group to recommend that during its 1995 meeting the treatment of ration in multispecies models be reviewed in depth.

The theory behind MSVPA assumes predators have a log-normal size preference function and some global species preferences. Past meetings devoted substantial time to fitting models to the estimates of suitability and M2. The goal was to capture the information in the thousands of individual suitability estimates with a small number of parameter estimates. Results were always encouraging but never satisfying; many models captured about half the variance in suitabilities, none captured much more. At this meeting the Working Group undertook a fundamental reconsideration of the size preference function. Some versions of foraging theory predict that optimal prey should be nearly the largest prey a predator can handle. Working Group members derived a method to add a single parameter to the size preference function, to allow trimming of the log-normal function for large prey, given the predator size. Past work also highlighted the importance of zero suitabilities in the model fitting; the absence of prey of particular sizes can be important information for tying down the tails of the size preference function.

The theoretical motivation and explicit models are developed in Section 5 of the Report. Subsections 6.6 and 6.7 present results of fitting the new model to the estimated suitabilities. Working predator by predator, between half (cod) and three-quarters (saithe) of the variance in suitabilities was captured by the basic species-size preference model. At most an additional 10% (haddock) of the total variance was captured when year effects and interactions were added. Because of the large number of degrees of freedom, even very small increases in fit were statistically significant, so one must conclude that suitabilities did change from 1981 to 1991. However, the changes are small compared to the systematic species and size preference effects.

The Working Group continued past investigations for evidence that prey switching was a cause of the year effects. Results were inconclusive, with substantially more detailed work required. The model fits suggested that changes in overlap of predator and prey, rather than simple changes in biomass of either one, might be responsible for the small interannual variation in suitabilities. Direct analyses of the differences in suitability estimates between 81-RUN to 91-RUN found little systematic pattern in the differences. A few specific predator-prey combinations showed large changes, but most variance appeared to be noise. When the differences in suitabilities were regressed on biomass level, to investigate evidence for prey switching, models explained at most 10% of the variation in the differences. Only for sprat did predators seem attracted to it when common, or use it relatively less when rare.

The Working Group went beyond the MSVPA inputs, to contrast MSVPA outputs with independent recruitment and mortality estimates from surveys. MSVPA has only marginal effects on recruitment, compared to single species VPA. Results looking at mortality estimates are inconclusive. Some survey data are inconsistent with MSVPA outputs, but one cannot tell if the survey estimates are too variable or the MSVPA estimates lack precision.

Finally, the Working Group determined how much the types of advice provided using MSVPA would be altered by using the new stomach data, by repeating two past sets of analyses where MSVPA was the basis for advice. The first was an evaluation of the effect of a 10% change in F of all species; the second was an increase in mesh to 130 mm for the human consumption roundfish fishery. For the 10% reduction in F, results using all data (KEYRUN), 81-RUN and 91-RUN were generally similar; catches generally decreased and biomasses increased. Differences among runs using different stomach data were generally small. Likewise projected consequences of use of the 130 mm mesh did differ somewhat depending on the stomach data input būt the differences were generally small. Both analyses had problems with forecasts of haddock. Further investigations are needed to determine if the problems are biological or arise from inaccuracies in the input data. Overall, the advice expected from MSVPA appears quite robust to the stomach data used; details vary, as they do with changes in catch or recruitment estimates, but patterns of advice are stable.

The various tests of the assumption of suitability allow a range of interpretations. A statistical purist might conclude that one must reject the Hypothesis that suitabilities are constant. A data analytic pragmatist might conclude suitability estimates are noisy if based on relatively few occurrences of a particular prey item, but otherwise are usefully stable. Forecasting properties of MSVPA are robust to the observed changes in suitabilities. We did identify some areas where we expect that the performance of MSVPA can be improved, however.

First of all, we expect to find some flaws in the 1991 stomach data, as we work more with those data. Some imperfections may be coding or entry errors. Some may be true observational outliers. As these imperfections are found and dealt with, we expect differences between MSVPA runs with the different stomach data sets will become even smaller.

Several analyses and interpretations were made more difficult because observations in the stomach (and other) data sets are made as lengths, but in MSVPA they are converted to ages with an age/length key. This conversion smears a lot of potentially useful information. The Working Group has considered length-based multispecies assessments at past meetings, and concluded they had potential value but were not a priority. Based on our experiences at this meeting, it may be time to have a thorough look at a length-based MSVPA. This is another issue to be addressed fully at the next two meetings of the Working Group.

Finally, although the Working Group is satisfied that its investigation of the effects of the new stomach data on MSVPA was thorough and fair, the Group is aware that the tests were of limited statistical rigour. Until the statistical properties of both stomach data and survey data are known well, it will not be possible to establish "expected values" rigorously.

The Working Group did address its other Terms of Reference. Several items were reviewed under the first Term of Reference of the Working Group: to continue to explore and extend multispecies methods of assessment. The products of these reviews are presented in Section 2. The Working Group was favourably impressed, in general, with the Report of the Planning Group on Multispecies, Multifleet Tools for Stock Assessment. The Working Group supports the DIFMAR programme to produce a new multispecies, multifleet software package. We do have concerns that the software under development requires some major advances in data management, and that progress on the data management appears slower and less coordinated than progress on developing the assessment software.

As long as the Working Group had to rely on the 1981 stomach data, its ability to work with predation both by and on 0-group fish was limited. The 1991 stomach data do include 0-group predators, and somewhat more information on the presence of 0-group as prey in the first half of the year. It became obvious to the Working Group that 0-group predators required special treatment. Some thoughts were discussed, and the topic was flagged for extensive review at the next meeting.

The Working Group also revisited the issue of estimating suitabilities when one has multiple years of stomach data. It would have been difficult to explore the issue in depth with the software available at this meeting. Rather, the Working Group encouraged the developers of the new MSVPA software to include different options for treatment of multiple years of stomach data. If the options are available at the next meeting, this issue will also be explored in detail.

The Working Group also considered including more species as MSVPA predators and prey. Data are available both from the Study Group on Seabird/Fish Interactions, and from analyses of stomachs of more predators during the 1991 collections. For seabirds, consumption estimates must be spatially disaggregated in ways consistent with other MSVPA data. For potential new fish predators and prey, age/length conversions are questionable or impossible. The Working Group decided not to add new predators with possibly poorer quality ancillary data to the MSVPA at this meeting, because such a step would be likely to weaken the tests of the constancy of suitabilities. Instead, the suite of MSVPA species will be increased two meetings hence, with intersessional work to improve current shortcomings in the data bases.

With the support of ACFM, the Working Group has established a practice of alternating the focus of its meeting between North Sea and boreal multispecies systems. In keeping with that practice, plans were developed for the 1995 meeting. Past meetings with a boreal emphasis have entailed analysing data on cod growth, on cod diets, and discussing papers on modelling boreal systems. The Working Group felt it is time to actually attempt to apply multispecies assessment models to some boreal systems, rather than continue with preliminary analyses of data.

There were many different opinions about what activities would comprise a suitable approach to that task. MULTSPEC represents one multispecies model for a boreal sea, and the Working Group agreed it was appropriate to explore the properties of MULTSPEC. Many members hoped that alternative models, or alternative modules for key components of MULTSPEC, could also be used at the meeting. Furthermore, partly because MULTSPEC is not an intrinsically cohort-based multispecies model, the Working Group felt that both rigorous sensitivity testing and applications to known test data were needed. All these tasks require significant preparation. Therefore, the Working Group is recommending that a Planning Group be established to ensure that the necessary preparations are undertaken. These discussions and plans are documented in Section 7.

The final Term of Reference of the Working Group was to review the statistical properties of stomach contents data. The major documentation was a paper "Statistical Analyses of Stomach Content Data" by Stefánsson and Pálsson. Unfortunately neither author was in attendance, so concerns about the applicability of the model to systems where predators have diverse diets could not be pursued. The Working Group also felt that design-based approaches needed to be compared analytically to the model-based approach proposed by Stefánsson and Pálsson. Since the authors may attend the next Working Group meeting for multispecies assessments of boreal systems, these concerns will be explored further at the next meeting.

Many analyses undertaken during Multispecies Assessment Working Group meetings have had implications well beyond the meeting's specific Terms of Reference. Contributions have been made to a number of areas of fisheries science and ecology, including population dynamics modelling, foraging theory, ecosystem properties, and stock assessment methodology. Past Working Group Reports have always included a section on "Food for Thought", to document such work. The Food for Thought Section has been important to the Working Group, to ICES, and to fisheries science. It has been our proven road to progress. Ideas which were speculative several meetings ago, such as modelling the suitabilities and M2s, are now core sources of insight into MSVPA, and generally to multispecies interactions and assessments.

The Food for Thought section of this report is substantially smaller than in previous reports. Possibly we thought less, although we feel we had to focus more on our specific Terms or Reference. A much smaller group and the demands of including and testing effects of the 1991 stomach data precluded time for more speculative investigations. The material which is included in Food for Thought, on modelling and data analysis possibilities for 0-group fish, lays a foundation for work which must soon be a focus of a Working Group meeting. The next meeting on modelling boreal systems should produce a much larger section on Food for Thought.

In summary, the meeting did a thorough job of discharging its core term of Reference, to include the 1991 stomach data in the North Sea MSVPA, and test the stability of suitability estimates. Results show that the new data do have many effects on parameter estimates, but the effects are generally small. Forecasting and hindcasting results are robust to the input stomach data. We have gained confidence in MSVPA with each past meeting. Now that future advice will be based on the full collection of stomach data from all years, we expect advice to be stable and reliable. The Working Group also did a thorough job of planning for the next meeting on multispecies assessments and modelling of boreal systems. If the Planning Group is approved and fulfils its mandate, we expect the next meeting to make significant progress at actually developing or testing multispecies models for boreal systems, rather than continuing to work around the edges of the problem.

1.4 Acknowledgements

The Working Group acknowledges the considerable support provided by the ICES Secretariat. General administrative support and secretarial support for report preparation remain at the exceptional standards of ICES. Problems with computer facilities which hampered progress at some past meetings were not encountered during this meeting; hardware, software, and human support were all excellent.

The Working Group gratefully acknowledges the herculean efforts of the staff of the many national institutes responsible for collecting and analysing the vast numbers of stomachs sampled in 1991. Particular thanks are due to the species coordinators, who ensured that (most) deadlines were met. Those concerned were: Peter Bromley (0-group gadoids); Niels Daan (other predators); Henrik Gislason (saithe); Tomas Grohsler (haddock); Henk Heessen (cod); Barbara Johnsson (rays); Sandy Robb (whiting); Dankert Skagen (mackerel). The Group also wishes to express its gratitude to Henk Heessen for maintaining the trawl survey data base, to Niels Daan for developing the computer programs used to assemble the data in a standardized form suitable for input to the MSVPA program, and especially to John Hislop for superb work coordinating the entire project.

The Working Group continues to be indebted to Henrik Gislason for carrying the major burden of MSVPA support for the Group, and to his family who rarely sees him whenever the Working Group meets.

2 FURTHER DEVELOPMENTS IN MULTISPECIES ASSESSMENT METHODS AND TOOLS

2.1 Review of Progress on Development of Multispecies, Multi-fleet Tools for Stock Assessment

The Working Group reviewed the Report of the Planning Group on the Development of Multispecies, Multi-fleet Assessment Tools, chaired by Per Sparre, with regard the Working Group's special interest and expertise in multispecies assessment.The Working Group noted that potential ICES development of such tools has been preempted in large part by the EEC-funded project at DIFMAR to develop such software. The Working Group is satisfied that this is a reasonable step, and it is appropriate to defer coordinated ICES plans for further developments of such software, such as implementation of multispecies tuning methods, until the DIFMAR routines are available.

Although the Working Group is satisfied with the current activities in development of software tools, it does have concerns in some related areas. First of all, the Working Group notes that there has been very little progress on the task of defining fleets within the North Sea in a consistent way. It is fine for the Report of the Planning Group to stress that data should be stored, and programmes should be able to run, at the finest level of disaggregated fleets. However, there is no indication of how those fleets are to be defined, nor are there indications of how the data are to be handled and accessed within the IFAP context, when software is to work at the fine levels of disaggregation. None of these tasks are within the mandate of the Multispecies Assessment Working Group, but the Working Group would like to call them to the attention of ACFM. Moreover, the Working Group has serious concerns about the long lags in updating of STCF data files. If these data sets are to become important for future assessment tools, their contents must be timely, reliable, and, if possible, annual.

Although the Working Group feels that the Planning Group discharged its Terms of Reference well, the Working Group does differ with Conclusion 1 of the Planning Group Report. Although it may be true that there is no *immediate* (emphasis ours) need for transfer of analytical multispecies, multi-fleet software, there are clients who would benefit from the availability of such tools. There is significant interest in multispecies assessment methods for systems other than the North and Baltic Seas. The ability to explore the usefulness of MSVPA to other systems is limited by difficulties in access to and use of the software. Moreover, mid-term and even short-term forecasts could be improved if it were possible to place the forecasts easily into a multispecies context. The Industrial Fisheries Working Group might also benefit directly from use of multispecies assessment tools in their routine activities, particularly for stocks where catch data are weak. For these reasons the Working Group encourages rapid progress on improved availability of multispecies assessment software. Because it appears that progress on tools is most likely to come through the DIFMAR project, the Working Group reiterates its concerns about the need for progress in fleet definitions, and the potential difficulties in data management which are likely to arise in the implementation of the DIFMAR software.

The Working Group also welcomes the Draft MSVPA Manual which was tabled at the meeting. This manual should be a significant aide in making MSVPA tools available to a wider group of potential users.

2.2 Handling Suitabilities with Multiple Years of Stomach Data

At the Woods Hole meeting of the Working Group (Anon., 1991a) the Working Group considered a new way of calculating suitabilities in the case of multiple years of stomach data. This was based on a suggestion by Sparholt and Gislason (1990), who averaged the stomach content and prey biomass over the years with stomach data before calculating the suitability, instead of averaging the suitabilities calculated for each year separately, as done in the present version of the North Sea MSVPA. Further analysis has since then been made by the Working Group on Multispecies Assessment of Baltic Fish and by Sparre (1993).

In the Baltic MSVPAs the "new" suitabilities are used because the analysis from Sparholt and Gislason and the analysis made by the Working Group on Multispecies Assessment of Baltic Fish were in favour of the "new" suitabilities.

However, the results presented by Sparre indicate that in some cases the "old" suitabilities might be better to use. These results were considered by the Working Group on Multispecies Assessment of Baltic Fish (Anon., 1994a), but the Working Group felt that they did not have the necessary expertise in mathematics/statistics to resolve the problem. They, therefore, requested assistance from the Working Group on Methods of Fish Stock Assessment or from the present Working Group.

The present Working Group is of the opinion that it is an important problem that should be resolved if possible. Time did only allow the present Working Group to have a discussion on the item based on the available material. No further analysis was made on the North Sea MSVPA, partly because the "new" suitability sub-model is not implemented as an option in the present version of the North Sea MSVPA software.

The present Working Group was not so worried about its impact on the present North Sea MSVPA runs because comparisons made at the Woods Hole meeting showed that predation mortalities only varied a few percentages as an effect of applying the two different suitability sub-models. Although the variation might increase now that multiple years of stomach data are available for all predators, it is still likely to be small.

The type of simulation as made by Sparre (1993) contributes in a valuable way to the attempts to resolve the problem. The actual statistical properties of the stomach data seem, however, to be important for both the simulations performed and for the choice of the appropriate suitability sub-model. Furthermore, it would be interesting to see simulations with more variable stomach data than used by Sparre, because high variability is observed in the stomach data when these are considered disaggregated by predator and prey age; c.v might be in the order of 1 on log transformed data.

Implicit in the "new" suitabilities is the assumption that most weight should be put on the data years with high stomach content and high prey stock biomasses. It is uncertain whether this is more appropriate than weighting all stomach data years equally.

The present Working Group thinks it is important that the "new" suitability sub-model should be implemented in the MSVPA software in order to compare MSVPA runs with alternative suitability assumptions. Ki-square comparisons of $[(\text{observed stomach content - estimated stomach content})/(\text{estimated stomach content})]^2$ as done by the Working Group on Multispecies Assessment of Baltic Fish might be one way of testing the two sub-models.

2.3 Inclusion of Additional Species

2.3.1 Other predators - general

The present MSVPA allows for inclusion of other predators. Required inputs are quarterly data on numbers and mean weights at age, with appropriate rations and food composition. At this meeting a run was made including a portion of the western mackerel stock in the North Sea. New data were also available on other predators, as described in the following sub-sections. However, careful preparation of the input data files is essential for reliable MSVPA runs, and M1 values have to be readjusted to avoid double-counting of mortality caused by Other Predators. Also, there were incomplete or unresolved aspects of several of the new data sets. Therefore, the Working Group decided not to revise the suite of predators included in its key runs at this meeting. Rather, it will work intersessionally to improve the data sets on other predators. A fully updated MSVPA, for production of new estimates of M1 and M2 for the North Sea, will be run the next time this Working Group focuses on the North Sea.

2.3.2 Seabirds

New information is available in the report of the Study Group on Seabird/Fish Interactions (Anon., 1994b). The Multispecies Assessment Working Group extends its thanks to members of that Study Group for greatly increasing the information available on seabird consumption of fish, particularly fish which are prey in MSVPA. We now have estimates of total consumption broken down by sub-area, quarter and prey type. The Working Group notes Conclusion 7 of the Study Group Report, that disaggregating the consumption data by age would take "considerable work". Unfortunately before these estimates can be used in MSVPA they must be broken out by prey age class or size class. Therefore, the Working Group RECOMMENDS that the Study Group on Seabird/Fish Interactions explore ways of breaking down their fish consumption data by age or size class, and provide updated estimates prior to our next "definitive" MSVPA run for the North Sea (likely in the winter 1996). The Working Group also takes note of Conclusion 8 of the Study Group Report, that "For useful linkage of seabird consumption to fisheries management models, it is essential that temporal and spatial scales used in the two types of analyses correspond." The Working Group comments that fisheries management models operate at the spatial scales they do because of properties of the fish stocks and fisheries. Although fish stock assessment models may move to spatial scales smaller than the entire North Sea, they are extremely unlikely to operate at the local scales referred to in the Study Group Report.

The Study Group reports that the total consumption of fish prey by seabirds is estimated to be about 600,000 t. About 50% of this is offal, discards and 'other food'. In the context of the MSVPA, although there is some predation by seabirds on gadoids (most of which are likely to be 0-groups) their most important prey are sandeels. The estimated total consumption of sandeels by seabirds in the North Sea is about 200,000 t. This no longer appears trivial in comparison with the updated estimates of consumption by the MSVPA species (350,000 t) and the yield (760,000 t in 1991), although it is still a relatively small fraction of the total biomass. A substantial part of this predation on sandeels (about 50%) takes place in the northwestern North Sea, outside the traditional sandeel fishing areas, and on stock components estimated somewhat less well by the sandeel assessment.

2.3.3 Marine mammals

There are no completely new data on the diet of seals in the North Sea. However, papers by the UK Sea Mammal Research Unit (SMRU) are beginning to appear in the literature. These generally give the definitive results of the analysis of material collected in 1985. In some cases there are appreciable differences between the preliminary reports and the final figures. Although it is not precisely known where seals feed, if it is assumed that half the British seal population feeds in the North Sea, their total annual consumption of fish is likely to lie within the range 100,000 - 150,000 t. Of this total, 30-40% may consist of sandeels. However, gadoid fish also represent a significant component of the diet of seals. In contrast to seabirds, seal predation is not more or less restricted to 0- and 1-group individuals. As with seabirds, however, seal predation is not uniformly distributed over the North Sea. It is likely to be concentrated in the north and west. Predation seems likely to increase in future; annual surveys made by the SMRU indicate that pup production at the major Scottish grey seal colonies is currently increasing at approximately 10% per annum (Hiby *et al.*, 1993).

There are rather few data on the diets and population numbers of cetaceans in the North Sea (see Anon., 1992c) although the results of a Norwegian survey indicated that there may be more than 80,000 harbour porpoises in the northern North Sea (Bjorge and Oien, 1990). Large-scale sightings survey of small cetaceans are planned to take place in the summer of 1994.

2.3.4 Other fish - results of the 1991 stomach sampling programme

Grey gurnards may consume large quantities of fish. Preliminary estimates by de Gee and Kikkert (1993) indicate a total annual consumption of more than 700,000 t. The principal MSVPA species eaten by grey gurnards are (in decreasing order of importance): sandeel, Norway pout, whiting and cod. At the moment there are no available data on the age composition of the predators and their prey. However, the data on prey size could be converted to age classes, using the ALKs applied to the prey of the primary predators, and consumption by the predators could be calculated using size classes and estimated biomass at length. This approach would not present any major difficulties, but would introduce another source of somewhat inconsistent inputs to MSVPA. *R. radiata* may also be worth considering, because it is the most abundant ray and its diet contains a high proportion of fish (mainly gadoids, according to Daan *et al.*, 1993).

2.3.5 Inclusion of other prey

At present, MSVPA treats only 9 of the 11 routinely assessed commercial North Sea fish species as prey species, whereas everything else is lumped in the category 'Other food'. However, the stomach content data base includes detailed information on other fish species, as well as a large number of invertebrate species, some of which are of commercial interest. For *Pandalus*, in particular, the stomach content data base has been used in the past to calculate rough estimates of the total consumption by the predator populations. Such estimates are not entirely satisfactory, because they are made outside the MSVPA context and do not conform to all the assumptions underlying MSVPA. There is no basic reason why such prey should not be routinely included specifically in the MSVPA output, because 'Other food' could easily be split into a number of different categories. With the growing amount of survey data, it should even be possible in principle to obtain data on changes in biomass of at least some of these prey. Including such information would to some extent relax the present assumption that the biomass of all 'Other food' is constant. It is RECOMMENDED that a new version of MSVPA allows for input of biomass data of selected other prey and for output of the quantities consumed. In particular, *Pandalus*, *Nephrops*, *Crangon* and dab should be considered as first priority species in this context. Because the fisheries on the invertebrate stocks are very localized, the information derived from MSVPA should become even more useful, when an area-based model has been developed.

Although plaice and sole are recorded in the stomachs of some predator species, these data have so far been excluded from the analysis, because there is a strong suspicion that the items found represent discards from the fishery. This introduces the possibility of mortality being double-counted. The disadvantage of the present procedure of leaving out the information is that it is not easy to evaluate the extent to which discards are being exploited as food by fish predators. If a separate discard category were added, from which food could be taken for species for which such information is available, this would be particularly appropriate for forecasts related to increases in mesh size, because these would reduce the availability of this food resource.

2.4 Handling O-Groups

Introduction

In accordance with its terms of reference, the Working Group discussed the practical and theoretical difficulties of extending the model back in age to include the pelagic O-group phase. Past studies have indicated considerable predation occurs within and between 0 group fish and justified a systematic collection of data. Evidence from the 1991 stomach project has confirmed that there is predation by O-groups on O-groups, including cannibalism. The problem of how to deal with O-groups is a difficult one. During the first year of life the fish increase in length and weight (and decrease in numbers) by several orders of magnitude. They change from animals which can only be surveyed with plankton samplers to fish large enough to be quantitatively sampled with a trawl. During this period M progressively changes from very high levels (probably mainly M1) to lower, but still high levels in which M2 probably predominates. At present the O-groups are included in the MSVPA during the second half of the year (i.e. Quarters 3 and 4). During this period the O-group become more accessible to standard survey gears and thus independent checks on MSVPA begin to become possible.

The availability of the O-group stomach content results for 1991 will facilitate data analysis and models of O-group fish. This section discusses some options.

Rationale

There is a need to clarify the purpose of studies of 0-group dynamics. Since there are few serious fisheries on pelagic 0-group fish, the scope for management manipulation of predation processes during the pelagic phase in the life cycle may be limited. There might be a modest management effect achievable through manipulation of the numbers of pelagic predators on pelagic 0-groups, such as saithe and mackerel. A much more important control would exist if numbers entering the 0-group relate to the SSB of stocks and if change in these numbers drives the resulting predation. While rather contrary to usual thinking on recruitment process such a process if it existed could act as a switch on the ecosystem and would be vital to understand. However, it is also possible that predation on 0-group fish by 0-group fish, may be a process, like the weather, that management has to react to rather than to manipulate. If this is the case then the aim should be to try to understand its influence on the stock recruitment process, rather than to see it as a simple extension of the MSFOR type prediction. The Working Group saw the need for appropriate data analysis and models to be developed intersessionally to help clarify these issues. Possible approaches are discussed in Section 8.1.2.

3 THE STOMACH SAMPLING PROJECT IN THE NORTH SEA IN 1991

3.1 Rationale and History

Until now, the MSVPA has depended almost entirely upon the stomach data collected in 1981. Since then there have been appreciable changes in the North Sea biomasses of both predators and prey.The 1991 stomach sampling programme resulted from a recommendation made during the 1988 meeting of the Multispecies Assessment Working Group (Anon., 1988a) and adopted by ICES at the 1988 Council Meeting (C.Res.1988/2:12). The objectives of the programme were:

- to obtain a reliable new data set on food consumption of the five main predator species in the North sea for use in MSVPA;
- to quantify predation on and by 0-group commercial fish species;
- to improve estimates of consumption by the various fish predators;
- to maintain compatibility of the results with those from the 1981 project;

The outlines of the project were drawn up by a Planning Group which met in Lowestoft in 1988 and a manual of sampling levels and procedures was prepared during a meeting of the species coordinators in Aberdeen in January 1991. The rest, as they say, is history.

3.2 Sampling Intensity

3.2.1 Primary predators (cod, haddock, whiting, saithe, mackerel)

The total numbers of stomachs of each species sampled in the North Sea (i.e., ICES roundfish sampling Areas 1-7) in each quarter of 1991 are given in Table 3.2.1.1. The corresponding values for 1981 are shown, for comparison. The number of cod stomachs examined in 1991 was slightly smaller than in 1981. More haddock, saithe and mackerel stomachs were sampled in 1991. In the case of whiting there was a very large increase, twice as many stomachs being sampled in 1991. (NB: In some quarters, stomachs were sampled in Areas 8 and 9. These have not been included in the analyses.)

The numbers of stomachs of cod, haddock, whiting and saithe from each statistical rectangle examined in each quarter of 1991 are shown in Figures 3.2.1.1 - 3.2.1.4. For technical reasons, it is not yet possible to display the mackerel data in this way. Thanks to the quarterly International Bottom Trawl Surveys, good coverage of the North Sea was achieved in each quarter and in the case of cod, haddock and whiting, any "patchiness" in the geographical distribution of the samples (e.g., cod in quarter 4) reflects the distribution of the fish, rather than the sampling effort.

The numbers of stomachs sampled within each predator size class in each quarter of 1981 and 1991 are given in Tables 3.2.1.2 - 3.2.1.6. A greater proportion of the samples collected in 1991 came from the lower and middle portions of the length range. This was partly by design; the sampling targets for 1991 (Anon., 1991b) were intended to provide better coverage of the 0- and 1-group predator age classes. The numbers of "large" fish sampled in 1991 were, however, smaller than in 1981:

Species	Size	1981	1991
Cod	>69 cm	1,717	968
Haddock	>49 cm	276	241
Whiting	>39 cm	516	220
Saithe	>69 cm	706	262
Mackerel	>39 cm	1,097	290

Because more research vessel survey hours were expended on samples collection in 1991, the relatively small numbers of large fish in the samples may reflect real differences between the size compositions of the predator populations in the two "Years of the Stomach". However, additional samples of large cod and saithe were obtained from the commercial fishery in 1981.

3.2.2 Other predators

Stomaches from a large number of "other" predator species were collected in 1991 (for a provisional catalogue, see Anon., 1991b). There was insufficient manpower to work up all this extra material and priority was given to the analysis of the stomaches of grey gurnard (*Eutrigla gurnardus*) and for *Raja* species (*R. clavata, R. montagui, R. naevus,* and *R. radiata*). These were chosen because they are known, or suspected, piscivores and, the biomasses of grey gurnard and *R. radiata* in the North Sea are believed to be large. The analyses of the gurnard and ray stomaches (financed by the Commission of the European Communities) have been completed (Gee and Kikkert, 1993; Dann *et al.*, 1993. The data included here have been copied from those reports. Because the majority of the ray stomaches (3201/3732) were from *R. radiata*, only data for this species have been extracted. The numbers of stomachs of grey gurnard and *R. radiata* from each statistical rectangle in each quarter are shown in Figures 3.2.2.1 and 3.2.2.2.

3.2.3 O-group gadoids

A distinction was made between 0-group gadoids sampled with pelagic trawls and those taken in bottom trawls. The stomach contents of 'demersal' 0-groups were treated in exactly the same way as those of the older fish. However, only fish sampled in quarters 3 and 4 have been included as predators in the MSVPA. It should be noted that 'demersal' 0-group cod, haddock and whiting were sampled more intensively than in 1981 (Tables 3.2.1.2 - 3.2.1.4).

Samples of 'pelagic' 0-group cod, haddock, whiting, saithe and Norway pout were collected from the northern and southeastern parts of the North Sea in June and from the northern North Sea in July. The stomachs of these fish were analysed at the Lowestoft Laboratory. None of this material was used as input to the MSVPA.

3.3 Analysis of the Samples

All the cod, whiting, saithe and mackerel stomachs have been analysed. Haddock tend to eat rather small invertebrate prey, covering a large range of taxa. Since it was not possible to undertake a detailed analysis of all the samples within the given time, it was decided to maintain a high degree of precision but to restrict the analysis to five stomachs per size class, rectangle and quarter. In achieving this aim, approximately 13,000 of the 20,250 stomachs collected in 1991 were processed. It is unlikely that the remaining samples will be analysed unless further funds can be obtained.

All the grey gurnard and *Raja* stomachs have been analysed, but it seems unlikely that the stomachs of the remaining species will be analysed in the near future.
All the 'pelagic' 0-group material (a total of 1,969 non-regurgitated stomachs) has been analysed. To date, however, only material collected east of the Shetlands in June 1991 has been examined in any detail.

3.4 Empty Stomachs

The percentage of stomachs within each predator size class that were classified as empty in each quarter of 1981 and 1991 are given in Tables 3.2.1.2 - 3.2.1.6. There are differences between the two years. In quarters 2, 3 and 4 the percentages of empty stomachs in 1991 were similar to, or lower than, the comparable values for 1981. Whiting showed the largest decrease. In quarter 1, however, the situation was completely different; the percentage of empty stomachs was higher than in 1981 for all five predators. The increase was trivial in the case of cod, but substantial for haddock, whiting, saithe and mackerel.

The Coordinators are aware that there were some problems with the classification at sea of the state of the stomachs. For example, Gee and Kikkert (1993) show that there were significant between-ship differences in the classification of grey gurnard stomachs. In particular, it proved difficult to distinguish between "empty" and "regurgitated" stomachs. However, the same problem occurred in 1981 and there is no *a priori* reason to believe that there should have been any systematic differences between the procedures employed in the two "Years of the Stomach", or that the criteria adopted in the first quarter of 1991 should have differed from those in the other quarters.

3.5 Mean Weight of Food in the Stomachs

For **cod** the data for 1991 and 1981 agree rather well, although for some size classes a slightly higher weight was observed in 1991 (Table 3.2.1.2).

In 1991, the mean stomach contents of **haddock** were lowest in quarter 1 for all but two size classes (120 and 600) (Table 3.2.1.3). The mean weights in size classes 100-120 are similar in quarters 2-4. The highest feeding activity for size classes 150-400 was in quarter 2; values in quarters 3 and 4 were slightly lower, but similar. At present, no comparisons of the 1981 and 1991 haddock weights (by size class) are possible because it has not been possible to locate the 1981 values.

In the case of **whiting** (Table 3.2.1.4), there are variations in the stomach content weight both between quarters in the same year and between quarters in different years. For the majority of the size classes there is a tendency for the highest stomach contents weights to occur in quarter 3. In 1991 however, the stomach contents weight for size class 200 was greatest in quarter 4. Compared with 1981, there was a pronounced increase in the stomach contents of all size classes in quarters 2-4 in 1991. In quarter 1, however, the picture is less clear, with some size classes showing an apparent decrease.

Average stomach contents weights of **saithe** in 1991 were lower in quarters 1 and 3 than in quarters 2 and 4 (Table 3.2.1.5). Compared with 1981, the 1991 values were lower in quarter 1 and similar or higher in quarters 2-4.

Mackerel stomach contents weights were lower in quarter 1 and highest in quarters 2 and 3 (Table 3.2.1.6). The quarter 2 values were consistently lower than, and the quarter 3 values higher than the corresponding weights in 1981.

3.6 Composition of the Stomach Contents in 1991

3.6.1 Primary predators

0-group cod fed mainly on crustaceans and at age 1 approximately equal weights of crustaceans and fish were eaten (Table 3.6.1.1). At age 2 the majority of the food consists of fish and this gradually increases up to age 6+, when cod feeds almost exclusively on fish. In 1991, almost all age groups had significantly more fish prey in their stomachs, in all quarters. All of the 11 fish species in the MSVPA except sole (*Solea solea*) were found in significant amounts in the stomachs of one or more age groups of cod in one or more quarters. The species composition of the prey differed markedly from 1981, in that cod, haddock, sprat and, especially, sandeel occurred in lower quantities, whereas the amounts of herring, whiting and mackerel were higher in 1991.

Annelida, crustacea, echinodermata and fish represented at least 80% of the total weight in each haddock age class in each quarter (Table 3.6.1.2). Crustacea were generally preferred by the younger and smaller fish, whereas annelida represented rather similar percentages of the stomach contents (10-30%). The importance of fish increases with age. The overall contribution of fish to the diet of haddock was smaller than in 1981. Commercially exploited species were of rather little importance to the diet in the first half of 1991, although herring made a significant contribution to the food of older haddock in quarter 1. The most important fish prey was sandeels (quarter 3) and Norway pout (quarter 4). Some cannibalism occurred (quarters 3 and 4) and this form of predation was more extensive than in 1981.

Fish and crustacea together account for at least 79% of the diet of whiting of all ages in all quarters (Table 3.6.1.3). The proportion of fish tends to increase with age. As in 1981, cephalopod molluscs were only important in quarter 1. Annelida were found in appreciable quantities throughout the year and the overall contribution by this prey group was greater than in 1981. At least 36% of the diet was commercially exploited species. Norway pout and sandeels were significant components of the diet in all seasons, as in 1981. In general, sprat, herring, whiting and, particularly, haddock contributed less to whiting diet than in 1981.

Fish were the predominant prey of saithe of all ages in all quarters of 1991, except for 3-year-old fish in quarter 2 (Table 3.6.1.4). Crustacea ranked second. Predation on fish was particularly high in quarters 3 and 4. Most of the fish prey consisted of Norway pout (eaten by younger saithe) and herring (eaten by older saithe). Mackerel were eaten in quarters 1 and 3, and haddock in quarters 2,3 and 4. Predation on herring was much greater than in 1981 and predation on haddock much lower.

Mackerel were feeding mainly on crustacea and fish (Table 3.6.1.5). There was no obvious tendency for older mackerel to eat more fish and less crustacea. Compared with 1981, consumption of fish was lower in quarter 2, similar in quarter 3 and higher in quarter 4. The principal commercial prey were sandeels (quarters 1, 2 and 3), Norway pout (quarters 3 and 4), sprat (quarters 2 and 4) and herring (quarter 4). Many of the fish prey were 0-groups.

3.6.2 Grey gurnards and *R. radiata*

Fish and crustacea together account for at least 85% of the weight of the stomach contents of grey gurnards of all size (Table 3.6.2.1). There is a switch from crustaceans to fish at a length of approximately 25 cm. The principal commercial species in gurnard stomachs are sandeels, Norway pout, whiting and cod. The small size of these fish suggests that they are mostly 0-groups (Gee and Kikkert, 1993)

Raia radiata switches from feeding mainly on crustaceans to feeding mainly on fish at a length of about 25 cm (Table 3.6.2.2). It was difficult to identify fish prey to species level, because rays tend to chew their food (Daan *et al.*, 1993). However, most of the fish prey which could be identified consisted of juvenile gadoids. Sandeels occurred only infrequently.

3.6.3 Pelagic 0-group gadoids

The stomach contents were difficult to analyse. Many fish could not be identified to species level, few could be measured and the numbers often had to be guessed. Nevertheless, whereas Norway pout fed almost exclusively on crustacea (mainly copepods), the other species contained considerable weights of fish (Figure 3.6.3.1). Over 70% of the stomach contents weight of cod and whiting was fish; haddock and saithe stomachs contained less fish. There was a general trend for the proportion of fish to increase with predator size in the case of cod, whiting and saithe but the picture for haddock is less clear (Figure 3.6.3.2). Sandeels and whiting formed the bulk of the fish prey (Figure 3.6.3.1). It was estimated that as much as 5% of the food in the stomachs of whiting was whiting, suggesting that a considerable amount of cannibalism may occur in the pelagic 0-group phase. Only about 1.5% of the diet of cod was cod. The catches in the young gadoid trawl indicated that 0-group sandeels were relatively abundant in 1991. This appears to be reflected in the high proportion of sandeels in the stomachs of cod and whiting. It is interesting to speculate on what happens when sandeels are scarce. Would there, for instance, be even higher levels of cannibalism?

3.7 Age/Length Transformations

For the purpose of MSVPA it is of particular importance to ensure that information based on the lengths of the predators and their prey can be reliably transformed into corresponding data based on age classes. As in the earlier stomach sampling projects, some problems were encountered.

3.7.1 The predators

Area age/length keys (ALKs) were available for most size classes of the five primary predators (problems with the smaller size classes are discussed in Section 9.2). Much of this information was collected during the quarterly International Bottom Trawl Surveys of the North Sea, which commenced in 1991. In the case of saithe, the survey data were inadequate and had to be supplemented with material from the commercial fishery.

No ALKs were available for grey gurnard and rays.

3.7.2 The prey

For cod, haddock, whiting and Norway pout, the only real difficulty was that the ALKs did not always adequately cover the lower part of the length range and the boundary between the 0-groups and the 1-groups had to be arbitrarily decided. This problem was most pronounced in the second and third quarters.

In the case of herring and sprat, individual ALKs were available for most area/quarter combinations. This represents a considerable improvement over 1981, when only two ALKs were used in each quarter, one being applied only to the stomach contents data in area 1, and the other to the data from areas 2-7. It should be noted that in 1991 age class 5 is the "plus" group for herring whereas age 6 is the "plus" group for the other prey species. This is because the IJmuiden programs treat age groups of herring as year classes, as with roundfish. Under this convention, fish born in August 1989 (i.e., 1989 year class) become one-year olds on 1 January 1990. North Sea herring biologists use a different convention, under which a herring is not regarded as a one-year old ("one-ringer") until 1 January 1991. When the IJmuiden data are translated into the ICES IYFS data base, via an exchange tape, one age group is lost and the 6+ herring become 5+.

In the case of sandeels, the 1991 age/length data are less than satisfactory. Although some ALKs based on samples from the Danish and Norwegian industrial fisheries were available, and additional material was collected during English and Scottish research vessel surveys, most of these otoliths were collected during quarters 2 and 3. Only three areas were sampled in quarter 1, and there was a complete lack of information for quarter 4. Even when area keys were available, they were often based on a large number of otoliths covering a rather small number of size classes (as in many of the samples from the industrial fishery) or a small number of otoliths spread over a large length range (research vessels). It was decided to apply a "northern" key to areas 1, 2, 3 and 7 and a "southern" key to areas 4, 5 and 6. These keys were not constructed by simply pooling the otoliths collected within each major area. Instead, the percentage age composition within each size class within each sampling area was calculated and the percentages were averaged, thus giving equal weight to each area. Further compromises were necessary. Thus, the keys for quarter 3 were applied to the data for quarter 4, and the percentage age compositions of the larger size classes of sandeels in quarter 1 were calculated using the keys for quarter 2.

During the analysis of the saithe stomachs, otoliths removed from fish prey as well as otoliths found loose in the stomachs, were identified and, where possible, aged. The otolith readings (excluding, in the first instance, otoliths found loose in the stomachs) were used to perform an age-based analysis in which the average age composition of commercially important fish prey was estimated directly from the age composition of the prey in the samples, i.e., without the use of prey ALKs. The results can be compared with those obtained by using prey ALKs.

3.8 General Comments

The project went largely according to plan. Sampling levels were satisfactory, thanks to the hard work and long hours put in by the sea-going members of the various institutes. The project manual prepared by the Coordinators at the start of the exercise (Anon., 1991b) proved generally useful, although it was agreed that a revised version is needed and should be prepared well in advance of any future large-scale stomach sampling programme. There are still problems over the identification of "empty" and "regurgitated" stomachs, and there is some confusion as to how to deal with very fresh prey fish which may or may not have been eaten in the trawl. It was agreed that it would have been useful to hold a workshop for the stomach analysts before, or in the early days of, the project.

Analysis and data processing proceeded more or less according to the timetable scheduled in Anon. (1992a). The decision to assemble the data for all species in a standard "exchange tape" format gave the species coordinators the freedom to use their own (familiar) computing hardware and software to prepare their data, whilst ensuring that the data were available in a form suitable for final processing, in a standardised form, using the analytical programs developed by Niels Daan in IJmuiden. It cannot be pretended, however, that no problems were encountered in reading data files, linking stomach contents data to the trawl survey data base assembled in IJmuiden by Henk Heessen and producing the final outputs during the meeting of the species Coordinators in IJmuiden in September 1993.

4 MSVPA RUNS WITH 1981, 1991 AND ALL STOMACH DATA

4.1 Rationale

The 1991 stomach content data makes it possible to base suitability estimates on two completely independent sets of stomach content data. Even though stomach content data were available from the first and third quarters of 1981, 1985, 1986 and 1987, all runs had previously to rely on stomach content data from the second and fourth quarter of 1981. Now runs can be based exclusively on stomachs collected in 1981 or on stomachs collected in 1991. In addition to these two runs, it is possible to make a keyrun based on all data available, i.e. the 1981 and 1991 stomach content data as well as the stomach content data collected in the first and third quarters of 1985, 1986 and 1987. The Working Group, therefore, decided to perform three basic runs:

- A **KEYRUN** based on stomach content data from 1981, 1985, 1986, 1987 and 1991.

- A **81-RUN** based exclusively on stomach content data from 1981.

- A **91-RUN** based exclusively on stomach content data from 1991.

Runs based on the 1981 and 1991 stomach content data will be referred to as **81-RUN** and **91-RUN**, respectively, in the subsequent sections, while the run based on all the available stomach content data will be referred to as the KEYRUN.

4.2 Input Data

The MSVPA for the North Sea includes 11 species (cod, whiting, saithe, mackerel, haddock, herring, sprat, Norway pout, sandeel, plaice and sole) of which five (cod, whiting, saithe, mackerel and haddock) are predators. For each of the 11 species the input to the model consists of quarterly catch-at-age data, weight at age in the sea and in the catch, maturity at age, residual natural mortality (M1) and fishing mortality in the last quarter of the terminal year. In addition, the five predators require estimates of the quarterly total food intake at age (kg/ind.), stomach content data representing the food composition at age by weight, data on the weight of one prey individual at the time of ingestion, and an assumption of the total amount of other food available. A complete set of input data is given in Annex 1, which is available on diskettes from the ICES Secretariat upon request.

<u>Catch at age</u>

The catch at age by year is given in Table 4.2.1.

Quarterly catch-at-age data for 1990 to 1992 were taken from the single-species Working Group reports, or supplied by Working Group members in the case of cod, whiting, saithe, haddock, plaice, herring and sole. Input fishing mortalities for the fourth quarter were tuned to produce stock sizes and annual fishing mortalities in accordance with the findings of the single-species assessment Working Groups.

<u>Norway pout</u>

Catch numbers at age by quarter were provided by the Norway Pout and Sandeel Assessment Working Group (Anon., 1994d). The catch numbers at age in 1990 were estimated by the Working Group as part of the assessment, since the sampling that year was insufficient. The terminal Fs for the plus groups were selected so that the stock numbers at the oldest true age were at the same level as in the single-species assessment. For the true age groups in 1992, the F values for the fourth quarter in the Working Group assessment were used.

<u>Sandeel</u>

Catches numbers at age by quarter were provided by the Norway Pout and Sandeel Working Group, except for 1990, where the catches in numbers at age were estimated as part of the assessment. These half-yearly catches were split into quarterly catches according to the quarterly distribution of the total catch. Catches from the Northern and the Southern stock were added together. The fishery in the Shetland area has been closed since 1990.

The strategy for selecting terminal Fs was to reproduce the stock numbers in the most recent year and season.

When these terminal Fs were applied in the multispecies VPA, an increasing trend in the average fishing mortalities appeared for the most recent years. Since there is no other evidence for such an increase in the fishing mortality, the terminal Fs for the youngest ages in 1992 were adjusted to reduce the terminal Fs in the most recent years to a level comparable with previous years.

Sprat

As in previous years no single species VPA has been run by the Working Group in charge of the single-species assessments, and except for 1992 available data on catch at age are very poor. Catch-at-age data have, therefore, been generated again by the method described in Anon. (1989). However, the regression of VPA estimates for the 1-group in quarter 1 had to be redone and was now based on the years 1978 and 1980 - 1984. 1979 had to be excluded because of abnormal conditions during the IYFS in that year. This regression was then applied to estimate the year-class strength in 1985 to 1992. Two of the estimated year-class values, 1985 and 1989, however, were adjusted downwards. The survey index for 1985 gave an unrealistically high stock estimate in 1986 and was, therefore, reduced to 1/3. The 1989 index is the highest on record being more than twice as high as the second highest index in 1993. But since this year class did not occur in the catches or in the subsequent survey in above-average numbers, the value was replaced for this analysis by the average of the two neighbouring years.

As noted by the Herring Assessment Working Group for the Area South of 62°N, the catch-at-age data generated deviate considerably from the few data which are available for the years after 1984. However, the agreement between observed and generated data is reasonable in 1992, which is the year with the most intense sampling:

Age Group	1	2	3	4
Observed (mill.)	8801	2140	405	40
Predicted (mill.)	11785	2090	112	40

Flatfish

Yearly catch-at-age data for sole and plaice were taken from the 1993 report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (Anon., 1994c). These were split into quarters assuming fishing and natural mortality to be evenly distributed over the four quarters. For plaice, 1st quarter weights at age for the stock were used, while for the sole weights at age for the 2nd quarter (H. Jensen, Netherlands Institute of Fisheries Research, in litt.).

Terminal fishing mortality in the last quarter for the plus age group for sole and plaice were adjusted so that the numbers of fish dying in the plus group due to fishing and natural mortality were equal to the number of survivors from the 14-year-old age group becoming 15 year olds on 1 January, obtained from the single-species assessments (Anon., 1994c). Terminal fishing mortality in the last quarter for all other age groups was adjusted so that the total fishing mortality for the year matched the fishing mortality obtained in Anon. (1994c).

North Sea mackerel

Very little information is available on this stock. The latest estimate of the stock size is from an egg survey in 1990. Egg surveys have been performed also in 1991 and 1992, but with only partial coverage of the spawning season. Catch in numbers at age were provided by the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy (Anon., 1993b). These numbers were constructed using the age composition in the survey samples in 1990 and 1992. Terminal Fs where chosen which gave the age composition in the stock in the 2nd quarter in 1992 which was comparable with the age composition in the catches in the 1992 survey. The age compositions in the 1990 and 1992 surveys are to some extent contradictory, which leads to an irregular F pattern in some years. The resulting stock size is smaller than estimated from the egg surveys.

Other input

M1 and weight at age in the sea and in the catch were the same as those used at previous meetings.

Maturity at age was kept as at previous meetings except for Norway pout where the proportion mature at age 1 was changed from 0.5 to 0.1 in line with the revision made by the Working Group on the Assessment of Norway Pout and sandeel.

The total food consumption per individual (kg/quarter) was assumed to remain constant. The biomass of other food was kept constant at 30 million t (the Helgason-Gislason assumption).

The 1991 stomach content data were entered into the database of the model. Based on the information found in the stomach content data files the program constructs a system of pointers which is used to identify predator-age/prey-age combinations in the stomach content. In order to speed up the computations, species/age groups which do not interact should be removed from the input data. Since a number of prey age groups in the 1991 data had not been previously recorded, the stomach content data files for 1981, 1985, 1986 and 1987 were revised slightly by adding additional zero observations.

No estimates were available of the weight of the prey at ingestion for mackerel in 1981. At previous meetings this weight was, therefore, assumed to be equal to the weight at age in the sea. For 1991, however, an estimate of the weight at age at ingestion was provided based on the observed weight in the stomach content of mackerel. This estimate was used for both 1981 and 1991. For cod, haddock, whiting and saithe, the average quarterly weight at age at ingestion was estimated as the mean of the observations from individual years weighted by the total weight of the prey species age group in the stomach content.

Western mackerel stock

Estimates of the proportion of the Western stock being in the North Sea each quarter, as well as the stock size in numbers, were provided by the Working Group on Mackerel, Horse Mackerel, Sardine, and Anchovy (Anon., 1993b). The mean stock numbers by quarter were computed using the quarterly distribution of the total catch to provide the fractional F by quarter. The stock numbers were allocated to two age classes: 'age 0' being 1 - 2 years old, and 'age 1' being 3 years old and older. The weights at age were not changed.

4.3 Output from the KEYRUN

Tables 4.3.1 a-k show the output from the KEYRUN in terms of the stock sizes in numbers at age, yearly fishing mortalities and yearly predation mortalities at age. Saithe, mackerel, plaice and sole are not eaten by the five MSVPA-predators and no predation mortalities are, therefore, estimated.

Mean values of M divided into residual mortality, mortality due to "Other" predators, M2 and fishing mortality are given in Table 4.3.2.

4.3.1 Who eats whom

Figure 4.3.1a-b summarizes trends in mean biomass, yield and the predated biomass of MSVPA species for the period 1974-1992 from the keyrun and runs with 1981 or 1991 stomach data only. The KEYRUN values are also given in Table 4.3.3a along with deviations (as a percent of KEYRUN values) from results of MSVPA runs with 1981 or 1991 stomach data only.

In the KEYRUN, overall mean biomass declined from 1974 (~9,500 mill. t) until the early 1980s followed by a relatively stable period (~6,000 mill. t) until 1985, then an increase towards 1987 (7,000 mill. t), after that a decrease until 1990 (~5,000 mill. t) and a new increase in the two last years (~6,4000 mill. t). In the two other runs the overall mean biomass was slightly higher, most pronounced in the 1981 stomach data run and in beginning of the period due to a higher biomass of haddock, Norway pout and sandeel. Yield has fallen from about 3.2 mill. t to 2.2 mill. t, while the predated biomass of MSVPA species has decreased from about 6.3 mill. t to 1.3 mill. t (KEYRUN). The predation figures from the 1991 stomach data run were higher in all years, while the corresponding figures from the 1981 stomach data run were lower than in the KEYRUN in most years.

Figures 4.3.2 a-c and 4.3.3a-c show mean biomass in 1974-1992 for MSVPA predators and prey, respectively, from the three runs. All runs show the same trends and the biomasses are quite similar, except for the earliest years when haddock, Norway pout and sandeel came out with a somewhat higher biomass in the 1981 stomach data run. Mackerel and sprat have declined greatly over this period, but it should be noted that the actual amount of mackerel in the North Sea is larger in part of year due to the presence of the western stock (see Section 4.4). Most of the other species have also decreased by 50% or more, but in recent years the biomass of Norway pout and sandeel has been increasing. The biomass of herring was at its lowest in 1977 (~90,000 t) and has after that increased to become one of the largest stocks in the North Sea (~1,5 mill. t).

The yield/biomass ratio (Table 4.3 and Figure 4.3.4) has varied somewhat around 0.4 over the period, the KEY-RUN having the highest values and 81-RUN the lowest values. The ratio of total MSVPA species eaten (TMSE) to yield has decreased from about 2 to slightly above 0.5 (Figure 4.3.5). This means that a relatively larger proportion of the ecosystem is harvested by man today. Again, the three runs show the same trends, values from the 1991 stomach data run being slightly higher. Ratio of total MSVPA species eaten to biomass of all MSVPA species also shows a clearly decreasing trend (Figure 4.3.6), starting at about 0.65 in 1974 and ending up at about 0.2 in 1992. Figure 4.3.7 shows the ratio of total MSVPA species eaten to average predator biomass (TMSE/-APDB). The ratio was close to 2 in 1974, decreased more or less gradually down to about 1 in the late 1980s and has since than increased to 1.3. In the two last plots the run based on 1991 stomach data only also had the highest values. This may be caused by a somewhat higher proportion of some of the MSVPA species in the stomachs collected in 1991 compared to those collected in 1981.

4.3.2 Contrasting estimates of M2

An important aspect of the new results based on the extended data set is to what extent the level of M2 has changed compared to earlier results of MSVPA, because these might affect the appropriate values to be used in single-species assessment. In Figure 4.3.8 the following estimates of predation mortality are contrasted:

- The values presently used in single-species assessments. It should be noted that in order to make the proper comparison, the M1 values are subtracted from the Working Group estimates of natural mortality in order to obtain the comparable M2 values;

- The average values for the period 1976-1981 obtained from the KEYRUN with all stomach content data, since these can be considered to represent an update for the period on which the values used by the Working Groups were originally based;

- The average values for the period 1986-1991 obtained from the KEYRUN with all stomach content data included in order to highlight possible changes in the level of M2;

- The average values for the period 1986-1991 obtained from the 81-RUN and 91-RUN, respectively. These allow a broad comparison of the variability resulting from the two data sets.

Cod: The M2 estimated from the KEYRUN for the earlier period corresponds remarkably closely with the values used by the North Sea and Skagerrak Demersal Working Group. However, the predation mortality on 0- and 1-group in recent years seems to have dropped by approximately 1/3 as a consequence of the reduction in the cod stock. The 1981 data set results in a rather similar trend as the total data set, whereas the 1991 data are more variable, which might be caused by the strong overall reduction in the cod stock.

Whiting: The trends in M2 appear to be very similar in all data sets and correspond well with the Working Group estimates, although the values for 0- and 1-group are estimated to be consistently higher. There is no significant difference between the earlier and the later period.

Haddock: Although the 0-group M2s estimated by the different data sets are virtually the same, there are huge discrepancies for the 1-group between the 1981 and 1991 data. When all data are used these differences are smoothed. The 1981 data result in rather high values on 4- and 5-group haddock, which requires further explanation. There is no marked difference in the level of M2 between the earlier and the later period, but it appears that the Working Group values of natural mortality are too low for the 0-group and too high for the 1-group.

Herring: The Working Group values of natural mortality for 0- and 1-group appear to be rather too high, whereas for the older age groups they are consistently too low. The reason for this is clearly that the 1981 data set contained very few older herring, which is most likely caused by the relatively low abundance of herring in that year. In the 1991 data set, these older age groups are well represented, and the resulting M2 values are relatively constant at a value of about 0.2. The picture provided by using the complete data set appears to be more realistic. There has been a marked reduction in the M2 during recent years compared to the earlier period.

Sprat: The 1991 data set resulted in a fairly smooth trend in M2 compared to the 1981 set. Combining the two results in rather higher values for the 3- and 4-group than used by the Working Group and 0-group seems to be not preyed upon at all. The data suggest a drop in M2 since the late 1970s, but it should be noted that the assessment of the sprat stock involved quite a lot of creativity, because no routine assessment had been attempted by an assessment Working Group.

Norway pout: The two years of stomach content data resulted in quite a bit of variation in M2 for individual age groups, but these average out when the full data set is used. The overall level is the same as used by the Industrial Fisheries Working Group, although the pattern over age is slightly different. There is no indication of a change in predation mortality over the period considered.

Sandeels: The estimates of natural mortality used by the Industrial Fisheries Working Group deviate markedly from the values obtained by any of the Keyruns. M2 appears to be rather constant with age, which does not seem unlikely given the low growth rate of sandeels. The level of M2 has dropped considerably since the earlier period probably as a consequence of the marked reduction in the populations of various predators.

Although there are clearly differences in the predation mortalities estimated from the individual data sets, overall there is a high degree of correspondence. In the KEYRUN the patterns of M2 with age have become smoother due to the averaging of the estimated suitabilities from the individual data sets.

4.4 MSVPA with the Western Mackerel Stock as Additional Predator

After the decline of the North Sea mackerel stock in the 1970s, the western stock of mackerel has taken over the northern North Sea as part of its feeding area (Iversen and Skagen, 1989). Also, parts of the juvenile western stocks seem to have moved into the Eastern North Sea (Anon., 1990a). This represents a substantial predating biomass which is not accounted for in the MSVPA.

The western mackerel can be introduced in the MSVPA as a 'visiting predator'. Its amount can be assessed outside the model, since it is assumed not to be eaten by any of the model predators. Having stomach data, suitabilities can be computed, and its impact on the prey stocks estimated (Anon., 1989). The input data are described in Section 3.

According to the stomach data, the diet of the mackerel includes mainly 0- and 1-group fish, in addition to zooplankton.

Table 4.4.1 shows mean values for the recent years for the biomass of all prey species eaten, when the western mackerel is included. These numbers can be compared with Tables 4.3.1 and 4.3.3 of the KEYRUN.

For Norway pout and sandeel, and to a lesser extent for herring and sprat, the M2 and N values have increased compared to the KEYRUN for the youngest ages. The reduction in M2 for the older ages is quite small. The fishing mortalities for Norway pout and sandeel have gone down, corresponding to the increased stock numbers.

The consumption of MSVPA prey by western mackerel is considerable, and is not far below that of all MSVPA predators together. The effect on the stock biomasses is only a small increase, and there are only small changes in the estimated amount of MSVPA prey eaten by MSVPA predators.

Since the cohorts in the MSVPA are fixed at the oldest age by the input terminal Fs, and the M1 values have not been adjusted, the results do not reflect what will happen in the real world if the predation pressure is increased, but rather how the MSVPA compensated for the presence of this predator. Thus, introducing the western mackerel as an additional predator in the model will mainly affect the estimated values for the 0- and 1-groups, and only affect the estimates for older fish indirectly. The apparent stock numbers for the youngest ages will increase to account for the increased predation. This in turn will reduce the apparent predation mortality of the older prey, since fish that can eat both, now has - again apparently - more juveniles at hand.

Provided better estimates of M1 can be obtained, inclusion of a larger part of the predators on the 0- and 1-group fish will primarily be useful as a source of information on the year-to-year survival of the pre-recruits. This has relevance both to the interpretation of pre-recruit survey indices, and to the study of stock/recruitment relationships. For the industrial species, where the fishery starts at the 0-group stage, it will also have direct implications for the assessments.

5 NEW DEVELOPMENTS IN SMOOTHING SUIT'S AND M2'S

5.1 Introduction

Traditionally the Multispecies Assessment Working Group has fitted smoothing models to the results of MSVPA (M2 per unit predator biomass and Suitabilities), by fitting predator*prey*quarter interaction terms, a log normal size preference and a term for log predator size (see Anon. 1989 section 6). These have been fitted by taking logarithms of the dependant variable and fitting only its non zero values. In some fits some zero terms on the "large predator small prey" side of the size preference function have been included as very low positive values.

Ignoring or only representing some of the zeros is statistically convenient but ignores important information about the limits of size selection and probably distorts the models fitted. It was suspected that in particular the spread of the log normal size preference is often over estimated. This is because omitting the zeros puts no penalty on predicting high fitted values at large and small size ratios, where observations are zero. In turn this tendency for smoothed values to spread precludes using smoothed values in models such as the Shepherd prediction model. This section indicates a new approach to include zeros in the fitting of size preference models.

A further potential problem is that the Ursin log normal size preference model may be significantly truncated or skewed particularly on its large prey limb. Appropriate approaches for dealing with this problem are also considered in this section.

5.2 Better Fitting of Zero Suitabilities

The problem of course is to include zeros without taking the logarithm of zero when fitting a log normal response to predator/prey weight ratios. The traditional solution to dealing with zeros in log transformed data is that of adding a small value to all terms. This is of course not possible in this application because it implies constant suitability at all the outer ranges of size ratio. Delta methods or binomial-gamma methods (Oláfsson and Stefánsson MS) also seem inappropriate because they do not include the zeros in the general size preference model. Zeros can be included in the model in at least three satisfactory ways. One way is to use the statistical package GLIM to fit the data using Poisson error structure with a log link function. That is to say with in the form,

$$Suit(pred,prey) = exp(a + bx + cx^2) + \varepsilon \qquad (5.2.1)$$

Where $x = Ln(predator\ weight/prey\ weight)$ and where ε is a error with a Poisson type error structure (i.e. with variance proportional to the mean).

Alternative possibilities are to fit only the positive values of SUIT's to models either of the form,

$$Suit(pred,prey) = exp(a + bx + off) + \varepsilon \qquad (5.2.2)$$

Where off is a pre declared offset,

$$off = \left[Ln \frac{(predatorweight/preyweight)}{\sigma} \right]^2 \qquad (5.2.3)$$

where σ is a guess of the standard deviation of the normal response surface of SUIT's to log (predator to prey weight ratio) and where ε has a Gaussian type error structure.

Alternatively a fit to positive values may be made in the form,

$$Ln\ (Suit(pred,prey)) = a + bx + off + \varepsilon \qquad (5.2.4)$$

Where ε has a Gaussian type error structure.

In either of these cases the fitted values based on the fit to the positive values may be tested against the negative values to see if the curve fitted (conditional on the value given to off) fits these points well or badly. Varying the value of off then leads to a "best fit".

The first of these options is much the most straight forward to adopt and it was used in the work of the Working Group.

5.3 Introducing Truncation or Skewness to the Ursin Size Preference Model

Observation of previous fits to the log normal (Ursin size preference) model suggested that some truncation might take place at the upper limit of prey to predator size. Moreover, it might be suspected that some physical constraint such as gape size or stomach capacity sets an upper limit to the size of prey a predator of a particular size can handle. An appropriate mathematical description of this might be the product of the Ursin size selection function with a logistic ogive (see Figure 5.3.1). That is to say,

$$\frac{\frac{1}{\sqrt{2}\pi\sigma^2} \exp\left[0.5\left[\frac{\chi-\mu}{\sigma}\right]^2\right]}{(1+\exp(\alpha+\beta\chi))} \qquad (5.3.1)$$

Where $\chi = Ln(predator\ weight/prey\ weight)$.

While such a model could describe all likely forms of truncation or skewness, such a model is difficult to fit in this form. It would be possible to fit the Ursin parameters, μ and σ, under assumptions of various fixed values of α and β the parameters of the ogive, but this would be laborious in practice. One possibility is to fit an extra term under the exponential of δ-x^2. That is fit,

$$\frac{1}{\sqrt{2}\pi\sigma^2} \exp\left[0.5\left[\frac{\chi-\mu}{\sigma}\right]^2 + \frac{\delta}{\chi^2}\right] \qquad (5.3.2)$$

This form results from a Taylor expansion of equation 5.3.1. and reduces the problem to a log-linear three parameter model. Given the pathological behaviour of δ-x^2 when x is near zero, it is wise to restrict x to the range x>0.1 if this form is fitted. Since fish predators seldom operate beyond this range (i.e. less than 10% weight differential between predator and prey) this is not a problem.

6 TESTS OF CONSISTENCY OF MSVPA RESULTS WITH VARIOUS INPUT STOMACH DATA

6.1 Introduction

The terms of reference required the Working Group to test the stability of suitability estimates. This request may be seen in the wider context of a need to validate the model. The advent of a complete new set of stomach data (1991) will allow various checks and comparisons to be made of the MSVPA model and of alternative models. In the various checks and comparisons considered below the working group has tried to address questions concerned with:-

1. What is a proper test against simpler models (or more complex models)?
2. Are the changes observed in SUIT's, M2's or stomach data greater than we would expect from sampling error?
3. Are there systematic patterns within any observed changes in SUIT's etc?
4. What are the consequences of changes in SUIT's etc.? Are the changes big enough to worry us?

Background

In examining questions concerned with predation, we are largely constrained to interpret the world through the medium of MSVPA, since this is the only appropriate technology available to us. This assumes that:-

* The ration of predators is constant.
* The suitability is constant.
* In the case of the Helgason and Gislason feeding model the available quantity of other food is constant.

To address the question of proper tests between simpler and more complex models, it is worth while to first consider what simpler or more complex models than the MSVPA should be considered and how the MSVPA results or stomach content results might deviate from the above assumptions if other models were better. Obvious model choices are:-

1. Constant M at age.
2. Constant Total M2 at age for each prey.
3. Constant M2 for each prey predator combination.
4. Constant UM2 for each predator prey combination (the unsmoothed Shepherd model).
5. Constant smoothed UM2 for each predator prey combination (the smoothed Shepherd model).
6. The existing MSVPA model (with Helgason and Gislason feeding model).
7. The existing MSVPA model (with Helgason and Gislason feeding model) but with smoothed suitabilities.
8. Variants of the MSVPA which include changes in suitability due to changes in predator prey overlap.
9. Variants of the MSVPA which include prey switching according to prey or predator biomass.

Of these 1 through 5 can be thought of as simpler models than MSVPA while 8 and 9 are clearly more complex. Model 7 is simpler or more complex depending on your philosophy, but is in any case not much different from MSVPA.

We are not in a position to comment on model 1, the original single species hypothesis, since we only have data which estimates the predation component (M2) of M. We note however that simple forms of this hypothesis e.g. M=0.2 have been rejected (Daan, 1973), and that to maintain hypothesis 1 rather than 2 implies a belief that changes in predation mortality are automatically compensated by equal and opposite changes in non predation mortality. This is not testable. Also, it deviates from the generally accepted assumption that sources of mortality are additive. We, therefore, do not intend to consider either this hypothesis or the existence of the tooth fairy further.

Model 2 is somewhat more tractable. It implies that constant proportions of a prey are removed by predation and thus that the total consumption of a prey species will increase as prey biomass increases. This in turn implies that *per capita* consumption by predators will increase directly as prey abundance increases and increase directly as overall abundance of the predators of this prey decline. This implies that with this model relative suitability as estimated by MSVPA would remain unchanged with prey abundance but that predators ration would have to increase as the prey increased or as the overall abundance of the predators of this prey declined. This model is used in single species assessments.

Model 3 leads to similar implications except that per capita consumption of a specific predator would have to increase directly in proportion to increases of abundance of individual prey and to declines in its own abundance.

Models 4 and 5 would both require that prey were consumed in proportion to their abundance but that per capita consumption would not be influenced by predator abundance. Thus relative suitability as measured by MSVPA would not be affected if this model held but ration would be. There might be differences in absolute suitability due to the effect of other food, and this complication warrants further investigation.

Models 8 and 9 imply changes in suitability from the MSVPA model but not necessarily changes in ration.

We note, therefore, that to test between MSVPA and simpler models we should consider the extent that ration changes with changes in prey and predator abundance but that changes in suitability do not discriminate between these models. We also note that departures from constant suitability either imply a more complex model or that year-to-year variation occurs that we cannot explain. If this latter explanation is the case then we can do no better than the constant suitability model, but we would probably wish to revise sampling schemes to a little but often approach.

If either suitability or ration varies from year to year in a non-predictable fashion, then we will be concerned to see whether these differences lead to changes in our predictions of how the system might react to future changes in fishing regime.

6.2 Comparisons of Predicted Consumption Patterns

6.2.1 Comparison of consumption by MSVPA predators predicted by the 1993 KEYRUN with the consumption estimated from 1981 and 1991 stomach data

Annual consumption of prey species by the MSVPA predator species in 1981 and 1991, as predicted by the KEYRUN, was compared with consumption estimated from MSVPA runs with only 1981 or 1991 food composition data. The results are referred to as predicted and estimated, respectively. The MSVPA run with 1981 food composition data only was used as the most suitable estimator of actual food consumption in 1981, and the MSVPA run with 1991 food composition data only was used as the most suitable estimator of actual food consumption in 1991. The comparison of interest then becomes how well the MSVPA KEYRUN can predict the estimated consumption in 1981 and 1991. The consumption of other food was not included in the analyses of MSVPA output. Predator consumption was aggregated over all age classes for simplicity of representation and because data from adjacent age classes are not independent. Results are presented as the relative rather than absolute consumption to aid presentation; the magnitude of predicted changes in abundance and consumption are presented in Sections 4.3.1 and 6.4. All consumptions are in terms of biomass not numbers.

Relative consumption by all predators of Norway pout was estimated to be higher in 1991 than in 1981 (Figure 6.2.1f), but was predicted by the KEYRUN to remain at similar levels. At the same time the relative consumption of sprat by all predators was estimated to decline between 1981 and 1991, but was predicted by the KEYRUN to remain at similar levels. Generally, the relative consumptions of prey species predicted by the KEYRUN for 1981 and 1991 were more similar to each other than the estimated consumptions for those years.

Estimated consumption by mackerel, whiting, and saithe was more variable between 1981 and 1991 than the predicted consumption (Figures 6.2.1d,b,c). Predicted consumption for haddock suggests a decline in the relative importance of Norway pout between 1981 and 1991, while the estimated consumption shows the opposite trend, although the differences are not great (Figure 6.2.1e).

Interpretation of changes in relative food consumption by cod is complicated by the diverse food habits of the cod (Figure 6.2.1a). The relative importance of cod, haddock, and sprat in the diet of cod declines between 1981 and 1991 in the estimated and predicted results, while the relative importance of herring increases for both sets of results. The decline in the relative consumption of sandeel is not picked up in the predictions, while the predicted decrease in the relative consumption of whiting is not shown in the estimated consumption.

Overall, there are more similarities than differences between the estimated and predicted results. The importance of the differences will depend on the particular analysis or predictions being made.

6.2.2 Examination of the difference between observed and expected proportion of prey in MSVPA predators

Proportion of prey by species and age in the stomachs of MSVPA predators by predator age group, quarter, and year predicted by the MSVPA KEYRUN was compared with the actual proportion of prey in stomachs for the years in which stomach samples were made (1981, 1985, 1986, 1987, and 1991). Proportions of other food are not included in the proportions of prey species are computed from total consumption including other food.

Observed minus predicted proportions are shown in Figure 6.2.2a. The difference between observed and predicted proportions ranges from 0 to about 0.3, with a few outliers beyond this range. A list of outliers is provided in Appendix 3. The differences are centred about 0, and most differences are less than 0.1. There is no obvious trend between years, indicating that the KEYRUN fit the stomach data from all years equally well.

A plot of the observed minus predicted proportions of prey in the stomachs against the number of samples from which the observed proportion is derived is given in Figure 6.2.2b. Differences between observed and predicted proportions decline rapidly with increasing sample number until the number of stomachs sampled reaches about 400. There is little additional decrease in the difference between observed and predicted proportions beyond this point.

6.3 Scatter Plots of Suitabilities and Partial M2s

6.3.1 Suitabilities

Scatter plots of suitabilities by prey species were constructed from the MSVPA runs with only the 1981 data (suit 1, y-axis) and only the 1991 data (suit 2, x-axis). Predator types are distinguished in the plots. Individual points compare the suitability for a particular year, quarter, predator species, predator age and prey age category. Points close to the 1:1 line indicate little change in suitability between runs. Only general patterns are described. Cod as prey (Figure 6.3.1.1a) had a comparatively higher suitability to saithe and mackerel in the 1981 run than in the 1991 run. Whiting prey had a higher suitability to whiting as predator in the 1991 run (Figure 6.3.1.1b), and there is some indication that whiting was more suitable to saithe as well. Haddock as prey (Figure 6.3.1.1c) was more suitable to saithe in the 1981 run and more suitable to haddock in the 1991 run. Herring as prey (Figure 6.3.1.1d) was more suitable to whiting in the 1981 run and more suitable to saithe in the 1991 run. The suitability of sprat to mackerel was higher in the 1991 run (Figure 6.3.1.1e). There was no clear change in the suitability of Norway pout between the runs with the two years' stomach data (Figure 6.3.1.1f). Sandeel suitability appeared to be somewhat higher for haddock in the 1991 run (Figure 6.3.1.1g).

6.3.2 Partial M2s in 1991

Scatter plots comparing the estimated M2s for 1991 from the MSVPA run using the 1981 stomach data (Partial M2-1, y-axis) and the MSVPA run using the 1991 stomach data (Partial M2-2, x-axis) were constructed by prey species. Data points reflect the values within each quarter, predator species, predator age, prey age category.

Cod had a higher M2 due to whiting and cod in the 1991 run compared to the 1981 run (Figure 6.3.2a). The partial M2 on whiting due to saithe is higher in the 1991 run (Figure 6.3.2b). The partial M2 on haddock was higher due to saithe in the 1981 run than in the 1991 run (Figure 6.3.2c). The partial M2 on herring and sprat in 1991 caused by whiting appeared to be somewhat higher in the 1981 run than in the 1991 run (Figure 6.3.2d-e). Partial M2 on Norway pout caused by saithe was considerably higher in the 1991 run (Figure 6.3.2f). The partial M2 on sandeel caused by mackerel was higher in the 1981 run (Figure 6.3.2g).

6.3.3 Conclusions

There were considerable shifts in the suitabilities of prey species between the run of MSVPA using the 1981 stomach data and the MSVPA using the 1991 stomach data. However, most of these shifts in suitabilities do not translate into substantial changes in partial M2s between the two runs. Notable exceptions are the higher M2 caused by saithe on haddock in the 1981 run and the higher M2 caused by saithe on Norway pout in the 1991 run.

6.4 Comparison of 1993 KEYRUN with Predictions Made at 1990 MSAWG Meeting

The 1990 MSAWG assessed that between a quarter and a third of the variance in stomach contents could be explained for in an independent year by the MSVPA. To test this assessment, the 1990 MSAWG predicted the diet composition and Fs at age that would occur in 1991 -- 'year of the stomach - II'. Unfortunately, this MSAWG could not extricate the key from the previous MSAWG chairman to access the "detailed 1991 forecasts for diet composition and Fs at age (that were) being maintained under lock and key." As a substitute for the earlier predictions, we recreated the 1990 MSVPA run from Woods Hole, using the stomach data from 1981 and 1985-1987, as were used in that earlier run. We did not have access to the predicted recruitment levels used in the earlier run so we substituted the real catch-at-age data that are now available; we believe this to be the only difference between the original predictions and the updated Woods Hole predictions.

Total estimated food consumption (biomass) by each MSVPA predator for each prey type for each quarter of 1991 is given in Figures 6.4.1a-f. Predictions from the updated Woods Hole run and the 1993 KEYRUN, are presented together with the estimate of actual 1991 prey consumption computed from the 1991 stomach data alone. Each axis represents the biomass consumed of a particular prey type. Each axis within a graph has the same scale; scales differ among graphs. The lines connecting biomass consumed for the different prey species are illustrative rather than meaningful.

Consumption by the combined predators predicted by the two MSVPA runs are very similar. Figure 6.4.1f is very consistent in all quarters. Both MSVPA runs underestimated the consumption of sandeel in the second quarter and overestimated the consumption of Norway pout in the fourth quarter.

Further differences appear when the MSVPA predator species are considered individually. Predicted consumption of sandeel by haddock in the first quarter was higher than the estimated consumption, while the predicted consumption of Norway pout was lower (Figure 6.4.1e); KEYRUN predictions were closer to the estimated values than the updated Woods Hole predictions. In the second quarter, predicted consumption by the updated Woods Hole model included Norway pout that did not appear to any extent in either the KEYRUN predictions or in the actual estimates. There were only minor differences between the predicted and estimated food consumption for the other quarters.

Similar observations can be made for the other species. Generally, the predicted values are close to the estimated values for mackerel, whiting, and saithe (Figures 6.4.1d,b,c). When differences occur the KEYRUN predictions are usually closer than the updated Woods Hole predictions to the estimated values.

There appear to be greater differences between the predicted and estimated prey consumption values for cod (Figure 6.4.1a), although there is also a considerable similarity. Predicted consumption of herring in the first quarter is higher than estimated, while predicted consumption of whiting is lower than estimated. In the second quarter, predicted consumption of sandeel is greater than estimated while predicted consumption of herring is lower. The predicted food consumption does not include the estimated consumption of sprat in the third quarter, and the overall consumption appears to be lower than estimated. Predicted consumption in the fourth quarter again appears lower than estimated, especially for whiting and Norway pout.

6.5 Changes in Stomach Content Level and Available Biomass

One of the basic assumptions of the presently used version of MSVPA is that the *per capita* rations of the predators are constant or do at least not change in a systematic way in relation to the available biomass of food. The existence of two full data sets on stomach contents of all five predators offers a chance for an investigation of the correctness of these assumptions. Ideally this kind of analysis should be based on the original stomach data by predator length, but the 1981 data were not available in the appropriate format.

As a starting point an investigation was set up based on the stomach content levels by predator age group and quarter. Scatterplots were produced, which plot the total stomach content (observed, other food included) by predator species, predator age and quarter against the biomass which was available to that particular predator age in that quarter. The available biomass is the sum of the MSVPA prey biomasses weighted by the suitabilities. Other food is included in this figure, but since its biomass do not change in the model, it does not contribute to changes in the available biomass of prey. Information on stomach contents and available biomass were taken from the NSVGLM.KEY-file (based on the KEYRUN), aggregation and analysis were performed in SPSS for windows.

Since suitabilities and hence available biomasses can only be compared within one predator age group, all information on available biomass and stomach contents were expressed in relative terms, with the 1981 data being the reference point. Values below 1 indicate that the respective value was lower in 1991 than in 1981 and *vice versa*. This allows a direct comparison of all species, age classes and quarters (Figures 6.5.1a-f).

Results:

Overall results: An obvious pattern of stomach content being positively correlated with available biomass emerged only in the data for saithe(Predsp 3, Figure 6.5.1a). In other species there is either no clear trend (haddock (Predsp 5), mackerel (Predsp 4)) or possibly a negative correlation (cod (Predsp 1) and whiting (Predsp 2)). It must be kept in mind, however, that the stomach contents include variable amounts of other food, whereas the available biomass does not take variations in other food into account. Since predators of different age classes rely to a variable extent on other food, the overall picture may be obscured by changes in suitability and biomass of the other food.

It is apparent from all datasets, that the available prey biomass was in most cases lower in 1991 than in 1981.

Cod (Figure 6.5.1b): Stomach contents are very similar between both years in the first quarter, higher values for 1991 occur mainly in the second and fourth quarter, whereas observations for older age groups in quarter 3 are much lower in 1991. Except for these values from quarter 3 there is no obvious correlation between available biomass and stomach content.

Whiting (Figure 6.5.1c): Stomach content level is on average similar between both years; however, differences occur between quarters: High values occur in 1991 for ages 1 to 4 in quarter 4, low values in all quarters mainly for older ages. In all quarters, except the second quarter, the available biomass was lower in 1991 than in 1981.

Saithe (Figure 6.5.1d): Quarter 1 exhibits outstandingly low stomach contents along with lower available biomasses. In the other quarters the situation is basically reversed. The available biomass has mainly increased for the upper age classes (7-9) in quarters 2-4.

Mackerel (Figure 6.5.1e): Data for the first quarter had to be excluded from this presentation due to some error in the available data. Stomach contents are much lower in ages 1-4 in quarter 4 in 1991. Quarter 2 is outstanding in terms of a higher available biomass in 1991, combined with slightly decreased stomach contents in some age groups.

Haddock (Figure 6.5.1f): With very few exceptions the stomach contents are much lower in 1991 than in 1981. The available biomass in 1991 is in most cases lower in the 3 and 4 quarters and, similar in quarters 1 and 2 when compared with 1981.

This first overview shows that there are indications only from the saithe data, that stomach content may in fact be positively correlated with available biomass. In addition, the haddock data suggests that there may be systematic changes in the overall stomach content level.

However, the methods have to be improved before any final conclusions can be drawn. Data should be analysed based on predator length instead of age and the available biomass may better be estimated from survey data, which could also give some indications on changes in many species of the other food. It must also be kept in mind that changes in stomach content do not necessarily reflect changes in ration. Gastric evacuation rates may have differed between both years due to differences in stomach content and temperature. Depending on the model used to calculate daily rations, differences in rations may be directly proportional to the observed differences in stomach contents, or may be scaled down somewhat, e.g., if consumption is assumed to be proportional to the square roots of stomach content values.

6.6 Modelling Suitabilities

Introduction

The terms of reference required the Working Group to test the stability of suitability estimates. We noted above (Section 6.1) that departures from constant suitability either imply a more complex model or that year to year variation occurs that we cannot explain. This section thus tests for departures from the constant suitability assumption.

6.6.1 Specific question/hypothesis and biological rational

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. The 1991 results being influenced by insufficient convergence in the MSVPA from 1992 to 1991.
3. Random variation in suitability through time.

These possibilities are considered in a latter subsection.

6.6.2 Statistical method

The data set used was the non zero estimates of suitability made with 1981 data and separately with the 1991 data. These together with information on quarter, and on prey and predator species and weight, 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. Data was 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.

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. This model coupled to the Poisson log-link function approach described in section 5 was adopted for this analysis. 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. The smoothing model adopted was thus of the form,

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

Where $x = Ln(predator\ weight/prey\ weight)$ and where ε is an error with a Poisson type error structure (i.e. with variance proportional to the mean). This smoothing model was fitted using the GLIM package. The scale parameter was set to the observed mean deviance so as to fit a generalised Poisson type model.

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.

6.6.3 Results

Table 6.6.1 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 50% (cod) to 77% (saithe) of the total variance. The skewness term was small in all cases. The effect of fitting age effects on the prey species*quarter scaling factors explained an extra 4% (cod, saithe, mackerel) to 10% (haddock) of the variance. Including year effects on the size selection terms increased the fit by at most 2% (whiting, saithe).

The degrees of freedom available to test the significance of these effects was sufficiently large that even minor effects are statistically significant. Only the skewness effects and the year.size suitability factors fail to attain the 5% level of significance. Figures 6.6.1a-e show the scatter of data about the size preference lines for each predator and year (data have been corrected to produce one line per predator year).

GLIM provides the parameter estimates fitted by the full model and estimates of their standard error (s.e.). 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;

$$Suit(pred,prey) = Scaling(pred,prey,quarter,year)*(predwt)^{\omega}* \frac{1}{\sqrt{2}\pi\sigma^2}\exp\left(-0.5\left(\frac{\chi-\mu}{\sigma}\right)^2\right)$$

Values of the canonical parameters and scalings are shown in Table 6.6.2. Approximate estimates of their standard errors (s.e.) derived by first order Taylor expansions are also shown. The table also shows the prefered predwt/preywt ratio for each predator. Generally these appear sensible but those for mackerel in 1991 and haddock in both periods have clearly only been fitted to one side of the normal curve which has resulted in the choice of an unrealistically high mean. 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 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 zero value appears in the estimate column and the word aliased in the s.e. column when no data was available for a parameter to be fitted.

The percentage difference in the canonical scalings (1991 as a percentage of 1981, both corrected for quarterly sums) are shown on Table 6.6.3. The percentages in particular indicate where feeding has increased or decreased markedly since 1981. Note, however, this shows absolute rather than relative change in suitability. Hence a suitability which has changed from .001 in 1981 to one of 0.1 in 1991 will show a large percentage change.

Relative percentage changes in scalings (corrected to 100%) are shown in Table 6.6.4. This indicates only mackerel and haddock have changed the absolute suitability levels of any prey in any quarter by more than 50%. In particular, haddock seem to have decreased feeding on Norway pout and increased feeding on haddock. Since this table shows changes in suitability it is possible to include aliased terms which have been treated as zeros.

6.6.4 Conclusions

More than 50% 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 by between another 5% to 10%. 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. This study does therefore indicate that some variation in suitability estimates 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. This is discussed in Section 6.7.

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 later sections.

6.7 Are Differences in the Suitability Estimates made from the 1981 and 1991 Stomach Data Sets due to Prey Switching?

Introduction

In the general introduction to Section 6 we noted that changes in suitability could arise if a more complex model than MSVPA described feeding. One such model is prey switching. This would be identifiable due to systematic shifts in suitability with changes in prey biomass (see Anon., 1992, Section 4).

6.7.1 Specific question/hypothesis and biological rational

In Section 6.6.3 it was found that smoothed suitability estimates showed some variation from 1981 to 1991. This might have arisen from a number of causes. One possibility is that suitability has a different functional form than that used in the MSVPA. One possible form is that the amount of a prey consumed is proportional to some power of the prey number or biomass. Thus,

$$no.eaten(prey,pred) = \frac{ration(pred)*P(pred)*\widetilde{Suit}(prey,pred)*P(prey)^{\phi}}{\sum_{All\ prey} \widetilde{Suit}(prey,pred)*Wt(prey)*P(prey)^{\phi}}$$

Where P is the predator or prey average population number; ϕ is the power of the prey number in the relationship; and the tilde over suit indicates it is the true value. If this were the case then suitability estimated by MSVPA from one years data assuming ϕ is 1 would be of the form,

$$Suit(prey,pred) \propto \widetilde{Suit}(prey,pred)*P(prey)^{\phi-1}$$

If this is the reason that suitability varies between years then including ln (P(prey)) in the linear predictor of the log-link function fit of Suit(pred,prey) should improve the fit over the basic model by an amount similar to nesting the basic model under year. Moreover, the coefficient of this term should be an estimator of ϕ-1.

6.7.2 Statistical method

The Suits were fitted as in Section 6.6 with the basic model plus the predator size effect. Instead of then fitting the year nesting, a prey biomass term was fitted nested by prey species.

$$Suit(pred,prey,quarter) = exp(a(pred,prey,quarter) + b(pred)\,\chi + c(pred)\,\chi^2 + d\ln(predwt) + (\phi-1)\ln(preybiomass)) + \varepsilon$$

Where $\chi = Ln(predatorweight/preyweight)$ and where ε is an error with a Poisson type error structure (i.e. with variance proportional to the mean).

The reduction of sum of squares due to this fit was then compared to that obtained by nesting the basic model under year (see Section 6.6). The estimates of Φ-1 obtained from this procedure were inspected for consistent trends between predators.

6.7.3 Results

Table 6.7.1 shows the reduction in sum of squares obtained by fitting prey biomass nested under prey species. In all cases this explains less of the total variance than does the year nesting. However, in the case of mackerel and haddock the term explains almost as much variance as the year nesting. The proportion of the variance explained was less for cod, whiting and saithe.

Table 6.7.2 shows the parameter estimates. Large and probably unbelievable estimates are seen for cod biomass with whiting and saithe as predator and on herring biomass with saithe and haddock as predator. Only cod biomass shows a consistently (negative) sign for all predators (haddock is aliased). Other prey biomass terms show a series of positive and negative switching for different predators.

Conclusions

While the sum of squares explained by fitting the biomass terms is a significant proportion of the amount explained by nesting the basic model under year, the individual estimates are unconvincing as evidence of a systematic switching model. Rather we would suspect that general trends in prey biomass may be confounded with the year effect and thus act as its proxy rather than as the cause of the year effect. Thus, at best we can bring in a not proven verdict on the switching model.

If the switching model does not explain the suitability changes then their explanation will need to be sought in changes in overlap or other aspects of prey predator interrelationships. For projections into the future this may mean that suitability will need to be thought of as varying randomly about an average level. Clarification of overlap change as a basis for changes in suitability may be revealed by comparisons of appropriate groundfish survey data with the 1981, 1985, 1986, 1987 and 1991 stomach data. The analysis of these data should be conducted as intersessional work for circulation by 1/1/1995.

6.8 Analysis of Change in Suitabilities

6.8.1 Question/hypothesis

A direct way to examine the stability of suitabilities estimated with different stomach data sets is to analyze the change in suitabilities from those estimated with the 1981 stomach data to those estimated with the 1991 stomach data. If all the change which occurs is due to sampling error, there should be no systematic patterns in the observed changes in suitability. If prey switching is important, then there should be a systematic relationship between changes in suitability and changes in either predator or prey biomass, or both, depending on the type of switching.

Two statistical complications are worth noting. First, the suitabilities are not independent of each other, because they sum to 1.0 for all prey (including other food) of a given predator age. Therefore, the analysis will be biased toward overemphasising the importance of prey switching, if it occurs. For example, any increase in suitability due to positive switching towards a specific prey/age must be accompanied by decreases in suitability of other prey/ages. Likewise for negative switching. Secondly, the suitability of other prey is not included in the analyses. Therefore any change in the use of other prey will appear as a corresponding change in suitabilities of prey in the analyses, so it would be possible to get overall main effects for predators, even though total suitability of all prey to a predator cannot change.

6.8.2 Methods

Data screening - Input data came from the RUN81 and RUN91. From the RUN81 the suitabilities, predator biomasses and prey biomasses for 1981 were extracted. From the RUN91 the suitabilities, predator biomasses and prey biomasses for 1991 were extracted. Where a suitability was estimated for a particular quarter-predator-age-prey-age-combination (hereafter, "record") in one year, but not in the other, suitability in the "missing" year was set to 0.0. Predator and prey biomasses were the actual estimates for the year.

Data preparation - For the three variables - suitability, predator biomass and prey biomass - of each record, the value in 1981 was subtracted from the value in 1991, and then divided by the mean of the two values. This treatment gives data which are changes in suitability and changes in biomass for each record, scaled by their average. Hence a doubling of biomass is the same value, regardless of absolute level.

Analyses - The distributions of variables were examined with univariate statistics. Most were platykurtic compared to normal, but did not show noteworthy skew. The correlation between means and variances were not extreme. With these results, patterns of change in suitability were examined with the General Linear Models procedures in SAS, and species effects were examined with a 2-way ANOVA. Effects of changes in biomass were examined with regression models, some including nested predator or prey species effects. All models included a term for quarter effects.

6.8.3 Results

6.8.3.1 Species effects model

A model fit to change in suitabilities, and including main effects for quarter, predator species and prey species, and all three two-way interactions explains 30% of the variance in changes in suitabilities (Table 6.8 [Model 1]). All terms are significant, but nearly 2/3 of the explained variance is captured by the predator-prey interaction term. Examination of the parameter estimates (Table 6.8.2a) shows that a few predator prey combinations show noteworthy changes, compared to most others. Suitability of cod and sprat as prey both decreased from 1981 to 1991 for cod and saithe as predators. Suitability of haddock for saithe also decreased substantially. Suitability of herring appears to have increased for most predators, and haddock as a predator appears to have eaten more fish (i.e. most prey suitabilities went up) although these interaction terms are aliased, and, therefore, may not be estimated accurately.

6.8.3.2 Regression of changes in biomass

Models fitting overall slopes of change in suitability to change in predator or prey biomass explain very little variance (Table 6.8.1 [Models 2-9]). Models fitting separate slopes for each species do somewhat better, but are still weak. Estimating separate slopes for each species and quarter again improves the models marginally, but explanatory power is still around 10%. In this suite of comparisons a few individual slopes are significantly different from 0.0; in particular, sprat biomass has a significant positive slope Table 6.8.2c, suggesting predators are attracted to it when it is common, or exploit it dispro-portinately lightly when it is less common. With the weak explanatory power of the models, however, this cannot be taken as a dominant pattern.

6.8.4 Conclusions

The regressions were biased towards finding evidence of switching, and yet they could not capture much variance. Therefore switching, if present, is weak. The species effects models shows that there are some changes in relationships among specific species. Suitability of sprat was lower in 1991 than in 1981, and the change in suitability was significantly related to the change in sprat biomass. This is consistent with, but not conclusive evidence for, less use of sprat by predators when its abundance was lower and its distribution may have been more restricted. There is no evidence of strong switching towards herring, despite its substantial increase in biomass from 1981 to 1991.

6.9 Testing MSVPA Output against Survey Data

As a consequence of the data hunger of MSVPA, there are very few independent data sets available against which the results can be tested. Survey data on abundance are used in tuning single-species VPA and since the resultant terminal fishing mortalities are used in setting up the quarterly MSVPA, they cannot be considered independent. Still it seemed worthwhile to compare the correlations between log-transformed IBTS estimates of abundance of 1- and 2-group cod, haddock and whiting and the numbers at age estimated both from MSVPA and SSVPA. The time series are shown in Figure 6.9.1a-c and the correlations in Figure 6.9.2a-c). It is quite clear that MSVPA does only marginally affect relative recruitment compared to SSVPA and that patterns of good and poor year classes remain unaffected. In practice, correlations between survey estimates and MSVPA estimates of recruitment are slightly less than for SSVPA (see text table). However, this does not necessarily mean that MSVPA is inferior, because the SSVPA is tuned against the survey values and, therefore, it is not unexpected that its results perform better.

Correlation coefficients for different estimates of recruitment

Cod		Haddock		Whiting	
N1	N2	N1	N2	N1	N2
MSVPA-IBTS					
0.56	0.77	0.83	0.86	0.18	0.07
SSVPA-IBTS					
0.64	0.80	0.89	0.87	0.31	0.08

Another way of comparing survey data with MSVPA output is by comparing catch ratios between 1- and 2-group of the same year class with the mortalities estimated by MSVPA. A problem is that catch ratios cannot be interpreted directly in terms of mortality because different age groups have different catchabilities in the survey gear. As a first trial, two periods were distinguished, 1976-1981 and 1986-1991. Using the average total mortality during the recent period, the average expected catch of 1-group was calculated as the average catch of 2-group during this period. This gives a correction factor (which can be thought of as 1/relative catchability of 1-group compared to 2-group) for the entire period, by which the 1-group has to be multiplied. From the corrected values of 1-group and the number per hour fishing of 2-group, a survey value of Z can be obtained, which is tuned to give the MSVPA estimates for the recent period. The text table below provides the estimated values of natural mortality from the survey in comparison to the MSVPA estimates.

	Cod		Haddock		Whiting	
	1986-1991	1976-1981	1986-1991	1976-1981	1986-1991	1976-1981
N1	8.1	14.5	444	395	751	498
N2	10.8	14.8	288	294	710	301
Z MSVPA	0.882	-	1.443		1.219	
N1 corr.	26.2	47.3	1219	1084	2402	1591
Corr. factor	3.251		2.745		3.197	
Z survey	0.882	1.161	1.443	1.306	1.219	1.667
F MSVPA	0.196	0.151	0.242	0.331	0.273	0.238
M survey	0.686	1.010	1.201	0.975	0.946	1.429
M MSVPA	0.686	0.808	1.201	1.338	0.946	1.097

For cod both survey data and MSVPA suggest a higher natural mortality in the earlier period, although the drop in the survey catches appears to be more pronounced. For haddock the survey would indicate a lower M and the MSVPA a higher M in the earlier period, whereas in whiting both data sets indicate an increase. Figure 6.9.3a-c show the values for individual years, which indicates a more variable pattern between years in the survey data than exists in the MSVPA results. The conclusion can only be drawn that the survey data are inconsistent with the MSVPA, but whether this is due to variability in the survey results or lack of precision in the MSVPA cannot easily be determined.

6.10 The Effect of Changing Stomach Data on the Long-Term Equilibrium State

The long-term equilibrium, which is achieved by running the MSFOR to convergence, is a function of the input recruitments, fishing mortalities and suitabilities. The purpose of this exercise was to evaluate the sensitivity of the equilibrium state to input parameters generated by MSVPA using the three sets of stomach data. This was done by evaluating the response to changes in the fishing mortalities.

A systematic study of this was not possible at this meeting. However, two examples are provided: A general reduction by 10% in the fishing mortality for all species, and a set of altered Fs representing an increase of the mesh size in the human consumption fishery to 130 mm with 75 meshes around the codend. The first of these options was supposed to represent a rather gentle perturbation of the system, while the 130 mm mesh size option is included as a rather hard test. The input Fs for this test were originally developed by an STCF study group and were used in previous tests of mesh size efforts (Anon. 1989).

For the latter example, an analysis of the effect of the recruitment on the induced change was also made.

The baseline run for these comparisons was, for each of the stomach data sets, the steady state assuming unchanged recruitments and fishing mortalities. The results of these baseline runs are shown in Figures 6.10.1 to 6.10.5. There are some differences between these runs, which may be due to different suitabilities, but also to different fishing mortalities and recruitment numbers generated by applying the three stomach data sets.

The effect of reducing all fishing mortalities by 10% is shown in Figures 6.10.6 to 6.10.8. For most stocks, the reduction in fishing mortality led to a reduction in catches and an increase in biomasses. Only for the saithe, did the catches increase. The change in catches and biomasses was not out of proportion to the change in fishing mortality in any case. The most prominent discrepancies between the runs with the various stomach data sets were for the haddock, and, to a lesser extent, for Norway pout and cod. Only in the case of haddock could the differences be a matter of concern.

The effect of the 130 mm mesh size option varies substantially between the sets of stomach data for some species (Figures 6.10.9 to 6.10.11). Again, this is mostly true for the haddock. The general impression is that the 1991 stomach data set induces a more favourable response to this change in fishing mortalities than the two others, which are more similar.

To explore the background for this discrepancy, the effect of the size of the saithe biomass on the results for haddock was studied as a possible candidate. The results (Figures 6.10.12 to 6.10.14) show that apparent benefit of the mesh size change depends on the assumed abundance of saithe. Time did not permit a more systematic study of similar effects of other predators. It should be noted that the stomach data for saithe may be less reliable than for the majority of predator species, due to a comparatively low number of samples both in 1981 and 1991. Therefore, results that are highly dependent on the abundance of saithe should be treated with some caution.

The dependence of the changes induced by the 130 mm fishing pattern on the abundance of the various stocks was studied by making a comparison between fishing patterns with all possible combinations of recruitments at either 0.5 or 1.5 of the *status quo* level. Tables 6.10.1 and 6.10.2 show the distributions of the outcomes from these runs for SSB and yield, respectively. This was done only with input data from the MSVPA with the KEYRUN set of stomach data. The change in SSB for haddock seems to be most strongly dependent on the recruitments of the various stocks. The changes in catches are more consistent. The change in catches of cod vary between gain and loss, but the range is quite narrow.

The general impression of this study is that the long-term equilibrium state, and its change with changing fishing effort, is not very sensitive to the choice of stomach data. In this respect, the assumptions underlying the MSVPA/MSFOR do not seem to be severely wrong. For the haddock, a problem has been identified, which should be further explored. It should also be borne in mind that the suitabilities generated from the 1991 data are likely to be improved in the future, both because the stomach data still need better checking, and because the cohorts to which the stock numbers of most prey belong are still far from converged in the VPA.

6.11 Conclusions of Tests and Comparisons

Each of the tests or comparisons performed in the previous sub-sections allowed the Working Group to draw some specific conclusions. These conclusions, taken together, lead to some general conclusions presented in Section 10. Conclusions address the stability of suitabilities in MSVPA as charged in our Terms of Reference, and more generally MSVPA, its assumptions, and their relationships to what we have learned or believe about the North Sea.

The diagrams in Section 6.2 show that MSVPA picks up the mean values of diets well, but does not track the interannual variation in food composition closely. Overall, when comparing results with the various data sets things were much more similar than they were different.

When considering the estimated suitabilities and M2s across the MSVPA runs (Section 6.3), considerable shifts were observed in some suitabilities from 1981 to 1991. These shifts in suitabilities do not translate into changes in M2s, however, except in a couple of species predator/age prey/age combinations. Large shifts in suitabilities only occurred for quarter-predator-prey combinations with relatively small samples of stomachs.

The fit of the data and MSVPA-estimated diets to the pseudo-Woods Hole predictions were quite good (Section 6.4). The fit was better when all the data were used.

When looking at the observed food in the MSVPA results, some variation in consumption levels and patterns occurred (Section 6.5). Only for saithe did there appear to be a relationship between available biomass and observed diets. More analyses are, however, required before conclusions can be drawn on the patterns in these data.

The fits to suitabilities with the smoothing models showed that a significant amount of variation can be explained by a common model (Section 6.6). There is a lesser, but statistically significant, amount of inter-year variation.

Some significant improvement can be obtained in model fit when year effects are added to the models (Section 6.7). Predator switching is a possible explanation for the pattern. The evidence for switching is, however, inconclusive.

When modelling the changes in suitabilities using 1981 and 1991 separately there are some weak but consistent patterns among species (Section 6.8). The only potential evidence for predator switching may be the decline in suitability of sprat as prey from 1981 to 1991.

Looking at the correlations of MSVPA outputs with survey data, MSVPA matches the average populations well, but does not track the interannual variation in mortalities estimated from survey data (Section 6.9). Because of the variation in the survey data, among other reasons, we cannot conclude if the failure to track the year-to-year patterns is good or bad for MSVPA.

The long-term equilibrium results are not critically dependent on the choice of input stomach data (Section 6.10). This is reassuring for MSVPA. Results did identify a potential problem with haddock, however, and preliminary examinations suggest that the problems may be data errors.

7 PREPARATION FOR MEETING ON BOREAL SYSTEMS

7.1 Background

It is intended that a significant portion of the next meeting of the MSAWG will be devoted to TOR related to multispecies models for assessments in Arcto-Boreal systems. At the 1990 Special Meeting of the MSAWG in Bergen, it was considered that the differences between the North Sea and boreal systems probably implied that different kinds of modelling approaches would have to be developed rather than using MSVPA in its current form (Anon., 1990b).

The main difference is that, whereas in the North Sea there are several interacting predator and prey species that are fished commercially, in boreal systems there are fewer interacting species of commercial importance. The primary focus in boreal systems tends to be on cod-capelin interactions. There is considerable emphasis on improving short-term predictions by taking multispecies considerations into account, as well as longer term predictions regarding joint management of interacting species.

VPA is carried out on cod catch data whereas capelin are assessed by acoustic surveys. The capelin TAC is set based on a forward projection of expected spawning biomass (constant escapement policy in Barents Sea and Iceland and constant proportion policy in Newfoundland). The cod TAC is set with the intention of achieving a particular level of fishing mortality in the forthcoming year and/or keeping the SSB at or above some prescribed level. There are two assessment-related questions of primary importance which follow directly from these management approaches: (i) what is the expected survival rate of capelin for use in the projection of spawner biomass at alternative TACs? and (ii) what is the expected weight-at-age of cod for use in the calculation of the fishing mortality associated with alternative TACs?

In three of the boreal systems (Barents Sea, Iceland shelf, Newfoundland-Labrador shelf) there are time series of cod catch-at-age, capelin numbers-at-age from acoustic surveys, cod stomach content data and cod growth data (length- and weight-at age). Two of these data sets have been analysed at previous meetings of the MSAWG - length- and weight-at-age (Anon., 1991a) and cod stomach content data (Anon., 1992b). Analysis of the cod growth data showed a strong year effect in all three systems and at least some evidence that this could be attributed in part to capelin abundance (Anon., 1991a). Subsequently Steinarsson and Stefánsson (1991) concluded that capelin is a significant factor influencing cod in growth on the Iceland shelf. Analysis of cod stomach content data from the three boreal systems showed that capelin weight in the stomach increased with increasing capelin abundance in the sea and that the ability of cod to compensate by eating more other prey when the amount of capelin in the stomach was low, varied among systems [partial compensation off Newfoundland-Labrador, less compensation off Iceland and weak compensation in the Barents Sea (Anon., 1992b)].

Based on analysis of cod growth and stomach content data, the MSAWG concluded that "...boreal systems are functionally different from highly-networked feeding webs such as the North Sea. Thus, the assumption of constancy of total food consumption, growth, and perhaps predator/prey suitability, which are incorporated in the MSVPA structure, do not seem to apply to boreal systems" (Anon., 1992b). It was recognized that "more appropriate models could be developed that incorporate retrospective stock size, F, and predation mortality (M2) estimation and allow for prey-mediated predator growth and environmentally-induced variation in predator/prey overlap. Development of such a retrospective model may capture the MAIN features of cod-capelin interactions, and allow testing of MAJOR assumptions." (Anon., 1992b).

Although a boreal component to the activities of the MSAWG is relatively new, there has been a long and intensive multispecies modelling project carried out on the Barents Sea, focussing mainly on cod-capelin interactions (MULTSPEC, e.g. Bogstad and Tjelmeland, 1990). The model is set up in such a way that it can be used both for estimation and projections. The estimation part of the MULTSPEC program finds values of parameters which best predict measured stomach contents from sampling. The prediction is based on a model relating migration/overlap of predators and prey, predator food preferences and stock sizes of both predator and prey, to the stomach content data. Parameters related to migration, predation and, for capelin, maturation are estimated by maximizing a likelihood function in a forward simulation. The parameterized model can be used in projections to examine various options for the joint management of interacting species.

The general MULTSPEC approach, extended to account for predator growth dependent on prey consumption, is being used in the development of a multispecies model for the Icelandic shelf [BORMICON, see Stefánsson (1993) Working Paper, Atlanto-Scandian Herring and Capelin WG].

7.2 Proposed Work for the Next Meeting

In terms of boreal work, the next meeting of the MSAWG will devote further attention to TOR (c) (Evaluate the statistical properties of stomach sampling schemes, and continue the statistical analysis of feeding data) and TOR (d) (Initiate data preparation and model construction to apply retrospective multispecies assessment techniques to boreal systems, including variable predator growth and spatial overlap of predators and prey). It is proposed that the following work be undertaken at the next meeting: (i) statistical analysis of boreal stomach content data with particular reference to capelin and "other food" prey types and incorporating spatial analysis; (ii) analysis of cod growth rate using models including explanatory variables derived from stomach content data; (iii) testing and sensitivity analysis of the Barents Sea MULTSPEC model developed by the Institute of Marine Research, Bergen; (iv) consideration of alternative models for boreal systems, for example, a modified version of MSVPA.

7.3 Potential Cooperation with PICES Bering Sea Working Group

PICES (the North Pacific Marine Science Organization) formed a Bering Sea Working Group at its 1992 meeting. The Working Group met in August 1993, and identified six Principal Scientific Questions regarding the Bering Sea marine ecosystem. In the Introduction to these Principal Scientific Questions, their Working Group Report highlights the value of comparative work across ecosystems. This interest in comparative investigations complements the approach taken by the Multispecies Assessment Working Group to the study of boreal systems in the North Atlantic, and raises the possibility of some cooperation between the groups.

The Multispecies Assessment Working Group reviewed the six Principal Scientific Questions identified by the PICES Bering Sea Working Group (**Appendix 7.1**??).

Although none of the Principal Scientific Questions address problems in stock assessment directly, one focuses on the predator-prey interactions which are a major part of the biological justification for multispecies assessments. Details of the four-part "question" highlight many of the same concerns which have arisen in the Multispecies Assessment Working Group during analysis of data from boreal systems in the Atlantic.

The Multispecies Assessment Working Group proposed two appropriate steps to open communication between the two Working Groups. The Chairman of the PICES Bering Sea Working Group will be added to the mailing list for the Multispecies Assessment Working Group. Also the Bering Sea Working Group is planning a mini-symposium to centre on their Principal Scientific Questions. The Chairman of the Bering Sea Working Group will be asked to send meeting announcements and related materials for the mini-symposium to members of the Multispecies Assessment Working Group.

8 FOOD FOR THOUGHT

8.1 Modelling and Data Analysis Possibilities for O-group Fish

The analysis and modeling of O-group fish poses a number of difficult problems. Some possible approaches are considered in this section.

Could we include the feeding of O-group fish directly in MSVPA? To do this it might be necessary to include O-group fish not as a single cohort but as a size range. The original paper of Helgason and Gislason 1979 used such an approach for O-groups. A problem with this approach is that, since O-group fish certainly feed within the cohort and because possibly their M2's are high, a MSVPA approach may not be unique. The criteria of Magnus and Magnusson, 1983, suggest that uniqueness of MSVPA solutions cannot be guaranteed when within-cohort predation occurs or if predation mortality rates become higher than 2.0 in a time period. While these criteria were sufficient rather than necessary conditions for uniqueness they must provide pause for thought before moving to a MSVPA interpretation of these data. However, if the O-groups are treated as several separate size groups then the uniqueness problem might be circumvented since the fish are not really eating themselves (i.e. bigger sub cohorts are eating smaller sub cohorts). Thus some MSVPA approach might be considered, though it would probably need to be decoupled from the main MSVPA.

What may be a bigger problem for a MSVPA approach is that, for practical reasons, in many cases the data may be rather unclear as to size and/or species of prey (see 3.6.3). This may be a bigger problem with using the MSVPA.

A possible alternative approach might be to regard M2 as proportional to predator biomass and to use the approach of Singh and Pope, 1992, that interprets stomach contents as being explained by the product of a local prey abundance and a predator prey effect. This factor is in effect the local manifestation of UM2 (the predation per unit predator biomass). It is local in the sense that it does not include species overlap but is the same at all stations. Thus if we consider predator S of weight W eating prey s of weight w then we would fit numbers in Predator stomach NS(S,W,s,w,r) at station r as

$$\ln(NS(S,W,s,w,r)) = \ln(\text{Prey } abundance(s,w,r)) + \ln(UM2(S,W,s,w)) + error$$

Thus the feeding data might be fitted by a prey station interaction term and a predator prey interaction term in a GLM. In practice having these terms by species and weight, and including zero observations, would make the analysis laborious. It might be simplified considerably if predator and prey distributions were described by simple Log normal distributions times an overall abundance and if UM2 were described by a Ursin log-normal size preference and a species interaction term.

$$\ln(NS(S,W,s,w,r)) = \ln(\text{Prey } abundance(s,r)) + \alpha 1(r)*\ln(w) + \alpha 2(r)*\ln^2(w) + \ln(UM2(S,s)) + \beta 1*\ln(W/w) + \beta 2*\ln^2(W/w) + error$$

Clearly there would be aliasing between the estimates of the prey weight abundance function and the UM2 function. These would have to be estimated by later reference to either direct population abundance estimates from the surveys or by reference to the MSVPA youngest age estimates. The general approach also gives some prospect of smoothing the data before use. This should be useful. At the worst such smoothing of the data might make valuable preliminary analysis.

The above discussions suggest that 0-group numbers should be modelled as size distributions and the smoothed O-group data used as data inputs. This should be done outside the main MSVPA with the view to improving our understanding of the main predation processes in O-group fish. Such a size-based approach might also find application in the MSVPA of older fish, making it possible to make use of the original (length based) stomach contents data rather than the age transformed data, which suffer from the need to introduce age length keys, which usually "smear" the data. One possible problem noted with the current approach of the

MSVPA to estimating O-group mortality rates is that it currently counts all O-group predation as equivalent. It is possible that some weighting to allow for differential M1 by size might help with this problem.

9 EVALUATION OF MODELS OF STOMACH CONTENTS DATA

Prompted by ACFM's well-intentioned suggestion (October 1992 Report) that Working Group concerns regarding the handling of zero observations in some of the files analyzed at the 1992 meeting had already been resolved in the literature, the Working Group reconsidered the issue of the proper statistical approach to stomach data and outputs of models using stomach data. The major new information reviewed was paper ICES 1993/CCC Symposium/ No. 46, "Statistical Analyses of Stomach Content Data" by G. Stefánsson and Palsson. Unfortunately, neither author was able to attend the meeting to address concerns from Working Group Members.

Stefánsson and Pálsson propose a wholly model-based approach to the analysis of stomach data. They propose breaking the analyses into two steps, first estimating the number of empty stomachs to be encountered, and then estimating the amount of food in the stomachs which are not empty. For the first step they propose fitting a logit model, assuming 1-P follows a binomial distribution (where P is the proportion of stomachs which may be empty). For the second step they propose a model assuming a Gamma function (which scales log-variance by log-mean to a slope of 2.0). Both steps allow covariates such as length, location, or water temperature.

The Working Group welcomed the Gamma-Bernoulli model as an important contribution to a persistent problem. They were concerned, however, about the generality of the model and its applicability to systems like the North Sea. Specifically, the reasoning behind the approach is developed for the case when there is only one prey, so the representation of that prey item in the stomach data can be modelled as an independent event. In that case the approach appears sound, although it does not deal with the issue of cluster sampling of stomachs which can be important in analysis of stomach data. The Working Group is concerned about the correctness of the model when applied to data with a number of different types of prey in the stomachs. In those cases the representation of any specific prey type is unlikely to be an independent Bernoulli-trial, but rather to vary conditionally the presence of other prey taxa. That case is not dealt with in the Stefánsson and Palsson paper, but is a common occurrence and appears inconsistent with the assumptions of the proposed model.

The Working Group also noted that the paper did not evaluate the effectiveness of the specific model-based approach to analysis of stomach data against design-based approaches for analysis of such data. The ICES approach to collecting stomach data has been strongly design-based, with significant effort applied to each spatial unit and quarter. Both theory and experience gave the Working Group some optimism that the design-based approach has provided stomach estimates without noteworthy bias or variance. However, the Working Group did note that the design had never been tested to see if the extensive design effort had actually succeeded in obtaining unbiased, low variance parameters for the stomach data. Such analyses would be very informative, and could comprise a major task at a future meeting of the Working Group.

The Working Group felt it inappropriate to pursue the model proposed by Stefánsson and Pálsson in their absence. At least one of the authors is likely attend the next meeting of this Working Group, if the meeting focuses on models of Boreal systems. Therefore, the Working Group RECOMMENDS that statistical properties of stomach data be kept in the Terms of Reference until the next meeting. Issues of concern to the Working Group should have a thorough review at that meeting. The Working Group further notes that even if the statistical properties of stomach data are clarified, and effective analytical methods are developed, its previous concern regarding the statistical treatment of zeros was in the context of proper modelling of suitabilities, given stomach data. The present meeting made substantial progress on these concerns (see Section 5).

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

1. The suitabilities do vary between runs with the different data sets. The changes are small, however. The forecasting properties of MSVPA appear generally robust to the observed level of changes in suitabilities. There are no models available which deal with changes in suitabilites better than MSVPA does.

2. To test MSVPA (or alternative models) with statistical rigour, it is imperative that the statistical distributions be known for both the stomach data and the survey data. Without such knowledge one cannot establish rigorous "expected" values to test model predictions against.

3. The Working Group noted that MSVPA showed little change in total mortality. The lack of change could have

several causes, including buffering of total mortality by M1 mortality, buffering suitabilities by inclusion of Other Food, and smearing true variability in food composition across several ages of prey and predator through use of age/length keys for the stomach data, or through the diverse mix of generalist and specialist predators in MSVPA. It is even unclear whether to consider the lack of variation to represent robustness or inertia.

4. A number of things we do would benefit greatly from not smearing the stomach data across ages, from sampling otoliths of the fish found in stomachs, and possibly from a version of MSVPA which was based on length classes, rather than ages.

5. We do not expect all our results to be stable forever. Based on our experience with the 1981 data, and several results of these first analyses of the 1991 data, we expect to isolate some incorrect values in the stomach data set. As these are corrected, we expect MSVPA performance using the 1991 stomach data to stabilize further. Moreover, some of the values for predator and prey populations at age are weak. Future information or further experience might lead to changes in some of these input data. In fact, some results even suggest it might be appropriate to tune VPAs of some stocks for which we have few data at present to the stomach contents.

6. The Working Group has not reviewed estimates of M1 and M2 fully enough to advise new values for other Assessment Working Groups at this time. This Working Group plans to revisit its advised estimates of M1 and M2 at its 1996 meeting, and may advise new values at that time.

10.2 Recommendations

10.2.1 It is recommended that the next meeting of the Multispecies Assessment Working Group (Chairman: Dr J.Rice, Canada) meets in Bergen, Norway in June 1995 to:

a) Continue the development of multispecies models of assessment. Give special attention to examining the application of multispecies assessment techniques to boreal systems, including variable predator growth and spatial overlap of predators and prey. Specific tasks will include:

   i) statistical analysis of boreal stomach content data with particular reference to capelin and "other food" prey types and incorporating spatial analysis;

   ii) analysis of cod growth rate using models including explanatory variables derived from stomach content data;

   iii) testing and sensitivity analysis of the Barents Sea MULTSPEC model developed by the Institute of Marine Research, Bergen;

   iv) consideration of alternative models for boreal systems, for example, a modified version of MSVPA.

b) Review and extend intersessional work on data analysis and modelling of predation processes on 0-group fish.

c) Review and extend intersessional work on comparisons of the northern and southern parts of the North Sea, with special reference to relating survey data to MSVPA results, and plan for a detailed treatment of this matter at the 1996 meeting.

d) Conduct the necessary planning for a thorough review of food rations in MSVPA to be conducted at the 1996 meeting of the Working Group.

10.2.2 It is recommended that a Planning Group on Boreal Multispecies Models (Chairman to be appointed) meets in Bergen, Norway in January 1995 to:

a) develop a suite of appropriate tests and sensitivity analyses to apply to the MULTSPEC model.

b) facilitate the timely transfer of information on MULTSPEC, and the tests and analyses devised, to Working Group members to allow for the necessary preparation.

Rationale

In order to investigate the potential of the MULTSPEC model for use in other boreal systems it is important that its sensitivity to various input parameters is evaluated. This requires considerable preparation in the intersessional period among scientists knowledgeable about MULTSPEC, MSVPA, spatial aspects of predator-prey interactions and mathematical/statistical methods. The Planning Group should obtain the necessary background information on MULTSPEC as early as possible, and meet sufficiently early to allow preparatory work to be carried out so that the tests and sensitivity analyses developed by the Planning Group can be applied at the next Working Group meeting.

10.2.3 The Working Group recommends that the basic data from the 1991 stomach sampling project in the North Sea be published as a Cooperative Research Report under the editorship of Dr. J.R.G. Hislop.

10.2.4 The Working Group recommends that intersessional work be conducted on data analysis and modelling of predation processes of O-group fish. Coordination will be provided by John Pope, Niels Daan, and the Chairman of the Working Group.

10.2.5 The Working Group RECOMMENDS that the Study Group on Seabird/Fish Interactions explore ways of breaking down their fish consumption data by age or size class, and provide updated estimates prior to our next "definitive" MSVPA run for the North Sea (likely in Winter 1996).

10.2.6 The Working Group RECOMMENDS that a new version of MSVPA allows for input of biomass data of selected other prey and for output of the quantities consumed. In particular, *Pandalus*, *Nephrops*, *Crangon* and dab should be considered as first priority species in this context. Because the fisheries on the invertebrate stocks are very localized, the information derived from MSVPA should become even more useful, when an area-based model has been developed.

10.2.7 The Working Group RECOMMENDS that statistical properties of stomach data be kept in the Terms of Reference until the next meeting. Issues of concern to the Working Group should have a thorough review at that meeting.

11 REFERENCES

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Anon. 1989. Report of the Multispecies Assessment Working Group. ICES, Doc. C.M.1989/ Assess:20.

Anon. 1990a. Report of the Mackerel Working Group. ICES Doc. C.M.1990/Assess:19.

Anon. 1990b. Report of the Special Meeting of the Multispecies Assessment Working Group. ICES, Doc. C.M.1990/Assess:28.

Anon. 1991a. Report of the Multispecies Assessment Working Group. ICES, Doc. C.M.1991/Assess:7.

Anon. 1991b. Manual for the ICES North Sea stomach project in 1991. ICES, Doc. C.M.1991/G:3.

Anon. 1992a. Progress report on the ICES 1991 North Sea stomach sampling project. ICES, Doc. C.M.1992/G:12.

Anon. 1992b. Report of the Multispecies Assessment Working Group. ICES, Doc. C.M.1992/Assess:16.

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Anon. 1994b. Final Report of the Study Group on Seabird/Fish Interactions. ICES, Doc. C.M.1994/L:3.

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Anon. 1994d. Report of the Working Group on the Assessment of Norway Pout and Sandeel. ICES, Doc. C.M.1994/Assess:7.

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Stefánsson, G. 1993. Working Paper to the 1993 Meeting of the ICES Atlanto-Scandian Herring and Capelin Working Group.

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APPENDIX 1

Contents of the "JAKEFILE"

The "JAKEFILE" is supposed to satisfy the need of even the most data-hungry member of the Multispecies Assessment Working Group. In year/quarter combinations for which stomach content data are available it contains information on prey suitability, estimated and observed stomach content, prey and predator weight at age (at ingestion and in the sea) etc. etc. etc. for every predator age/prey age combination.

Each record contains 19 variables:

1.	Year.	
2.	Quarter.	
3.	Predator species code.	
4.	Predator age.	
5.	Prey species code.	
6.	Prey age.	
7.	Predator-age/Prey-age index utilised within the model.	
8.	Suitability of the particular prey-age group to predation by the predator-age group.	
9.	Observed proportion of the prey-age group in the stomach content.	INPUT
10.	Observed Total stomach content of 1000 predator-age group individuals.(g)	INPUT
11.	Number of stomach sampled from the predator-age group.	INPUT
12.	Estimated proportion of the prey-age group in the stomach.	
13.	Av. weight of prey-age group at time of ingestion (g).	INPUT
14.	Av. weight of prey-age group in the sea (g).	INPUT
15.	Av. weight of predator-age group in the sea (g).	INPUT
16.	Partial M2: Amount of predation mortality generated by the predator-age group on the prey-age group (per year).	
17.	Biomass of predator-age group at beginning of quarter (tonnes).	INPUT
18.	Biomass of available prey: Sum over prey-age groups of suitability times prey biomass (tonnes).	
19.	Biomass of prey-age group at beginning of the quarter (tonnes).	

The MSVPA program outputs data to the JAKEFILE in year/quarters where the model has been fed stomach content data. Records are only added if the partial M2 generated is larger than 0.0000001.

The Predator and prey species codes for the North Sea are:

1. Cod
2. Whiting
3. Saithe
4. Mackerel
5. Haddock
6. Herring
7. Sprat
8. Norway pout
9. Sandeel
10. Plaice
11. Sole

APPENDIX 2

POTENTIAL intersessional (or future meeting) analytical questions arising during discussion of Section 6. These are ordered to correspond to the sections of the text, and position reflects no value judgments about relative importance. This Appendix is prepared to archive the ideas and concerns which arose during discussion sessions of the Working Group. It is not to be taken as either expanded Terms of Reference for the Working Group, or as an indication of lack of faith in the results of the MSVPA runs.

6.2

1. How would SMOOTHED suitabilites for RUN81 and RUN91 perform in the pies and radar plots?

2. Make comparisons across all predators. Do specific ages /sizes ALL show increases in eating of, say, Norway pout?

3. Comparing 81 and 91 predator-prey correlations age by age.

6.3

1. From pattern of variance by N, explore tuning VPAs to stomach data when catch data are weak.

6.5

1. Use survey estimates of biomass as independent checks on some of these results.
2. Do analyses on lengths, not ages.

6.6

1. Explore how nesting the size effect under prey really captures more variance. Is there some confounding with possible year effects?
2. Estimate an annual suitability rather than quarter by quarter.

6.7

1. Explore how the survey results vary and correlate with material at end of last paragraph.
2. Look for differences in suitabilities between southern and northern North Sea.

6.8

1. Consider alternative scalings, and weighting points by number of stomachs prior to doing regressions.

6.9

1. Plot the number of samples going into each M2 estimate
2. Weight the M2 by number of samples per predator age and recalculate
3. Deal with the ALK smearing problem, and redo these analyses

6.10

1. Look into haddock SSVPA and MSVPA relationships. Is the SSVPA age 1 in accordance with the surveys?

APPENDIX 3

Possible outliers in the 1991 stomach data set, based on results of analyses conducted at the meeting:

- cod (ages 4-6) feeding cod in the second quarter seem high;
- cod (ages 2-3) on herring in the fourth quarter seem low;
- haddock (ages 3-5) on herring in the first quarter seem high;
- whiting (ages 3-6) on whiting in the second quarter seem low;
- saithe (ages 7-9) on haddock in the second quarter seem high;
- saithe (age 9+) on whiting in the second quarter seem high;
- mackerel (ages 1-2) on herring in the fourth quarter seem high;
- mackerel (ages 5-6) on sprat in the fourth quarter seem high.

Individual values will be investigated intersessionally.

APPENDIX 4

List of Working Papers Tabled at the 1993 Working Group Meeting and ICES Reports Reviewed by the Working Group

Anon. 1993. The Report of the Planning Group for the Development of Multispecies, Multifleet Assessment Tools. ICES, Doc.C.M.1993/Assess:8.

Anon. 1993. Draft Report of the Study Group on Seabird/Fish Interactions. ICES, Doc. C.M.1993/L:10. [See C.M.1994/L:3 for final report]

Anon. 1992. Progress Report on the ICES 1991 North Sea Stomach Sampling Project. ICES, Doc. C.M.1992/G:12.

WP 1 Working Paper submitted by the Coordinators of the ICES Stomach Sampling Project in the B/North Sea in 1991. Hislop, J. and 9 co-authors (P. Bromley, N. Daan, H. Gislason, T. Grohsler, H. Heessen, B. Johnsson, S. Robb, D. Skagen, A. Temming)

WP 2 Recruitment Variability and Growth of Northeast Arctic Cod; Influence of Physical Environment, Demography, and Predator-Prey Energetics. Nilssen, E.M., Pedersen, T., Hopkins, C.C.E., Thyholdt, K., and Pope, J.G. ICES, Doc. 1993/CCC Symposium/No.30.

WP 3 Vague First Thoughts on Handling Feeding in the O-group. Pope, J.G.

WP 4 Measurements of the Stomach Evacuation Rate of Mackerel. Bohle, B., and Skagen, D.

WP 5 Building a Biomass Box Model for a Boreal Ecosystem. Shelton, P.A., and Lilly, G.R.

WP 6 Cod Distribution and Temperature in the North Sea. Heessen, H., and Daan, N.

WP 7 PICES Bering Sea Working Group; Prinicipal Scientific Questions. Rice, J.C.

WP 8 Feeding Habits of Demersal Fish Species and Predation Mortality of Shrimp in Greenland Waters. Pedersen, S.A.

WP 9 Statistical Analyses of Stomach Content Data. Stefansson, G., and Palsson, O.K. ICES Doc. 1993/CCC Symposium/No,. 46

WP 10 Bias in the MSVPA Estimates of Suitabilities When More than One Year of Stomach Data are Available. Sparholt, H., and Gislason, H. (First tabled as WP-2 at 1990 meeting of Multispecies Assessment Working Group).

WP 11 Comparisons of Suitability Submodels. Sparholt, H. (Tables from WP first presented to Baltic Multispecies Assessment Working Group in 1992 [C.M.1992/Assess:7]).

WP 12 Discussion of the Estimation of Suitability Coefficients from More than One Year's Stomach Content Data. Sparre, P. (First tabled as Working Paper for Baltic Multispecies Assessment Working Group in 1993).

Table 3.2.1.1

Number of stomachs of each species examined at sea in each quarter of 1981 and 1991. Total North Sea

Primary Predators

Species	Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Cod	1981	4146	2430	2329	2513	11418
	1991	2188	3174	2373	1999	9728
Haddock	1981	2810	3795	5825	4966	17396
	1991*	2333	2752	4938	2961	12984
Whiting	1981	7832	4211	3727	3447	19217
	1991	6152	11330	11543	9373	38398
Saithe	1981	547	185	899	559	2190
	1991	784	1179	395	854	3212
Mackerel	1981	248	1277	2737	683	4945
	1991	292	2330	2797	705	6124

*Number of haddock stomachs analysed to date. Total sample size exceeds 20,000.

Additional Predators

Species	Year	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Grey gurnard	1991	1916	4128	3955	1701	11700
Raja radiata	1991	637	651	1475	438	3201
R. clavata	1991	109	18	72	7	206
R. montagui	1991	45	13	29	46	133
R. naevus	1991	83	54	51	4	192

Table 3.2.1.2. Number of cod stomachs sampled, percentage of empty stomachs and mean weight of stomach contents in each predator size class in each quarter of 1981 and 1991. Total North Sea

Size class	1981			70		100		150	200	250	300		400	500		700		1000*	
	1991	50	60	70	80	100	120	150	200	250	300	350	400	500	600	700	800	1000*	Total
QUARTER 1																			
Number sampled	1981			1		113		251	531	601	837		455	556		684		117	4146
	1991					4	42	117	123	61	172	207	327	324	283	186	258	84	2188
% empty	1981			100		12		11	11	12	10		10	18		15		16	13
	1991					0	21	21	12	12	11	12	17.1	15	20	17	16	28	16
Mean weight of contents, g	1981			(0.00)		0.4		0.6	1.1	2.0	5.2		14.5	37.1		83.8		165	
	1991					0.2	0.3	0.8	1.8	1.8	4.0	6.8	14.5	27.0	54.3	60.8	95.7	125	
QUARTER 2																			
Number sampled	1981					36		176	328	370	538		391	392		180		19	2430
	1991	40	19	7		1	6	216	498	331	248	334	564	428	245	112	96	29	3174
% empty	1981					11		15	16	11	9		10	6		1		0	10
	1991	10	5	0		0	17	16	13	9	11	9	10	6	7	6	0	7	10
Mean weight of contents, g	1981					0.3		0.8	1.3	3.1	8.2		14.9	37.0		111.7		189	
	1991	0.04	0.1	0.2		0.4	0.2	0.7	1.9	3.4	5.7	10.8	18.0	40.1	81.4	109.1	231.9	306	
QUARTER 3																			
Number sampled	1981			90		355		232	87	185	370		337	367		257		.49	2329
	1991	22	72	140	254	193	55	4	149	392	320	158	263	165	99	41	36	10	2373
% empty	1981			22		13		10	24	16	14		17	17		13		39	16
	1991	18	24	20	16	10	7	50	9	8	8	9	3	6	5	0	6	0	9
Mean weight of contents, g	1981			(0.10)		0.3		0.9	1.4	2.4	6.6		17.0	38.8		137.8		377	
	1991	0.3	0.04	0.05	0.1	0.2	0.3	2.7	2.3	3.3	5.1	8.1	18.0	33.5	50.1	104.4	118.2	209	
QUARTER 4																			
Number sampled	1981			1		189		199	199	233	424		404	453		357		54	2513
	1991		2	9	61	212	165	335	102	80	257	230	205	119	107	73	33	10	1999
% empty	1981			0		21		13	14	13	10		9	7		3		7	10
	1991		0	9	11	10	10	8	7	12	12	8	4	3	2	1	7	0	8
Mean weight of contents, g	1981			(0.2)		0.3		0.6	1.3	2.6	5.8		13.4	30.2		104.1		148	
	1991		0.05	0.04	0.1	0.3	0.3	0.8	1.4	2.7	5.2	7.5	14.0	27.9	52.7	101.1	177.5	492	
ALL QUARTERS																			
Number sampled	1981			92		693		858	1145	1389	2169		1587	1768		1478		239	11418
	1991	62	93	156	315	410	268	672	872	864	996	927	1359	1032	732	412	423	133	9728

Table 3.2.1.3. Number of haddock stomachs sampled, percentage of empty stomachs and mean weight of stomach contents in each predator size class in each quarter of 1981 and 1991. Total North Sea

Size class	1981 1991	 50	 60	70 70	 80	100 100	 120	150 150	200 200	250 250	300 300	 350	400 400	500 500	 600	700 700	 800	1000 1000	 Total
QUARTER 1																			
Number sampled	1981					238		444	572	629	690		195	542					2810
	1991				1	17	289	520	438	328	320	226	148	45	1				2333
% empty	1981					0		2	4	4	8		15	7					5
	1991				0	24	11	10	16	22	23	31	31	22	0				18
Mean weight of contents, g	1981																		
	1991				0.00	0.03	0.17	0.24	0.36	0.46	0.78	1.04	1.98	3.39	28.16				
QUARTER 2																			
Number sampled	1981					457		576	693	802	840		360	66		1			3795
	1991			3	13	2	34	482	555	526	462	345	266	51	12	1			2752
% empty	1981					31		23	15	14	14		17	15		0			18
	1991			0	0	0	6	7	6	6	7	5	3	2	8	0			6
Mean weight of contents, g	1981																		
	1991			0.01	0.09	0.11	0.12	0.51	1.08	1.70	2.85	4.23	6.81	10.85	19.47	1.28			
QUARTER 3																			
Number sampled	1981					772		679	1049	1333	1451		455	82		4			5825
	1991	1	12	41	378	585	602	373	763	856	620	419	237	46	5				4938
% empty	1981					23		20	16	10	7		10	11		50			13
	1991	0	8	20	16	6	5	12	9	8	9	6	6	9	0				8
Mean weight of contents, g	1981																		
	1991	0.02	0.02	0.03	0.05	0.11	0.16	0.30	0.88	1.21	2.44	3.44	4.44	11.69	27.99				
QUARTER 4																			
Number sampled	1981					692		812	919	947	1012		503	80		1			4966
	1991				42	181	311	429	376	523	536	309	174	63	17				2961
% empty	1981					6		7	4	7	8		5	3		0			6
	1991				9	4	5	8	12	5	12	8	7	8	6				10
Mean weight of contents, g	1981																		
	1991				0.06	0.12	0.16	0.25	0.56	1.08	1.57	3.12	4.43	14.99	42.21				
ALL QUARTERS																			
Number sampled	1981					2159		2511	3233	3711	3993		1513	270		6			17396
	1991	1	12	44	434	785	1236	1804	2132	2233	1938	1299	825	205	35	1			12984

Table 3.2.1.4. Number of whiting stomachs sampled, percentage of empty stomachs and mean weight of stomach contents in each predator size class in each quarter of 1981 and 1991. Total North Sea

Size class	1981			70		100		150	200	250	300		400	500		700		1000	
	1991	50	60	70	80	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
QUARTER 1																			
Number sampled	1981					1525		1638	1623	1616	1250		176	4					7832
	1991		1		49	292	891	1341	1284	1262	789	205	37	1					6152
% empty	1981					18		26	28	29	28		28	0					26
	1991		0		16	23	31	35	54	57	54	53	32	0					45
Mean weight of contents, g	1981					0.30		0.46	0.54	1.63	3.72		10.72	20.26					
	1991		0.00		0.03	0.13	0.20	0.47	0.83	1.27	2.33	3.43	8.53	8.42					
QUARTER 2																			
Number sampled	1981					428		756	889	1161	924		53						4211
	1991					92	495	2148	3010	3422	1742	331	81	9					11330
% empty	1981					16		24	24	22	19		26						22
	1991					11	17	13	12	12	12	10	12	0					12
Mean weight of contents, g	1981					0.35		0.59	1.36	2.26	2.90		8.21						
	1991					0.31	0.26	0.77	1.55	2.80	5.66	8.71	12.02	10.43					
QUARTER 3																			
Number sampled	1981					231		321	843	1131	1032		163	6					3727
	1991	19	88	147	668	883	754	1061	2387	3084	2084	344	24						11543
% empty	1981					23		26	27	27	26		26	33					26
	1991	47	25	12	16	10	5	13	13	11	5	16	17						12
Mean weight of contents, g	1981					0.38		0.42	0.88	2.57	4.93		11.49	4.40					
	1991	0.00	0.04	0.05	0.13	0.33	0.63	0.70	1.42	2.99	5.92	8.79	15.86						
QUARTER 4																			
Number sampled	1981					524		519	729	821	740		110	4					3447
	1991	3	9	16	98	548	673	1755	1910	2136	1606	551	68						9373
% empty	1981					23		19	24	21	21		6	0					21
	1991	0	11	22	15	16	15	4	7	7	6	5	3						7
Mean weight of contents, g	1981					0.70		0.39	0.79	1.48	4.32		13.16	7.34					
	1991	0.06	0.05	0.03	0.07	0.19	0.29	1.01	1.67	3.54	5.32	5.81	10.65						
ALL QUARTERS																			
Number sampled	1981					2708		3234	4084	4729	3946		502	14					19217
	1991	22	98	163	815	1815	2813	6305	8591	9904	6221	1431	210	10					38398

Table 3.2.1.5. Number of saithe stomachs sampled, percentage of empty stomachs and mean weight of stomach contents in each predator size class in each quarter of 1981 and 1991. Total North Sea

Size class	1981			70		100		150	200	250	300		400	500		700		1000	
	1991	50	60	70	80	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
QUARTER 1																			
Number sampled	1981												3	26		32		11	70
	1991									2	97	175	369	70	37	20	11	3	784
% empty	1981												33	22		16		25	
	1991									100	38	17	27	27	19	40	45	67	27
Mean weight of contents, g	1981												13.2	23.5		50.1		119.7	
	1991									0	1.1	2.3	2.7	7.4	27.2	23.1	23.6	280.9	
QUARTER 2																			
Number sampled	1981										14		7	45		113		6	185
	1991								3	6	9	254	353	204	93	75	72	10	1179
% empty	1981										14		14	0		4		0	
	1991								67	17	22	2	1	4	1	1	1	0	2
Mean weight of contents, g	1981										6.7		20.1	37.6		51.8		89.5	
	1991								1.0	2.8	4.7	13.11	22.1	44.5	93.1	114.3	180.8	202.3	
QUARTER 3																			
Number sampled	1981										45		114	167		108		4	438
	1991							1	1		4	56	198	69	27	15	24		395
% empty	1981										29		12	41		19		0	
	1991							0	0		0	7	19	13	26	7	4		15
Mean weight of contents, g	1981										4.2		7.2	9.7		33.2		44.3	
	1991							0.5	0.6		0.9	4.6	6.6	19.9	17.2	44.8	255.3		
QUARTER 4																			
Number sampled	1981												46	82		78		173	379
	1991							2			4	73	499	194	50	13	13	6	854
% empty	1981												0	13		26		26	
	1991							50			0	22	9	11	4	15	0	17	11
Mean weight of contents, g	1981												9.8	10.3		17.4		25.2	
	1991							0.3			2.3	5.4	13.3	22.0	45.8	83.8	108.2	201.1	20.2
ALL QUARTERS																			
Number sampled	1981										59		170	403		507		199	1338
	1991							3	4	8	114	558	1519	537	207	123	120	19	3212

Table 3.2.1.6. Number of mackerel stomachs sampled, percentage of empty stomachs and mean weight of stomach contents in each predator size class in each quarter of 1981* and 1991. Total North Sea

Size class	1981			70		100		150	200	250	300		400	500		700		1000	
	1991	50	60	70	80	100	120	150	200	250	300	350	400	500	600	700	800	1000	Total
QUARTER 1																			
Number sampled	1981								145		75		28						248
	1991							71	134	48	33	5	1						292
% empty	1981								19		15		21						18
	1991							8	42	90	94	80	100						48
Mean weight of contents, g	1981*								0.11		0.72		0.21						
	1991							0.76	0.49	0.06	0.04	0.63	0.00						
QUARTER 2																			
Number sampled	1981								253		556		468						1277
	1991							2	207	554	970	468	129						2330
% empty	1981								9		7		7						8
	1991							50	7	4	4	3	7						4
Mean weight of contents, g	1981*								2.76		6.05		9.12						
	1991							0.04	1.02	2.08	3.00	5.17	7.49						
QUARTER 3																			
Number sampled	1981								764		1519		454						2737
	1991								66	616	1359	629	126						2797
% empty	1981								8		10		14						10
	1991								15	9	8	9	10						9
Mean weight of contents, g	1981*								1.63		2.86		3.82						
	1991								0.74	2.28	3.14	4.15	9.07						
QUARTER 4																			
Number sampled	1981								120		416		147						683
	1991							22	50	100	274	225	34						705
% empty	1981								18		15		19						16
	1991							5	6	33	13	21	35						19
Mean weight of contents, g	1981								1.51		2.73		4.30						
	1991							1.03	2.60	0.68	1.47	2.43	3.95						
ALL QUARTERS																			
Number sampled	1981								1282		2566		1097						4945
	1991							95	457	1318	2636	1327	290						6124

* Mehl and Westgard (1983)

TABLE 3.6.1.1 SUMMARY OF COD STOMACH CONTENTS IN 1991 BY PREDATOR AGE CLASS AND QUARTER (TOTAL NORTH SEA)

Age class	0	1	2	3	4	5	6+
QUARTER : 1							
Nr of stomachs sampled		312	566	686	280	119	218
% empty stomachs		16.35	13.07	16.76	17.14	15.97	20.18
Mean length		18.38	37.14	51.92	70.00	81.70	96.64
Total weight all prey		0.93	8.27	25.14	62.82	90.01	115.10
Total nr of prey items		2.32	3.28	3.26	4.05	4.59	5.39
Average weight per prey		0.40	2.52	7.71	15.53	19.60	21.34
WEIGHT % BY MAJOR TAXA							
ANNELIDA		7.05	5.16	2.96	2.44	1.53	1.01
CEPHALOPODA		0.02	1.70	1.17	5.24	10.92	10.09
CRUSTACEA		51.42	20.73	12.80	8.72	6.93	6.23
GNATHOSTOMATA		36.72	69.14	82.32	83.41	80.46	82.56
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA			0.20	0.85	1.29	1.09	0.88
MELANOGRAMMUS AEGLEFINUS			1.47	2.56	2.32	2.19	2.14
MERLANGIUS MERLANGUS		0.27	18.05	27.37	24.35	23.79	24.97
TRISOPTERUS ESMARKI		1.12	11.35	7.40	4.87	3.03	1.41
CLUPEA HARENGUS		0.04	5.86	11.54	15.22	14.33	11.64
SPRATTUS SPRATTUS		5.88	0.84	0.67	0.44	0.26	0.24
AMMODYTIDAE		8.81	3.75	1.18	0.27	0.35	0.25
PLEURONECTES PLATESSA				0.12	0.28	0.38	1.45
SOLEA SOLEA			0.58	1.07	1.17	1.04	1.49
LIMANDA LIMANDA		0.04	3.50	7.67	10.09	10.79	17.41
SCOMBER SCOMBER			0.76	5.59	11.92	12.39	7.56
NEPHROPS NORVEGICUS		0.03	2.59	1.72	2.01	2.41	3.20
CRANGON CRANGON		2.29	0.14	0.09	0.03	0.02	0.01
QUARTER : 2							
Nr of stomachs sampled	67	1210	984	695	102	51	62
% empty stomachs	7.46	11.98	9.25	7.34	3.92	1.96	3.23
Mean length	4.99	23.65	42.57	56.86	70.93	84.43	97.25
Total weight all prey	0.03	2.24	21.14	52.64	119.74	193.06	242.49
Total nr of prey items	3.71	23.19	21.08	10.43	9.02	11.31	11.58
Average weight per prey	0.01	0.10	1.00	5.05	13.28	17.07	20.94
WEIGHT % BY MAJOR TAXA							
ANNELIDA	0.73	5.59	4.32	2.74	2.45	2.74	2.85
CEPHALOPODA		0.49	0.27	0.19	0.10	0.10	0.37
PYCNOGONIDA		0.00	0.00	0.00	0.00	0.00	
CRUSTACEA	45.01	56.42	23.64	14.66	14.47	15.93	14.80
GNATHOSTOMATA	54.26	32.12	67.01	79.51	81.35	79.45	80.95
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA		0.10	0.20	0.48	5.15	8.66	4.98
MELANOGRAMMUS AEGLEFINUS		0.04	1.40	2.97	7.16	9.05	9.25
MERLANGIUS MERLANGUS		0.17	5.91	7.77	7.03	6.04	11.94
TRISOPTERUS ESMARKI		5.13	13.54	10.53	4.76	2.93	3.82
CLUPEA HARENGUS		0.48	8.21	16.35	15.58	13.38	13.75
SPRATTUS SPRATTUS		0.17	0.40	0.45	0.23	0.24	0.36
AMMODYTIDAE	6.28	10.37	7.16	4.46	2.53	1.46	0.69
PLEURONECTES PLATESSA				0.02	1.07	1.91	1.11
SOLEA SOLEA		0.36	0.32	0.84	1.70	1.75	3.62
LIMANDA LIMANDA		0.52	7.89	12.79	14.05	15.64	15.73
SCOMBER SCOMBER						0.03	0.76
NEPHROPS NORVEGICUS		3.19	5.48	3.46	5.44	7.10	8.78
CRANGON CRANGON		0.81	0.03	0.02	0.00	0.00	0.00
QUARTER : 3							
Nr of stomachs sampled	741	998	381	185	41	8	16
% empty stomachs	15.38	7.82	4.99	4.86	2.44		
Mean length	7.63	29.71	46.82	52.99	76.22	87.93	101.07
Total weight all prey	0.07	4.49	21.82	49.18	96.57	103.46	148.41
Total nr of prey items	5.54	4.39	5.12	6.99	8.77	6.75	7.55
Average weight per prey	0.01	1.02	4.26	7.04	11.01	15.32	19.65
WEIGHT % BY MAJOR TAXA							
ANNELIDA	5.95	4.25	3.13	2.76	2.12	1.37	5.24
CEPHALOPODA		0.31	0.16	0.16	0.31	0.00	
CRUSTACEA	77.25	35.41	19.82	17.80	16.89	16.71	19.85
GNATHOSTOMATA	16.50	57.94	76.24	78.82	80.36	81.30	74.42
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA	1.10	5.36	2.52	1.01	0.20	0.13	0.91
MELANOGRAMMUS AEGLEFINUS	0.00	4.43	5.54	4.55	0.65	0.86	3.52
MERLANGIUS MERLANGUS	0.56	4.32	3.56	7.45	6.26	5.90	2.49
TRISOPTERUS ESMARKI	0.93	12.54	18.96	14.52	11.29	4.76	3.83
CLUPEA HARENGUS		1.47	15.49	25.92	41.98	46.73	25.06
SPRATTUS SPRATTUS		0.50	0.68	2.30	0.48	0.13	
AMMODYTIDAE	0.17	19.45	6.66	4.34	2.30	0.25	0.05
PLEURONECTES PLATESSA		0.00	0.00				
SOLEA SOLEA			0.04	0.03	0.00		2.17
LIMANDA LIMANDA	0.13	0.15	6.02	7.93	6.38	9.29	9.26
SCOMBER SCOMBER				0.00	0.05	0.10	0.04
NEPHROPS NORVEGICUS	0.02	4.09	4.49	3.60	6.31	7.02	7.46
CRANGON CRANGON			0.00	0.00	0.00	0.00	
QUARTER : 4							
Nr of stomachs sampled	882	672	238	131	47	9	18
% empty stomachs	10.09	8.93	3.36	2.29	2.13		5.56
Mean length	15.85	34.55	51.93	65.79	75.25	91.35	102.26
Total weight all prey	0.66	7.14	27.37	57.03	88.46	233.68	338.94
Total nr of prey items	3.23	4.28	6.83	8.12	8.81	9.31	9.77
Average weight per prey	0.20	1.67	4.00	7.03	10.04	25.09	34.69
WEIGHT % BY MAJOR TAXA							
ANNELIDA	9.51	2.52	2.68	2.38	1.43	0.16	0.06
CEPHALOPODA	0.10	0.17	0.51	0.41	0.20	0.02	0.00
CRUSTACEA	75.18	40.44	28.74	18.93	13.33	3.48	1.77
CEPHALOCHORDATA			0.00	0.00	0.00		
GNATHOSTOMATA	15.09	54.31	67.10	76.91	83.75	95.87	97.87
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA	0.00	0.66	0.38	0.28	0.29	0.17	0.09
MELANOGRAMMUS AEGLEFINUS	0.00	12.47	11.16	11.10	11.76	5.17	3.55
MERLANGIUS MERLANGUS	0.00	6.89	14.55	14.98	17.59	8.05	4.51
TRISOPTERUS ESMARKI	0.01	14.21	13.05	13.25	14.08	5.51	3.04
CLUPEA HARENGUS		0.27	1.96	2.76	2.48	40.25	50.93
SPRATTUS SPRATTUS	0.66	3.35	0.23	0.22	0.22	0.35	0.41
AMMODYTIDAE	0.65	2.07	0.98	0.21	0.04	0.01	0.01
PLEURONECTES PLATESSA						9.71	12.37
SOLEA SOLEA		0.03	0.47	0.52	0.47	0.10	0.02
LIMANDA LIMANDA	0.05	0.85	8.08	14.36	15.82	13.20	12.72
SCOMBER SCOMBER			1.26	5.50	9.20	4.36	2.15
NEPHROPS NORVEGICUS	8.61	2.14	2.18	2.39	1.54	0.34	0.17
CRANGON CRANGON	16.10	6.89	4.26	1.23	0.26	0.03	0.01

TABLE 3.6.1.2 SUMMARY OF HADDOCK STOMACH CONTENTS IN 1991 BY PREDATOR AGE CLASS AND QUARTER (TOTAL NORTH SEA).

Age class	0	1	2	3	4	5	6+
QUARTER : 1							
Nr of stomachs sampled		1213	587	270	67	141	54
% empty stomachs		12.37	21.64	27.41	29.85	29.08	27.78
Mean length		18.16	27.49	33.63	37.86	39.37	45.71
Total weight all prey		0.25	0.50	0.90	1.40	1.57	2.78
Total nr of prey items		9.43	6.23	6.14	7.03	7.46	9.47
Average weight per prey		0.03	0.08	0.15	0.20	0.21	0.29
WEIGHT % BY MAJor TAXA							
ANNELIDA		28.77	31.99	32.21	24.08	21.72	13.41
CEPHALOPODA		11.21	4.63	1.47	1.31	1.36	1.11
CRUSTACEA		18.58	22.30	19.40	15.57	14.48	11.29
ECHINODERMATA		25.89	16.10	11.36	14.71	15.74	13.84
GNATHOSTOMATA		5.76	15.00	28.12	37.93	40.44	51.73
UNKNOWN		5.21	5.41	4.34	3.83	3.63	2.46
WEIGHT % COMMERCIAL SPEC.							
TRISOPTERUS ESMARKI		0.00	1.34	6.06	5.92	5.49	3.74
CLUPEA HARENGUS			0.02	6.39	24.85	25.03	19.29
SOLEA SOLEA		0.00	0.09	0.25	0.16	0.13	0.05
NEPHROPS NORVEGICUS		0.04	0.68	2.06	1.73	1.52	0.79
CRANGON CRANGON		0.47	0.17	0.01	0.00	0.00	0.00
QUARTER : 2							
Nr of stomachs sampled	18	1378	635	325	114	199	85
% empty stomachs		6.39	6.30	4.62	3.51	3.52	4.71
Mean length	6.97	21.66	28.95	34.08	37.92	37.36	36.93
Total weight all prey	0.02	1.03	2.04	3.38	4.75	4.41	4.36
Total nr of prey items	4.82	111.60	165.98	202.51	203.60	179.83	205.37
Average weight per prey	0.00	0.01	0.01	0.02	0.02	0.02	0.02
WEIGHT % BY MAJor TAXA							
ANNELIDA	0.93	7.73	9.09	7.89	7.71	7.32	7.71
CEPHALOPODA		0.00	0.00	0.00	0.00	0.00	0.00
CRUSTACEA	25.62	45.21	37.79	33.07	30.01	30.08	29.76
ECHINODERMATA		9.04	13.90	15.99	18.04	17.75	17.61
GNATHOSTOMATA	62.99	29.05	29.50	31.84	31.06	34.01	33.20
UNKNOWN	4.46	3.86	1.96	1.85	2.31	2.23	2.06
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA		0.01	0.03	0.01	0.00	0.00	0.00
TRISOPTERUS ESMARKI		0.02	0.07	0.14	0.33	0.21	0.24
CLUPEA HARENGUS						0.06	0.52
SPRATTUS SPRATTUS			0.00	0.08	0.20	0.13	0.15
AMMODYTIDAE		1.84	3.52	3.87	3.38	4.32	2.84
PLEURONECTES PLATESSA		0.04	0.00	0.00	0.00	0.00	0.00
SOLEA SOLEA		0.01	0.00				
NEPHROPS NORVEGICUS				0.00	0.05	0.05	0.05
CRANGON CRANGON		0.00	0.00	0.00	0.00	0.00	0.00
QUARTER : 3							
Nr of stomachs sampled	1947	1877	813	163	25	97	16
% empty stomachs	9.14	8.42	7.38	7.36	4.00	7.22	
Mean length	10.88	25.70	33.66	39.39	39.56	37.99	41.02
Total weight all prey	0.10	1.12	2.44	4.47	4.05	4.47	5.24
Total nr of prey items	17.53	39.08	30.72	26.70	26.03	28.05	24.41
Average weight per prey	0.01	0.03	0.08	0.17	0.16	0.16	0.21
WEIGHT % BY MAJor TAXA							
ANNELIDA	24.13	12.42	12.42	10.56	11.47	9.80	9.10
CEPHALOPODA	0.70	0.39	0.09	0.02	0.02	0.02	0.01
CRUSTACEA	35.22	16.70	12.24	8.61	10.09	8.40	8.09
ECHINODERMATA	6.54	11.40	15.37	16.00	17.20	13.99	14.03
GNATHOSTOMATA	16.85	49.27	51.48	58.05	53.04	62.01	62.35
UNKNOWN	11.20	5.25	3.77	2.63	3.29	2.26	2.57
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA				0.10	0.05	0.08	0.06
MELANOGRAMMUS AEGLEFINUS		0.94	1.74	1.93	2.77	1.34	2.03
TRISOPTERUS ESMARKI	0.16	2.53	3.19	2.37	2.65	9.61	14.60
AMMODYTIDAE	7.19	16.86	16.08	13.46	14.13	13.61	13.00
PLEURONECTES PLATESSA		0.00	0.00	0.00			
SOLEA SOLEA		0.05	0.00				
NEPHROPS NORVEGICUS	0.00	0.76	0.91	0.36	0.44	0.47	0.20
CRANGON CRANGON	0.18	0.03	0.02	0.01	0.01	0.01	0.01
QUARTER : 4							
Nr of stomachs sampled	1028	1299	328	122	48	107	29
% empty stomachs	7.10	12.78	8.84	8.20	6.25	7.48	6.90
Mean length	15.44	27.33	33.61	38.93	40.99	42.75	51.16
Total weight all prey	0.21	1.01	1.91	3.09	4.11	4.95	13.59
Total nr of prey items	13.63	11.88	11.37	11.64	11.94	12.32	14.94
Average weight per prey	0.02	0.08	0.17	0.27	0.34	0.40	0.91
WEIGHT % BY MAJor TAXA							
ANNELIDA	25.32	19.02	18.73	13.19	10.02	8.50	3.63
CEPHALOPODA	0.98	0.80	0.93	0.50	0.34	0.46	0.43
CRUSTACEA	29.13	24.45	21.03	21.43	19.95	19.89	13.74
ECHINODERMATA	21.17	14.28	11.70	12.65	14.00	14.23	17.48
GNATHOSTOMATA	16.01	30.55	37.84	38.35	41.84	42.07	53.52
UNKNOWN	4.31	6.68	4.37	3.86	3.08	2.97	0.72
WEIGHT % COMMERCIAL SPEC.							
MELANOGRAMMUS AEGLEFINUS			0.02	1.42	2.24	3.34	4.41
TRISOPTERUS ESMARKI	3.07	15.73	18.67	19.41	22.06	19.97	28.17
CLUPEA HARENGUS		0.01	0.03	1.02	1.61	2.40	3.17
AMMODYTIDAE	0.47	3.65	3.92	2.59	2.35	1.65	2.10
NEPHROPS NORVEGICUS	0.05	1.36	2.97	2.02	1.55	0.73	0.14
CRANGON CRANGON		0.03	0.00	0.00	0.00	0.00	0.00

TABLE 3.6.1.3 SUMMARY OF WHITING STOMACH CONTENTS IN 1991 BY PREDATOR AGE CLASS AND QUARTER (TOTAL NORTH SEA)

Age class	0	1	2	3	4	5	6+
QUARTER : 1							
Nr of stomachs sampled		2748	1562	1132	417	231	64
% empty stomachs		33.48	54.87	55.57	53.96	52.81	51.56
Mean length		15.93	24.46	26.80	28.88	29.28	29.84
Total weight all prey		0.42	1.08	1.45	1.82	1.90	2.35
Total nr of prey items		7.80	2.15	1.42	1.19	1.16	1.11
Average weight per prey		0.05	0.50	1.02	1.53	1.63	2.12
WEIGHT % BY MAJOR TAXA							
ANNELIDA		10.61	4.83	3.43	2.86	2.79	2.35
CEPHALOPODA		9.34	2.87	4.08	4.13	4.16	3.67
CRUSTACEA		25.56	10.22	7.43	6.95	6.80	6.92
GNATHOSTOMATA		53.43	81.19	84.46	85.56	85.79	86.64
WEIGHT % COMMERCIAL SPEC.							
MELANOGRAMMUS AEGLEFINUS		0.02	0.35	0.65	0.99	1.06	1.22
MERLANGIUS MERLANGUS		0.77	6.53	9.30	13.10	13.04	16.28
TRISOPTERUS ESMARKI		14.61	22.87	24.14	26.61	27.03	28.97
CLUPEA HARENGUS		0.81	3.12	3.90	3.73	3.94	3.73
SPRATTUS SPRATTUS		4.65	13.40	14.76	12.25	11.80	8.90
AMMODYTIDAE		17.64	14.35	11.32	9.07	8.71	6.93
CRANGON CRANGON		2.58	1.90	1.21	0.92	0.86	0.70
QUARTER : 2							
Nr of stomachs sampled		4499	2600	2136	1191	551	343
% empty stomachs		12.78	11.58	11.52	11.42	11.43	11.37
Mean length		18.47	24.31	26.59	28.09	28.94	29.11
Total weight all prey		1.00	1.98	2.64	3.21	3.50	3.62
Total nr of prey items		114.19	121.36	122.75	115.49	108.68	98.68
Average weight per prey		0.01	0.02	0.02	0.03	0.03	0.04
WEIGHT % BY MAJOR TAXA							
ANNELIDA		8.89	4.45	3.79	3.45	3.31	3.25
GASTROPODA		0.77	0.34	0.21	0.15	0.13	0.12
BIVALVIA		0.01	0.04	0.06	0.05	0.04	0.03
CEPHALOPODA		2.07	0.69	0.45	0.34	0.30	0.28
CRUSTACEA		25.02	19.70	16.82	15.10	14.40	13.97
GNATHOSTOMATA		60.83	73.84	77.97	80.20	81.08	81.57
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA		1.15	0.93	0.60	0.40	0.32	0.29
MELANOGRAMMUS AEGLEFINUS		0.13	0.25	0.37	0.33	0.28	0.18
MERLANGIUS MERLANGUS		0.18	0.38	0.66	1.09	1.34	1.75
TRISOPTERUS ESMARKI		1.28	5.88	8.60	9.91	10.35	11.36
CLUPEA HARENGUS		0.15	0.93	1.69	2.41	2.90	2.99
SPRATTUS SPRATTUS		3.14	5.23	4.38	4.46	4.69	5.13
AMMODYTIDAE		40.70	39.52	39.81	39.50	39.09	38.42
MICROSTOMUS KITT		0.00	0.00	0.00	0.00	0.00	0.00
LIMANDA LIMANDA		0.08	0.00				
CRANGON CRANGON		0.36	0.18	0.10	0.07	0.07	0.07
QUARTER : 3							
Nr of stomachs sampled	2561	3978	2453	1766	512	233	40
% empty stomachs	11.05	12.82	12.27	13.36	14.06	14.59	15.00
Mean length	9.55	21.41	26.54	28.30	29.40	30.71	32.80
Total weight all prey	0.20	1.30	2.66	3.37	3.84	4.27	5.75
Total nr of prey items	31.03	23.62	17.22	14.96	14.22	12.86	11.04
Average weight per prey	0.01	0.06	0.15	0.23	0.27	0.33	0.52
WEIGHT % BY MAJOR TAXA							
ANNELIDA	1.28	4.34	3.59	3.24	2.87	2.68	1.91
CEPHALOPODA	0.02	0.22	0.05	0.03	0.04	0.04	0.04
CRUSTACEA	29.44	17.21	9.15	7.09	5.97	5.28	3.55
GNATHOSTOMATA	66.63	77.38	86.62	89.15	90.68	91.61	94.23
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA		0.15	0.58	0.64	0.59	0.58	0.45
MELANOGRAMMUS AEGLEFINUS	0.54	2.30	4.01	4.09	4.09	4.24	3.89
MERLANGIUS MERLANGUS	1.80	3.10	3.67	3.89	4.31	4.43	7.56
TRISOPTERUS ESMARKI	21.08	18.27	24.83	26.41	27.16	27.74	28.07
CLUPEA HARENGUS	0.00	1.38	7.18	11.20	14.17	15.43	21.24
SPRATTUS SPRATTUS	0.00	4.45	8.52	8.50	7.97	7.97	6.20
AMMODYTIDAE	12.42	27.87	20.68	18.30	16.76	15.88	12.27
LIMANDA LIMANDA		0.05	0.01	0.00	0.00		
NEPHROPS NORVEGICUS		0.55	0.31	0.20	0.15	0.11	0.05
CRANGON CRANGON	0.47	0.32	0.05	0.03	0.02	0.02	0.01
QUARTER : 4							
Nr of stomachs sampled	2970	3091	1473	1016	362	317	145
% empty stomachs	8.75	5.92	5.97	5.71	5.52	5.05	4.83
Mean length	14.40	24.08	26.42	28.82	29.15	30.27	29.72
Total weight all prey	0.57	2.17	2.92	3.72	3.69	3.91	3.90
Total nr of prey items	18.04	8.74	7.33	5.74	5.85	5.28	5.34
Average weight per prey	0.03	0.25	0.40	0.65	0.63	0.74	0.73
WEIGHT % BY MAJOR TAXA							
ANNELIDA	1.93	2.93	2.86	2.92	3.00	3.39	3.11
CEPHALOPODA	4.14	0.26	0.25	0.25	0.25	0.22	0.26
CRUSTACEA	27.72	14.29	11.49	9.45	9.56	9.00	8.92
GNATHOSTOMATA	65.75	82.35	85.19	87.07	86.89	87.01	87.33
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA	0.07	0.41	0.19	0.05	0.06	0.04	0.04
MELANOGRAMMUS AEGLEFINUS	3.55	1.30	1.97	2.71	2.84	3.58	3.46
MERLANGIUS MERLANGUS	0.48	1.33	2.41	3.43	3.29	3.53	3.68
TRISOPTERUS ESMARKI	35.80	44.51	42.13	41.10	41.26	41.95	41.42
CLUPEA HARENGUS	0.05	0.75	1.33	1.91	1.83	2.00	2.06
SPRATTUS SPRATTUS	3.44	5.44	6.92	7.26	7.21	6.59	6.75
AMMODYTIDAE	3.40	8.34	10.06	10.17	10.14	9.22	9.28
SOLEA SOLEA	0.03	0.02	0.09	0.16	0.15	0.17	0.19
LIMANDA LIMANDA	0.03	0.00	0.01	0.02	0.02	0.02	0.02
NEPHROPS NORVEGICUS		0.00	0.05	0.13	0.13	0.20	0.16
CRANGON CRANGON	2.37	2.71	2.05	1.58	1.60	1.46	1.47

TABLE 3.6.1.4 SUMMARY OF SAITHE STOMACH CONTENTS IN 1991 BY PREDATOR AGE CLASS AND QUARTER (TOTAL NORTH SEA)

Age class	3	4	5	6	7	8	9+
QUARTER : 1							
Nr of stomachs sampled	365	299	45	31	17	15	9
Nr of stomachs with food	230	176	24	17	9	7	4
% empty stomachs	25.48	26.09	26.67	25.81	35.29	40.00	55.56
Mean length	39.20	45.12	55.26	61.59	67.24	73.90	96.27
Total weight all prey	3.19	5.04	12.50	15.35	19.22	22.65	165.69
Total nr of prey items	12.43	7.65	4.31	4.65	4.37	3.35	4.36
Average weight per prey	0.26	0.66	2.90	3.30	4.40	6.77	37.99
WEIGHT % BY MAJOR TAXA							
CEPHALOPODA	15.64	2.00	0.31	0.14	0.04	0.00	
CRUSTACEA	13.20	10.03	4.57	5.48	4.61	2.98	0.08
GNATHOSTOMATA	70.49	87.15	95.03	94.37	95.35	97.02	99.92
WEIGHT % COMMERCIAL SPEC.							
TRISOPTERUS ESMARKI	48.75	37.88	18.64	22.41	24.08	24.18	1.39
CLUPEA HARENGUS	1.07	25.80	59.87	56.41	58.39	59.49	72.92
AMMODYTIDAE	0.58	0.80	0.62	0.30	0.09	2.44	0.52
SCOMBER SCOMBER	0.08	0.11	0.01	0.00			
QUARTER : 2							
Nr of stomachs sampled	451	429	105	57	40	66	35
% empty stomachs	2.22	2.33	2.86			1.52	
Mean length	41.77	46.65	54.63	67.10	76.23	82.43	95.32
Total weight all prey	14.11	19.00	42.82	70.51	99.26	137.31	177.02
Total nr of prey items	84.75	77.82	86.49	98.36	103.25	95.83	65.66
Average weight per prey	0.17	0.24	0.50	0.72	0.96	1.43	2.70
WEIGHT % BY MAJOR TAXA							
CEPHALOPODA					0.00	0.00	0.00
CRUSTACEA	57.34	47.30	26.86	27.41	22.09	13.08	7.16
GNATHOSTOMATA	42.65	52.69	73.11	72.59	77.91	86.92	92.84
WEIGHT % COMMERCIAL SPEC.							
MELANOGRAMMUS AEGLEFINUS	0.01	0.06	0.13	0.03	3.68	8.64	9.06
MERLANGIUS MERLANGUS			0.01	0.05	2.83	6.55	15.59
TRISOPTERUS ESMARKI	14.04	22.28	33.59	25.30	17.60	11.75	7.15
CLUPEA HARENGUS	0.00	0.25	4.60	12.13	21.69	31.29	37.58
AMMODYTIDAE	11.73	13.06	14.99	7.05	3.78	5.55	4.81
MICROSTOMUS KITT	0.00	0.00	0.00	0.00			
QUARTER : 3							
Nr of stomachs sampled	242	71	28	10	12	12	10
% empty stomachs	16.12	14.08	17.86	20.00			
Mean length	42.31	51.60	60.64	67.19	77.33	81.26	93.48
Total weight all prey	9.31	15.15	16.80	17.05	143.30	203.59	312.79
Total nr of prey items	8.22	7.79	7.85	8.64	11.36	13.39	20.11
Average weight per prey	1.13	1.94	2.14	1.97	12.61	15.21	15.56
WEIGHT % BY MAJOR TAXA							
CRUSTACEA	9.35	4.81	4.96	5.34	2.59	2.56	2.75
GNATHOSTOMATA	90.57	95.16	95.02	94.63	97.40	97.43	97.24
UNKNOWN	0.02	0.01					
WEIGHT % COMMERCIAL SPEC.							
MELANOGRAMMUS AEGLEFINUS	23.35	10.81	5.18	3.36	1.06	0.97	0.89
MERLANGIUS MERLANGUS	4.40	2.93	3.04	3.40	0.20	0.09	0.06
TRISOPTERUS ESMARKI	39.14	59.48	64.46	59.89	14.90	12.52	8.99
CLUPEA HARENGUS	0.09	2.27	8.33	20.59	74.01	76.53	79.66
SPRATTUS SPRATTUS	0.05	0.01					
AMMODYTIDAE	8.18	4.32	1.70		0.07	0.07	0.08
CRANGON CRANGON			0.00	0.01	0.00	0.00	
QUARTER : 4							
Nr of stomachs sampled	628	165	27	8	5	3	13
Nr of stomachs with food	452	111	19	5	4	2	11
Nr of regurgit. stomachs	96	37	6	2	1		1
Nr with skeletal remains	11	2					
Nr of empty stomachs	69	16	2	1	1		1
% empty stomachs	10.99	9.70	7.41	12.50	20.00		7.69
Mean length	44.43	53.61	65.75	73.94	80.88	86.98	96.63
Total weight all prey	13.57	19.45	40.02	56.22	88.33	133.44	154.43
Total nr of prey items	3.28	3.83	4.13	3.43	3.85	5.64	6.61
Average weight per prey	4.14	5.08	9.68	16.40	22.95	23.64	23.38
WEIGHT % BY MAJOR TAXA							
ANNELIDA	0.01	0.02	0.00				
CEPHALOPODA	0.00	0.00	0.00	0.00			
CRUSTACEA	0.55	0.66	0.45	0.42	0.25	0.09	0.07
GNATHOSTOMATA	99.28	98.94	99.39	99.44	99.67	99.90	99.93
WEIGHT % COMMERCIAL SPEC.							
MELANOGRAMMUS AEGLEFINUS	8.01	5.69	3.09	4.85	3.53	1.30	1.53
MERLANGIUS MERLANGUS	1.30	1.16	0.46	0.95	0.72	0.20	0.42
TRISOPTERUS ESMARKI	80.41	77.79	49.15	26.67	11.87	7.99	8.05
CLUPEA HARENGUS	0.40	5.20	37.70	57.78	76.88	86.01	85.15
AMMODYTIDAE	0.01	0.02	0.00				
LIMANDA LIMANDA							1.94
SCOMBER SCOMBER	0.05	1.67	3.69	1.51			

TABLE 3.6.1.5 SUMMARY OF MACKEREL STOMACH CONTENTS IN 1991 BY PREDATOR AGE CLASS AND QUARTER (TOTAL NORTH SEA)

Age Class	0	1	2	3	4	5	6+
QUARTER : 1							
Nr of stomachs sampled		205	67	6	8	2	4
% empty stomachs		30.24	91.04	100.00	87.50	50.00	75.00
Mean length		20.57	28.86	32.00	33.99	36.20	39.40
Total weight all prey		0.44	0.32	0.35	0.38	0.41	0.43
Total nr of prey items		31.25	6.29	0.51	0.65	1.65	1.79
Average weight per prey		0.01	0.05	0.69	0.57	0.25	0.24
WEIGHT % BY MAJOR TAXA							
CEPHALOPODA					8.77	76.74	79.88
CRUSTACEA		94.19	86.09				
GNATHOSTOMATA		3.45	13.61	97.87	89.33	23.18	20.12
WEIGHT % COMMERCIAL SPEC.							
AMMODYTIDAE			13.61	97.87	87.12	3.85	
QUARTER : 2							
Nr of stomachs sampled		238	993	325	224	150	410
% empty stomachs		7.14	3.83	3.69	3.57	3.33	4.63
Mean length		23.38	29.28	32.27	34.08	34.83	37.56
Total weight all prey		1.06	2.42	3.18	3.52	4.12	5.26
Total nr of prey items		51.25	318.73	565.07	665.37	824.05	904.92
Average weight per prey		0.02	0.01	0.01	0.01	0.01	0.01
WEIGHT % BY MAJOR TAXA							
ANNELIDA		0.08	1.21	2.06	2.05	1.68	1.00
CEPHALOPODA		0.03	0.11	0.92	1.54	2.87	3.44
CRUSTACEA		27.86	36.61	32.27	30.42	27.29	24.32
GNATHOSTOMATA		39.92	34.56	41.45	44.05	48.17	53.59
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA		0.28	0.60	0.21	0.13	0.08	0.42
MELANOGRAMMUS AEGLEFINUS		0.02	0.03	0.00	0.00		
TRISOPTERUS ESMARKI		0.30	0.76	0.48	0.44	0.44	0.44
CLUPEA HARENGUS		0.00	0.33	0.88	1.08	1.37	1.26
SPRATTUS SPRATTUS		2.72	0.22	1.92	3.15	5.69	6.80
AMMODYTIDAE		25.53	19.98	26.38	28.14	30.23	35.22
SCOMBER SCOMBER		0.00	0.00	0.01	0.01	0.00	0.00
QUARTER : 3							
Nr of stomachs sampled		521	960	327	204	194	589
% empty stomachs		9.79	8.23	7.95	8.33	8.25	9.00
Mean length		27.34	30.35	32.62	34.46	35.79	37.79
Total weight all prey		2.56	2.80	3.11	3.46	3.92	4.89
Total nr of prey items		178.48	316.62	436.34	454.73	470.65	613.22
Average weight per prey		0.01	0.01	0.01	0.01	0.01	0.01
WEIGHT % BY MAJOR TAXA							
ANNELIDA		0.05	0.05	0.04	0.03	0.01	0.00
CEPHALOPODA		0.17	0.31	0.37	0.32	0.25	0.21
CRUSTACEA		52.68	53.59	51.16	45.13	38.34	36.57
GNATHOSTOMATA		34.05	32.16	34.20	40.67	47.94	50.58
WEIGHT % COMMERCIAL SPEC.							
GADUS MORHUA		0.00	0.06	0.09	0.07	0.04	0.07
MERLANGIUS MERLANGUS		0.00	0.01	0.02	0.04	0.06	0.05
TRISOPTERUS ESMARKI		3.41	4.73	7.50	11.13	15.15	16.04
CLUPEA HARENGUS		0.01	0.20	0.34	0.39	0.43	0.46
SPRATTUS SPRATTUS		0.00	0.02	0.08	0.17	0.27	0.23
AMMODYTIDAE		26.11	21.40	19.83	22.89	26.48	27.00
PLEURONECTES PLATESSA		0.00	0.06	0.08	0.06	0.03	0.01
SCOMBER SCOMBER		0.00	0.00	0.00	0.00	0.00	0.00
CRANGON CRANGON		0.01	0.01	0.00	0.00	0.00	0.00
QUARTER : 4							
Nr of stomachs sampled	30	239	246	84	40	8	56
% empty stomachs	3.33	20.50	16.26	19.05	20.00	25.00	30.36
Mean length	18.03	30.49	33.25	34.52	35.17	37.42	38.69
Total weight all prey	1.14	1.34	1.65	1.77	1.87	2.12	3.06
Total nr of prey items	13.64	1253.31	1405.14	1435.00	1460.25	1421.70	980.64
Average weight per prey	0.08	0.00	0.00	0.00	0.00	0.00	0.00
WEIGHT % BY MAJOR TAXA							
ANNELIDA		0.03	0.04	0.03	0.02	0.01	0.00
CEPHALOPODA	6.47	0.63	0.55	0.49	0.43	0.34	0.14
CRUSTACEA	24.38	51.95	47.65	47.93	48.16	46.40	37.89
GNATHOSTOMATA	68.65	35.69	37.90	38.46	38.88	42.39	55.72
WEIGHT % COMMERCIAL SPEC.							
TRISOPTERUS ESMARKI		10.40	8.06	10.31	12.02	12.08	5.14
CLUPEA HARENGUS		6.16	8.38	5.74	3.72	2.77	7.11
SPRATTUS SPRATTUS	27.82	9.55	13.91	11.52	9.68	10.31	20.70
AMMODYTIDAE	13.79	0.53	1.11	3.12	4.66	7.28	12.15
CRANGON CRANGON		0.00	0.00	0.00	0.00	0.00	0.00

Table 3.6.2.1 Summary of Grey Gurnard stomach contents in 1991 by predator size class and quarter (Total North Sea)

A. Percentage by weight of major prey taxa

Length class (mm)	80	100	120	150	200	250	300	350	400
Quarter 1									
Annelida				5.91	3.18	0.63	0.01		
Gastropoda				0.71	0.21	0.08			
Bivalvia				4.40		0.15	0.02		
Scaphopoda						0.05			
Cephalopoda				0.23	4.40	10.66	3.21	0.56	7.57
Crustacea			100.00	77.66	68.97	21.20	9.41	4.48	0.04
Echiura					0.01				
Echinodermata				0.15		0.04			
Gnathostomata				10.86	23.15	67.19	87.35	94.96	92.39
Unknown				0.09	0.09				
Quarter 2									
Annelida			0.15	1.77	1.18	0.82	0.02	0.20	
Gastropoda					0.01		0.01		
Bivalvia		0.96		0.03		0.57		0.26	
Cephalopoda				1.19	2.75	6.97	1.53		
Crustacea		98.12	71.14	62.95	45.13	19.85	10.60	7.42	7.32
Echinodermata					0.01	0.01	0.02		
Gnathostomata		0.91	28.71	34.06	50.92	71.79	87.82	92.13	92.68
Quarter 3									
Annelida				0.41	0.12	0.43	0.08		
Bivalvia			2.88	0.50	0.72	0.39	0.02	0.17	
Cephalopoda				0.80	0.02	0.11		0.23	
Crustacea		97.68	54.41	64.65	38.15	16.79	9.29	7.10	14.38
Gnathostomata		2.32	42.71	33.64	60.98	82.29	90.61	92.50	85.62
Quarter 4									
Annelida		0.13	4.87	0.74	0.68	0.56	0.01		
Bivalvia		2.20		0.34	0.09	0.33			
Cephalopoda				2.85	3.52				
Crustacea	100.00	87.53	91.88	81.06	44.17	41.37	15.31	11.36	55.34
Ectoprocta						0.03			
Gnathostomata		10.14	3.25	15.01	51.53	57.71	84.68	88.64	44.66

B. Proportion of different commercial important fish prey expressed as % of total fish weight

Length class (mm)	80	100	120	150	200	250	300	350	400
Quarter 1									
Gadus morhua						13.92			
Melanogrammus aeglefinus						3.62			
Trisopterus esmarki				1.29	43.02	11.53	65.15	30.88	23.2
Merlangius merlangus						3.18	2.97	31.97	64.76
Ammodytidae				40.88	21.81	37.89	13.03	12.62	
Scomber scomber								0.29	
Limanda limanda					0.78				
Other fish				57.83	34.38	29.86	18.86	24.24	12.05
Quarter 2									
Sprattus sprattus						0.28	3.25		
Clupea harengus				0.03	0.02			4.30	
Gadus morhua					1.63	0.67	6.74	0.36	
Melanogrammus aeglefinus						0.33	0.59		
Trisopterus esmarki				2.14	3.00	5.10	2.77	7.46	36.88
Merlangius merlangus				1.26	2.87	1.91	10.19	14.19	26.56
Ammodytidae			32.53	33.35	41.83	50.98	28.89	27.04	1.48
Limanda limanda				2.58	1.77	0.14	1.14		
Pleuronectes platessa						0.06			
Other fish		100.00	67.47	60.63	48.88	40.53	46.44	46.66	35.08
Quarter 3									
Sprattus sprattus					3.95	5.55		0.35	
Gadus morhua				0.42	3.18	5.43	3.26	16.18	
Melanogrammus aeglefinus					0.20	0.77	1.24	4.12	
Trisopterus esmarki				2.85	9.23	10.67	17.57	7.55	
Merlangius merlangus				1.66	3.71	7.62	3.77	18.96	
Ammodytidae			37.91	63.23	48.44	43.77	46.26	43.36	92.43
Scomber scomber							2.12		
Limanda limanda				1.87	0.25	0.11	0.20		
Other fish		100.00	62.09	29.96	31.04	26.08	25.58	9.48	7.57
Quarter 4									
Sprattus sprattus					0.83		0.18		
Gadus morhua						13.69	5.93	4.23	
Melanogrammus aeglefinus					10.19		5.83		
Trisopterus esmarki							8.82	2.54	
Merlangius merlangus		0.30			7.47	5.70	29.15	14.88	96.91
Ammodytidae			84.31	33.91	58.22	18.35	21.33	36.94	
Limanda limanda				1.53	0.89	0.16			
Other fish		99.70	15.69	64.56	22.39	62.10	28.77	41.41	3.09
Annual total									
Sprattus sprattus					2.14	2.69	0.84	0.11	
Clupea harengus				0.01	0.01			1.38	
Gadus morhua				0.21	2.04	6.89	3.53	5.69	
Melanogrammus aeglefinus					1.86	1.11	1.36	1.30	
Trisopterus esmarki				2.32	7.99	8.33	26.84	12.90	25.50
Merlangius merlangus		0.29		1.33	3.92	5.29	8.74	20.29	49.38
Ammodytidae			40.82	48.81	46.83	41.34	28.46	29.62	6.47
Scomber scomber							0.66	0.07	
Limanda limanda				2.04	0.79	0.10	0.35		
Pleuronectes platessa						0.01			
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28.66	18.65

TABLE 3.6.2.2 SUMMARY OF *RAJA RADIATA* STOMACH CONTENTS IN 1991 BY PREDATOR SIZE CLASS (mm) AND QUARTER (TOTAL NORTH SEA)

Size class	50	60	70	80	100	120	150	200	250	300	350	400	500	600	700	800	1000
QUARTER 1																	
Nr of stomachs sampled							39	60	115	98	99	207	19				
% empty stomachs									27.83	29.59	30.30	39.61	47.37				
Mean length																	
Total weight all prey							0.35	0.31	1.00	1.07	1.69	2.70	2.72				
Total nr of prey items							9.20	6.09	3.07	1.80	3.02	2.56	1.80				
Average weight per prey							0.04	0.05	0.32	0.59	0.56	1.05	1.51				
WEIGHT % BY MAJor TAXA																	
ANNELIDA							7.71	25.53	10.52	4.58	3.61	3.70	0.34				
GASTROPODA												0.05					
BIVALVIA										3.95							
CEPHALOPODA								0.44				0.52					
CRUSTACEA							57.02	63.06	25.76	34.65	27.22	15.52	5.81				
GNATHOSTOMATA							3.98	9.51	63.59	56.45	65.44	79.86	93.84				
UNKNOWN							31.30	1.46	0.14	0.36	3.73	0.35	0.01				
WEIGHT % COMMERCIAL SPEC.																	
TRISOPTERUS ESMARKI									4.44			4.16					
SPRATTUS SPRATTUS											0.42						
AMMODYTIDAE										1.08	6.42	1.14					
CRANGON CRANGON							0.82	2.28									
QUARTER 2																	
Nr of stomachs sampled							25	66	60	85	107	278	41				
% empty stomachs							4.00	13.64	20.00	28.24	28.04	29.50	36.59				
Mean length																	
Total weight all prey							0.29	0.18	0.70	1.10	2.03	2087.00	2.85				
Total nr of prey items							5.59	3.50	3.42	2.39	1.93	1.78	1.21				
Average weight per prey							0.05	0.05	0.21	0.46	1.05	1174.48	2.35				
WEIGHT % BY MAJor TAXA																	
ANNELIDA							32.36	26.94	14.17	10.31	2.44	0.00	0.93				
GASTROPODA										0.03							
BIVALVIA									0.18	0.01							
CEPHALOPODA										0.87		0.00					
CRUSTACEA							40.66	45.92	51.77	30.01	25.26	0.05	22.47				
ECHINODERMATA							4.40					0.00					
GNATHOSTOMATA							12.77	18.59	31.95	58.01	71.26	99.94	75.69				
UNKNOWN							9.82	8.55	1.93	0.76	1.04	0.00	0.91				
WEIGHT % COMMERCIAL SPEC.																	
MELANOGRAMMUS AEGLEFINUS												0.02					
MERLANGIUS MERLANGUS												0.01	12.31				
TRISOPTERUS ESMARKI										14.04	6.73	0.00					
CLUPEA HARENGUS													8.51				
LIMANDA LIMANDA													8.09				
QUARTER 3																	
Nr of stomachs sampled					2	2	78	207	219	268	300	346	53				
% empty stomachs								4.35	10.96	11.57	12.33	19.65	39.62				
Mean length																	
Total weight all prey					0.14	0.06	0.18	0.32	0.77	1.17	2.03	2.18	3.65				
Total nr of prey items					4.00	1.00	3.79	2.60	2.07	2.07	2.22	1.95	1.00				
Average weight per prey					0.04	0.06	0.05	0.12	0.37	0.57	0.91	1.12	3.64				
WEIGHT % BY MAJor TAXA																	
PHAEOPHYTA												0.00					
ANNELIDA					9.09		16.57	28.72	8.34	4.61	3.67	4.37	0.14				
BIVALVIA								1.21	0.07	0.20	0.09	0.06	0.11				
CEPHALOPODA								0.06		0.21							
CRUSTACEA					90.91	100.00	73.56	49.80	32.30	27.97	32.41	28.23	19.22				
PRIAPULIDA									0.49								
ECHINODERMATA								0.01		0.01	0.00						
GNATHOSTOMATA							8.70	20.11	58.80	66.51	63.52	66.90	80.42				
UNKNOWN							1.17	0.07		0.49	0.31	0.44	0.11				
WEIGHT % COMMERCIAL SPEC.																	
GADUS MORHUA									0.33		1.27	0.38	35.18				
MERLANGIUS MERLANGUS											1.01		1.63				
TRISOPTERUS ESMARKI									5.79	7.46	8.49	12.54	3.13				
CLUPEA HARENGUS											4.43						
LIMANDA LIMANDA									3.39	1.42	0.65						
QUARTER : 4																	
Nr of stomachs sampled						4	20	29	60	102	125	192	21				
% empty stomachs								17.24	18.33	18.63	19.20	19.27	14.29				
Mean length																	
Total weight all prey						0.29	0.36	0.19	0.83	1.31	2.20	3.97	5.11				
Total nr of prey items						1.50	6.59	2.25	3.76	3.71	2.72	3.22	4.83				
Average weight per prey						0.20	0.05	0.08	0.22	0.35	0.81	1.23	1.06				
WEIGHT % BY MAJor TAXA																	
PHAEOPHYTA											0.01						
ANNELIDA							9.64	8.85	16.19	4.58	3.01	1.09	5.30				
GASTROPODA							0.80										
BIVALVIA								0.25				0.00					
CEPHALOPODA									0.09	0.17	0.02						
CRUSTACEA						100.00	77.64	85.89	58.69	38.66	28.06	26.74	45.92				
AGNATHA											0.03						
GNATHOSTOMATA							11.92	5.01	24.26	55.29	67.74	71.87	48.00				
UNKNOWN									0.78	1.27	1.16	0.29	0.77				
WEIGHT % COMMERCIAL SPEC.																	
GADUS MORHUA								1.27									
MELANOGRAMMUS AEGLEFINUS												0.77	3.69				
MERLANGIUS MERLANGUS												2.92					
TRISOPTERUS ESMARKI									1.57	8.68	18.45	30.30	0.13				
CLUPEA HARENGUS													19.48				
AMMODYTIDAE											2.08	0.12					
SOLEA SOLEA										14.11							
LIMANDA LIMANDA											1.40	0.77					
CRANGON CRANGON										0.06							

Table 4.2.1 Catch in numbers of age (1000) 1974-1992.

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	55431.	48470.	93193.	42050.	161152.	85776.	87459.	189784.	60296.	119265.
3	10716.	17106.	18630.	21608.	14859.	37349.	29367.	27017.	55842.	18436.
4	14869.	3748.	6052.	4714.	8977.	2965.	9973.	7561.	6941.	10128.
5	4392.	6567.	1504.	1768.	3041.	3021.	1503.	3755.	3170.	2565.
6	920.	1751.	2697.	533.	1004.	641.	1042.	763.	1802.	1185.
7	417.	398.	860.	630.	402.	350.	379.	542.	344.	564.
8	373.	156.	116.	229.	407.	118.	158.	139.	211.	144.
9	318.	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.
AND TOTAL NUMBER CAUGHT :	102367.	109731.	129273.	155924.	214809.	170747.	199371.	252918.	198490.	174421.
SOP	202000.	188770.	204400.	195295.	275889.	234721.	258737.	325926.	287894.	246875.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.	0.	0.	0.	0.	1.	0.	0.	1.
1	65578.	8448.	56886.	19108.	16530.	19850.	11258.	13572.	27287.
2	58124.	114816.	21896.	104054.	46872.	31671.	49412.	22324.	28878.
3	28270.	15710.	34649.	6980.	37321.	15238.	8436.	14992.	7109.
4	3461.	7612.	4936.	7908.	3148.	8221.	3775.	2357.	4602.
5	3144.	1338.	2727.	1392.	2462.	911.	1957.	1180.	859.
6	955.	1252.	651.	999.	637.	907.	251.	915.	446.
7	441.	367.	612.	208.	304.	221.	243.	183.	294.
8	249.	182.	174.	208.	64.	126.	38.	120.	49.
9	64.	79.	58.	58.	51.	23.	43.	22.	38.
10	45.	14.	48.	33.	12.	24.	7.	3.	17.
11	23.	22.	13.	15.	12.	8.	3.	9.	9.
GRAND TOTAL NUMBER CAUGHT :	160354.	149840.	122650.	140963.	107413.	77201.	75423.	55677.	69589.
SOP	211534.	211969.	189470.	185132.	175639.	128096.	109402.	90484.	94081.

Continued

Table 4.2.1 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	32094.	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	352.	1561.	21.	229.	280.	241.	685.	248.	364.	647.
9	52.	158.	271.	6.	11.	20.	57.	45.	57.	82.
10	19.	4.	36.	183.	10.	8.	22.	39.	32.	36.
GRAND TOTAL NUMBER CAUGHT :	2572538.	1968388.	2435899.	2439067.	1729054.	1893514.	1419305.	1483641.	861458.	1362016
SOP	336029.	270350.	341950.	288723.	203973.	257505.	227373.	209240.	152632.	170142.

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

Continued

Table 4.2.1 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	14750.	50643.	23310.	12540.	11854.	18967.	23775.	17902.	24217.	33764.
3	60680.	58016.	127765.	15935.	14363.	11653.	13333.	19006.	24887.	24997.
4	31803.	46993.	56418.	40783.	27367.	13242.	10534.	9102.	35432.	18559.
5	12431.	19590.	19416.	22988.	20032.	12016.	9576.	7011.	10812.	25944.
6	20595.	9485.	7916.	5399.	4256.	6695.	7273.	4373.	6692.	4588.
7	14504.	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	412.	284.	500.	415.	494.	356.	339.	382.	116.	202.
12	222.	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 :	166520.	201632.	248853.	113774.	82756.	68448.	74091.	71984.	108968.	115470.
SOP	297636.	296983.	351419.	193177.	141485.	110451.	120286.	116690.	159959.	171556.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.	0.	0.	0.	0.	1.	0.	0.	1.
1	74.	346.	79.	2352.	14.	5340.	292.	353.	294.
2	33018.	4285.	5862.	25521.	3341.	9529.	3385.	12725.	5477.
3	79206.	114882.	47752.	26683.	13114.	13721.	30474.	43178.	16348.
4	32121.	54661.	91388.	79485.	13468.	24283.	13714.	27405.	30435.
5	11754.	11684.	14795.	14439.	28616.	11313.	9181.	6598.	11867.
6	12297.	4610.	4706.	2335.	2966.	9800.	3754.	3072.	2833.
7	1289.	2436.	1610.	1282.	902.	1146.	2113.	1345.	1401.
8	1057.	422.	958.	883.	340.	474.	492.	758.	626.
9	260.	226.	255.	754.	241.	271.	147.	295.	459.
10	190.	82.	127.	218.	174.	119.	68.	88.	130.
11	102.	76.	100.	132.	61.	71.	45.	52.	49.
12	71.	66.	78.	48.	33.	52.	26.	43.	58.
13	27.	23.	36.	32.	25.	14.	20.	11.	11.
14	41.	22.	32.	37.	16.	26.	6.	9.	10.
15	55.	35.	45.	59.	60.	20.	21.	13.	53.
GRAND TOTAL NUMBER CAUGHT :	171562.	193856.	167823.	154260.	63371.	76180.	63738.	95945.	70052.
SOP	216102.	238496.	248245.	207757.	113025.	119148.	92964.	120713.	108175.

Continued

Table 4.2.1 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
0	0.	1.	0.	0.	0.	0.	0.	0.	1.
1	25.	6633.	3380.	510.	2906.	2080.	1302.	490.	3774.
2	3025.	853.	28495.	510.	3118.	8156.	4323.	11811.	16176.
3	61900.	7118.	2521.	510.	3368.	8095.	21180.	13081.	12343.
4	37000.	39057.	5311.	200.	1905.	2346.	5640.	6395.	2955.
5	19600.	21838.	8260.	400.	388.	1323.	1640.	1421.	1812.
6	9700.	13085.	4251.	540.	1623.	282.	917.	552.	566.
7	2700.	5822.	2550.	400.	952.	1129.	194.	1263.	228.
8	5500.	1869.	1475.	310.	1076.	673.	794.	0.	112.
9	5100.	6244.	1401.	740.	35.	741.	458.	474.	1.
10	5200.	4132.	2711.	100.	547.	35.	529.	552.	1.
11	3100.	3766.	1908.	200.	122.	388.	18.	395.	75.
12	1825.	3381.	2803.	100.	18.	89.	265.	158.	188.
13	1900.	2295.	1966.	200.	142.	153.	53.	158.	75.
14	825.	2036.	1518.	100.	85.	60.	1.	79.	1.
15	4200.	5263.	4216.	800.	567.	488.	388.	335.	415.
GRAND TOTAL NUMBER CAUGHT :	161600.	123393.	72766.	5620.	16852.	26038.	37702.	37164.	38723.
SOP	71700.	58237.	31443.	2863.	6687.	9863.	14137.	13132.	12774.

Continued

Table 4.2.1 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	1213968.	1822979.	142656.	228665.	446442.	300327.	635314.	134582.	276090.	158564.
2	174438.	678225.	1017986.	105357.	143783.	232334.	374652.	417372.	83625.	238007.
3	326841.	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	1320.	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	22.	104.	745.	24.	95.	111.	151.	64.	25.	181.
10	32.	52.	57.	162.	7.	26.	70.	21.	15.	44.
11	8.	11.	3.	2.	70.	19.	40.	37.	10.	14.
GRAND TOTAL NUMBER CAUGHT :	2383896.	2756948.	1568654.	923256.	1086861.	1491590.	1395705.	1350348.	969667.	1268963.
SOP	387645.	504337.	424403.	249533.	202970.	184880.	236571.	221724.	215955.	228053.

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

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

Continued

Table 4.2.1 Continued

NUMBER CAUGHT SPRAT

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	1596000.	690200.	2860000.	1118100.	643100.	433000.	530800.	373200.	55600.	142700.
1	19064500.	21482500.	36358200.	12245600.	28257600.	36747500.	16243800.	12289600.	8538000.	5055700.
2	12075100.	28018900.	14220400.	18931400.	7135400.	8757100.	16427900.	7997500.	6593700.	2091500.
3	1307500.	4733200.	8070900.	1492700.	4947000.	2809100.	1442100.	1200600.	613200.	562000.
4	293100.	319100.	459400.	130800.	560100.	167900.	124200.	29400.	173900.	41200.
GRAND TOTAL NUMBER CAUGHT :	34336200.	55243900.	61968900.	33918600.	41543200.	48914600.	34768800.	21890300.	15974400.	7893100.
SOP	278787.	568852.	545796.	319439.	416678.	428610.	320755.	195657.	140940.	79136.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	91400.	0.	0.	0.	0.	0.	0.	0.	1.
1	6455200.	1616358.	244426.	2188794.	4902121.	4428931.	4820383.	11423889.	11785608.
2	1078500.	2443554.	622471.	454281.	3027422.	502851.	952679.	637232.	2089709.
3	310800.	36433.	468626.	114241.	183309.	1135542.	186465.	116098.	111982.
4	43100.	10256.	9310.	88879.	100034.	201528.	633821.	44219.	39332.
GRAND TOTAL NUMBER CAUGHT :	7979000.	4106601.	1344833.	2846195.	8212886.	6268852.	6593348.	12221438.	14026632.
SOP	73815.	49010.	15850.	31166.	87028.	62916.	72523.	107894.	124253.

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
0	2210000.	671000.	5436000.	229000.	2971000.	4732000.	1613000.	2683000.	490000.
1	13657000.	7365000.	3448000.	7461000.	1143000.	5730000.	5218000.	3944000.	9588000.
2	4907000.	2427000.	1407000.	853000.	1425000.	478000.	1600000.	1984000.	1923000.
3	416001.	221001.	83001.	18000.	20001.	25000.	65000.	136000.	143000.
GRAND TOTAL NUMBER CAUGHT :	21190001.	10684001.	10374001.	8561000.	5559001.	10965000.	8496000.	8747000.	12144000.
SOP	457486.	225166.	157583.	156689.	91559.	155909.	139819.	144603.	235770.

Continued

Table 4.2.1 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
0	6793000.	21009200.	9336000.	1272000.	17600000.	9045560.	12366000.	25731000.	7068001.
1	87160000.	13747800.	31628000.	40434000.	13520000.	107110000.	24275000.	74190000.	74158001.
2	5334100.	46201200.	7796000.	40648000.	36723000.	3083001.	22488000.	11938000.	14462001.
3	14482030.	6043300.	2757000.	1750000.	21544000.	4597000.	3736000.	2347000.	1645001.
4	460010.	854400.	353000.	339000.	2075000.	3258310.	491000.	682000.	647001.
5	156004.	236500.	60000.	86000.	647000.	48005.	2382000.	93000.	181001.
6	91001.	88901.	15001.	21001.	251001.	18001.	11001.	1.	132001.
GRAND TOTAL NUMBER CAUGHT :	114476145.	88181301.	51945001.	84550001.	92360001.	127159877.	65749001.	114981001.	98293007.
SOP	899008.	803145.	388222.	809760.	933079.	845903.	555861.	763331.	687715.

Continued

Table 4.2.1 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.	1143.	1318.	979.	253.	3334.	1214.
2	20288.	28124.	33643.	56969.	60578.	58031.	64904.	100927.	47776.	119695.
3	60018.	61623.	77649.	43289.	62343.	118863.	133741.	122296.	209007.	115034.
4	60547.	31262.	96398.	66013.	54341.	48962.	77523.	57604.	69544.	99076.
5	40235.	25419.	13779.	83705.	50102.	47886.	24974.	35745.	28655.	29359.
6	18737.	21188.	9904.	9142.	35510.	39932.	17982.	12414.	16726.	12906.
7	7944.	11873.	9120.	5912.	5940.	24228.	13761.	9564.	7589.	8216.
8	6354.	5923.	6391.	5022.	3352.	4161.	8458.	8092.	5470.	4193.
9	5748.	4106.	2947.	4061.	2419.	2807.	1864.	4874.	4482.	3013.
10	4161.	3337.	2020.	1927.	2176.	2333.	1326.	1406.	3706.	2947.
11	12017.	1741.	2111.	1301.	1145.	1849.	952.	1097.	1134.	2144.
12	1901.	7935.	911.	1357.	603.	1113.	1173.	830.	712.	1219.
13	2051.	1080.	4478.	489.	689.	707.	433.	796.	575.	581.
14	1483.	1424.	388.	2290.	330.	707.	284.	468.	519.	344.
15	3748.	4178.	2644.	1827.	2525.	2579.	1209.	1306.	2007.	1052.
GRAND TOTAL NUMBER CAUGHT :	246850.	210194.	265203.	286524.	283196.	355476.	349563.	357672.	401236.	400993.
SOP	111248.	93781.	103012.	112202.	108563.	138293.	125429.	126140.	141329.	138035.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.	0.	0.	0.	0.	0.	0.	0.	1.
1	108.	121.	1674.	0.	1.	1260.	1549.	1460.	3097.
2	63252.	73552.	67125.	104586.	17446.	46168.	35459.	46134.	40793.
3	274209.	144316.	163717.	119980.	283622.	101733.	105320.	87563.	79760.
4	53549.	185203.	93801.	104127.	82089.	228268.	117052.	121415.	68464.
5	37468.	32520.	84479.	58551.	52985.	51556.	170573.	76487.	69406.
6	13661.	15544.	24049.	31686.	28065.	19012.	28513.	82686.	32396.
7	6465.	6871.	9299.	9971.	18589.	10407.	8904.	15965.	29403.
8	5544.	3650.	4490.	3832.	6063.	7479.	4635.	5724.	6978.
9	2720.	2698.	2733.	1948.	3560.	2081.	3851.	3390.	3354.
10	2088.	1543.	2026.	1469.	1882.	1672.	1239.	2631.	2394.
11	1307.	1030.	1178.	907.	1025.	915.	798.	1072.	1721.
12	1143.	1070.	1084.	588.	1010.	623.	511.	679.	972.
13	455.	727.	806.	483.	554.	433.	338.	401.	606.
14	310.	371.	628.	268.	559.	326.	244.	339.	605.
15	1262.	1057.	1228.	1158.	1743.	1551.	1231.	1297.	1604.
GRAND TOTAL NUMBER CAUGHT :	463541.	470273.	458317.	439554.	499193.	473484.	480217.	447243.	341554.
SOP	156430.	163821.	165971.	155757.	180328.	173652.	186012.	178581.	139185.

Continued

Table 4.2.1 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.	1747.	27.	9.	637.	423.	2660.	389.
2	15380.	22954.	3543.	22328.	25031.	8180.	1209.	29217.	26435.	34408.
3	21540.	28536.	27966.	12073.	29292.	41170.	12512.	3259.	45746.	41386.
4	5487.	11717.	14013.	15307.	6129.	16061.	17781.	6866.	1843.	21189.
5	7061.	2088.	4819.	7440.	6639.	2996.	7297.	8223.	3536.	625.
6	1923.	3830.	966.	1779.	4250.	3222.	1450.	3661.	4790.	1378.
7	1585.	791.	1909.	319.	1738.	1747.	2197.	948.	1678.	1950.
8	658.	908.	551.	1112.	611.	817.	1409.	886.	615.	979.
9	401.	508.	425.	256.	646.	242.	367.	766.	605.	386.
10	609.	234.	204.	211.	192.	393.	54.	197.	527.	301.
11	2364.	252.	195.	94.	235.	154.	415.	107.	149.	423.
12	104.	1905.	132.	122.	123.	117.	52.	160.	74.	31.
13	32.	25.	1320.	108.	106.	103.	52.	92.	201.	14.
14	305.	84.	39.	852.	68.	73.	32.	21.	12.	177.
15	1401.	945.	773.	729.	879.	687.	589.	331.	315.	230.
GRAND TOTAL NUMBER CAUGHT :	58951.	75041.	57896.	64477.	75966.	75971.	46053.	55157.	89186.	103866.
SOP	16663.	19141.	15904.	16785.	19023.	19415.	13841.	14187.	20718.	24108.

AGE	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	0.	0.	0.	0.	0.	0.	0.	0.	1.
1	191.	165.	373.	92.	10.	115.	824.	121.	906.
2	30734.	16118.	9351.	29208.	13187.	46029.	11913.	14383.	6634.
3	43931.	43213.	18494.	21703.	47140.	18161.	103899.	28795.	43944.
4	22554.	20286.	17703.	9210.	15248.	22525.	9768.	89894.	16054.
5	8791.	9403.	7745.	6623.	4400.	4681.	9454.	7624.	37693.
6	741.	3556.	5522.	3133.	3890.	1687.	3885.	4320.	2494.
7	854.	209.	2272.	1527.	1554.	1449.	1188.	1979.	3081.
8	1043.	379.	110.	892.	898.	652.	1295.	824.	774.
9	524.	637.	282.	94.	526.	465.	613.	825.	435.
10	243.	200.	620.	114.	38.	238.	270.	365.	482.
11	209.	192.	355.	176.	34.	45.	329.	347.	182.
12	146.	189.	173.	142.	86.	36.	60.	426.	242.
13	30.	94.	126.	69.	42.	48.	29.	18.	146.
14	24.	33.	105.	56.	9.	27.	63.	17.	7.
15	243.	267.	305.	167.	111.	94.	218.	178.	249.
GRAND TOTAL NUMBER CAUGHT :	110258.	94941.	63536.	73206.	87173.	96252.	143808.	150116.	113324.
SOP	26371.	23773.	17907.	17748.	21418.	22341.	34080.	40937.	32351.

Table 4.3.1.a 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
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0853	.1426	.0576	.2284	.1160	.1869	.1519	.1634	.2478
2	.8130	.7546	.9719	.8611	1.0594	.8368	.9012	1.0083	.9491
3	.7195	.7978	.8561	.7229	.9484	.9254	.9319	.9671	1.2282
4	.7064	.6620	.7982	.5811	.8089	.5362	.7298	.7174	.7797
5	.7110	.7908	.6128	.5707	.9616	.7341	.5716	.6791	.7760
6	.7030	.6786	.9125	.4547	.7490	.5437	.6006	.6426	.8429
7	.6559	.7473	.8612	.5549	.7347	.6595	.7195	.7286	.6895
8	.7221	.5414	.4969	.6049	.8708	.5083	.7091	.6326	.7229
9	1.1287	.9462	.4604	.5342	.9821	.7728	.6285	.6881	.6889
10	.6956	.9239	.9486	.3931	.7991	.6960	.7010	.6972	.5803
11	.6000	.6002	.6002	.6002	.8013	.6334	.7061	.2155	.9520
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8									
	.7187	.7104	.7871	.6215	.8761	.6777	.7377	.7680	.8555

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.1643	.2320	.1468	.2222	.1694	.2281	.1646	.2085	.1859
2	1.0706	.9795	.9841	.8256	.9056	.9379	1.0305	.8953	.9137
3	1.1470	.9794	.9189	1.1324	.7354	1.2024	1.0665	1.0025	.8395
4	.8576	.7282	.8377	.9118	.9042	.9447	1.0202	.9014	.8993
5	.7756	.7222	.7057	.8490	.7203	.8266	.7964	.7254	.8042
6	.7735	.7509	.7143	.9056	.9022	.8889	.8554	.5319	.9235
7	.7147	.7401	.7318	.9498	.8656	.8000	.9235	.5936	.9587
8	.7248	.8125	.8044	.9614	1.0938	.7520	.9568	.3845	.6583
9	.5950	.8319	.6580	.6440	1.0962	.9057	.6512	1.1875	.4289
10	.5203	.9318	.4289	1.1788	1.0279	.7110	1.9002	.4245	.1977
11	.5592	.9567	.9504	.2490	.7490	.5751	.8002	.8113	.7117
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8									
	.8663	.8161	.8138	.9337	.8753	.9075	.9499	.7192	.8567

AGE	1992
0	.0000
1	.1102
2	.8112
3	.9566
4	.6984
5	1.0418
6	.8500
7	.9091
8	.7815
9	.4377
10	.6467
11	.6473
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8	
	.8641

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

Continued

Table 4.3.1.a Continued

STOCK NUMBERS COD

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	277300.	432830.	205717.	764403.	462336.	472566.	940669.	367733.	610547.
2	124979.	114413.	181555.	92701.	292360.	181863.	176736.	362570.	119198.
3	24193.	35254.	35712.	47136.	26618.	68794.	53435.	48921.	86832.
4	32315.	8480.	11953.	11602.	17393.	7821.	20850.	15958.	13895.
5	9442.	12907.	3540.	4371.	5273.	6303.	3718.	8182.	6326.
6	1993.	3797.	4792.	1570.	2022.	1650.	2477.	1719.	3397.
7	948.	808.	1577.	1575.	816.	783.	785.	1112.	740.
8	793.	403.	313.	546.	740.	320.	331.	313.	439.
9	514.	316.	192.	156.	244.	254.	158.	134.	136.
10	164.	136.	100.	99.	75.	75.	96.	69.	55.
11	433.	121.	80.	58.	87.	49.	51.	115.	41.
TOTAL STOCK BIOMASS ON 1. JANUARY	328268.	288439.	287528.	262707.	355036.	321449.	354198.	429984.	352577.
SPAWNING STOCK BIOMASS ON 1. JANUARY	169775.	142121.	118399.	100017.	114518.	103048.	118044.	129556.	132770.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	297635.	569350.	125472.	519452.	228248.	149424.	228265.	107176.	134968.
2	218103.	112701.	220909.	49265.	205148.	93009.	58533.	99519.	43721.
3	30360.	49983.	28982.	57265.	14911.	58821.	25607.	14899.	28875.
4	19173.	7258.	14462.	8918.	14309.	5564.	13847.	6908.	4276.
5	5172.	6606.	2848.	5096.	2918.	4727.	1762.	4074.	2285.
6	2384.	1950.	2627.	1151.	1785.	1162.	1693.	651.	1615.
7	1197.	900.	753.	1053.	381.	593.	391.	589.	313.
8	304.	480.	352.	297.	333.	131.	218.	127.	267.
9	175.	121.	174.	129.	93.	91.	51.	69.	71.
10	56.	79.	43.	74.	55.	25.	30.	22.	17.
11	47.	40.	37.	63.	30.	30.	16.	6.	19.
TOTAL STOCK BIOMASS ON 1. JANUARY	314511.	261439.	274986.	224108.	238867.	211937.	159819.	143328.	121974.
SPAWNING STOCK BIOMASS ON 1. JANUARY	116583.	98258.	93652.	88807.	77375.	74390.	67579.	54270.	50436.

AGE	1992
0	0.
1	432067.
2	60522.
3	12605.
4	9848.
5	1419.
6	837.
7	525.
8	98.
9	113.
10	38.
11	20.
TOTAL STOCK BIOMASS ON 1. JANUARY	131010.
SPAWNING STOCK BIOMASS ON 1. JANUARY	47604.

Continued

Table 4.3.1.a Continued

PREDATION MORTALITY COD

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	1.1222	1.0836	.9568	.9026	.8985	.7668	.8919	.6425	.6098
1	.3200	.2462	.2595	.2528	.3371	.3166	.3215	.4831	.3016
2	.1826	.1397	.1066	.1167	.1175	.1180	.1133	.1509	.1486
3	.1188	.0737	.0582	.0641	.0664	.0584	.0666	.0816	.0723
4	.0114	.0116	.0078	.0075	.0062	.0073	.0055	.0080	.0086
5	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.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

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.5190	.6111	.4852	.5287	.6665	.5230	.5887	.4470	.3556
1	.3268	.2347	.3081	.2268	.2483	.2291	.1855	.2081	.1362
2	.1327	.1086	.0960	.0995	.0736	.0820	.0678	.0721	.0601
3	.0740	.0508	.0497	.0444	.0405	.0340	.0337	.0358	.0261
4	.0079	.0075	.0053	.0055	.0035	.0048	.0034	.0049	.0039
5	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
6	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.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

AGE	1992
0	.3933
1	.1352
2	.0473
3	.0264
4	.0024
5	.0000
6	.0000
7	.0000
8	.0000
9	.0000
10	.0000
11	.0000

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

Table 4.3.1.b WHITING

FISHING MORTALITY WHITING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0470	.0500	.0650	.0708	.0495	.0353	.0514	.1139	.0308
1	.4234	.2409	.2153	.4591	.1703	.2753	.1169	.1882	.2372
2	.8884	.7714	.9756	.5361	.4104	.5106	.4233	.3140	.3250
3	1.0519	1.0462	1.2282	.8983	.6937	.7929	.7918	.7305	.5043
4	.9401	1.0367	1.0917	.9901	.8512	.7181	.9833	.9605	.7009
5	1.0298	1.0262	.7959	.8382	.7263	.9227	1.1416	1.0138	.9113
6	1.9770	.9541	1.2503	1.0247	1.1576	.9982	1.4186	1.3739	1.1891
7	1.1648	1.0853	.7455	.8360	1.6045	.9029	1.1571	1.3727	.9564
8	.8891	1.2307	.6574	2.2173	1.7511	1.0046	1.9675	1.0598	1.3312
9	2.3431	1.4816	.7125	.3927	.7077	.5364	.7599	.7375	.7571
10	1.2000	1.2013	1.2000	1.2000	1.3731	1.0093	1.3711	1.1593	.9852
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6	1.1774	.9669	1.0683	.8575	.7679	.7885	.9517	.8785	.7261

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.1522	.0526	.0309	.0436	.0249	.0680	.0315	.1201	.2214
1	.2826	.3125	.2625	.3549	.1572	.4290	.1788	.3291	.1901
2	.4599	.4980	.3220	.4134	.4327	.4781	.5020	.6681	.5859
3	.7160	.8349	.6199	.6520	.8225	.7134	.7735	1.0350	.6322
4	.7434	1.0521	.8961	1.2427	1.3143	1.0580	.9195	1.0547	.9991
5	.9213	1.0448	1.0053	1.0559	1.3488	1.1000	1.6906	1.3252	1.1571
6	1.0058	1.3262	1.1640	1.4868	1.5934	1.3831	1.5908	1.2565	.8154
7	1.2792	1.2323	1.3219	1.6293	1.9008	.6176	1.5846	1.1103	1.5279
8	1.3788	1.4108	2.4062	1.5693	2.2163	.8998	2.7695	2.1835	2.9252
9	1.2543	2.2000	2.9464	1.8968	1.0138	2.2352	3.3657	1.9391	1.5836
10	1.0352	1.1693	1.4022	1.1711	1.2521	2.7003	1.2402	1.6900	1.5202
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6	.7693	.9512	.8015	.9702	1.1023	.9465	1.0953	1.0679	.8379

AGE	1992
0	.3987
1	.2074
2	.4775
3	.7256
4	.9440
5	1.3678
6	1.3391
7	1.5087
8	2.3968
9	1.5751
10	.3870
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6	.9708

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

Continued

Table 4.3.1.b Continued

STOCK NUMBERS WHITING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	3622862.	7142379.	4774628.	4658434.	5346464.	5709395.	5608419.	2720044.	2138048.
2	2098855.	943228.	2284740.	1444600.	1122125.	1518535.	1465239.	1679009.	570484.
3	424508.	535495.	278293.	546804.	534546.	468844.	566411.	601675.	728776.
4	61959.	100721.	130107.	56550.	153948.	185962.	145741.	177783.	196058.
5	8643.	17355.	26150.	32000.	15279.	48078.	65698.	39440.	48497.
6	1613.	2348.	4783.	9074.	10600.	5672.	14587.	15995.	10787.
7	9253.	170.	688.	1043.	2455.	2532.	1570.	2643.	3001.
8	654.	2364.	47.	267.	370.	404.	840.	404.	548.
9	63.	220.	565.	20.	24.	53.	121.	96.	115.
10	29.	7.	54.	301.	14.	14.	32.	62.	54.
TOTAL STOCK BIOMASS ON 1. JANUARY	520767.	548757.	582684.	511433.	519851.	589872.	598033.	520181.	392567.
SPAWNING STOCK BIOMASS ON 1. JANUARY	374029.	291413.	394109.	335293.	323054.	376514.	388712.	408978.	312650.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	1946833.	2557039.	2232015.	3805770.	3295701.	2387632.	3760416.	1845110.	1426925.
2	588027.	515343.	731122.	603467.	1050584.	1067436.	563598.	1250305.	495207.
3	249975.	233798.	201046.	337278.	255663.	449709.	427635.	227940.	430476.
4	297118.	84958.	71121.	76038.	122537.	80715.	155289.	141609.	58486.
5	69374.	103636.	21936.	21514.	16117.	24818.	20878.	46741.	37593.
6	14737.	21244.	28189.	6212.	5768.	3270.	6422.	3022.	9798.
7	2439.	4131.	4310.	6771.	1069.	912.	633.	1026.	679.
8	944.	556.	986.	941.	1087.	131.	403.	106.	277.
9	119.	195.	111.	73.	160.	97.	44.	21.	10.
10	62.	37.	22.	6.	12.	50.	11.	1.	3.
TOTAL STOCK BIOMASS ON 1. JANUARY	327135.	290573.	266014.	332781.	360774.	357075.	365515.	338912.	244923.
SPAWNING STOCK BIOMASS ON 1. JANUARY	253680.	196665.	181229.	194648.	235875.	263526.	229355.	262365.	190442.

AGE	1992
0	0.
1	2085201.
2	504135.
3	185277.
4	164725.
5	16369.
6	9310.
7	3411.
8	121.
9	12.
10	4.
TOTAL STOCK BIOMASS ON 1. JANUARY	245512.
SPAWNING STOCK BIOMASS ON 1. JANUARY	168094.

Continued

Table 4.3.1.b Continued

PREDATION MORTALITY WHITING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.6980	.9835	.8851	.9413	.9899	.9982	1.3883	.8061	.7854
1	.3623	.3390	.4202	.4045	.5284	.5249	.5293	.8137	.4936
2	.1576	.1292	.1344	.1381	.1423	.1556	.1468	.2006	.1801
3	.1067	.0886	.0854	.0892	.0822	.0955	.0870	.1108	.1129
4	.1024	.0818	.0809	.0886	.0826	.0924	.0937	.1086	.1080
5	.0636	.0526	.0526	.0566	.0546	.0600	.0612	.0725	.0698
6	.0742	.0732	.0722	.0825	.0741	.0863	.0897	.0994	.0979
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.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

`GE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.5943	.8570	.8289	.9452	1.1015	.8660	1.1145	.7719	.5769
1	.4865	.3796	.4854	.3723	.4102	.4546	.3623	.4261	.2903
2	.1425	.1233	.1317	.1255	.0958	.1166	.0832	.0782	.0772
3	.0832	.0752	.0724	.0805	.0505	.0699	.0517	.0453	.0484
4	.0799	.0720	.0696	.0787	.0526	.0642	.0512	.0415	.0443
5	.0521	.0472	.0464	.0504	.0361	.0418	.0322	.0272	.0286
6	.0661	.0689	.0623	.0727	.0507	.0598	.0432	.0368	.0399
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.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

AGE	1992
0	.5249
1	.2320
2	.0567
3	.0338
4	.0375
5	.0245
6	.0346
7	.0000
8	.0000
9	.0000
10	.0000

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

Table 4.3.1.c SAITHE

FISHING MORTALITY SAITHE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0084	.0004	.0025	.0864	.0039	.0047	.0106	.0300	.0052
2	.0628	.1570	.1851	.1562	.1481	.2475	.1370	.1669	.1932
3	.4493	.3820	.7373	.1822	.2654	.2085	.2763	.1540	.3723
4	.5093	.7734	.8045	.5541	.5442	.4065	.2983	.3069	.4728
5	.3654	.6987	.9158	.9566	.5684	.4809	.5743	.3314	.7081
6	.5982	.5340	.6985	.6970	.4310	.3764	.5905	.5713	.5808
7	.6762	.5344	.5773	.3690	.2859	.4490	.5299	.5808	.5232
8	.5064	.5327	.5992	.4659	.2787	.3928	.3757	.8200	.5460
9	.4223	.2889	.3977	.3519	.2679	.2262	.4527	.4476	.6676
10	.3670	.2679	.4258	.2796	.2582	.1808	.3467	.4449	.3792
11	.3462	.2054	.4350	.2193	.2693	.2438	.3525	.5492	.3173
12	.3604	.3720	.5041	.4843	.2676	.2673	.2451	.7133	.3771
13	.6820	.4149	.4618	.3713	.5597	.1554	.2913	.5458	.4700
14	.3096	.4015	.6969	.6188	.3972	.2768	.2316	.6813	.6040
15	.2823	.3001	.3000	.3001	.3572	.2401	.3432	.6202	.4982
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6	.4806	.5970	.7890	.5975	.4523	.3680	.4349	.3409	.5335

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0004	.0002	.0029	.0006	.0287	.0001	.0295	.0028	.0030
2	.1427	.1031	.0166	.0640	.2602	.0536	.0779	.0242	.1739
3	.3026	.6013	.5855	.2598	.4576	.2156	.3179	.3693	.4849
4	.5236	.8164	1.1560	1.4980	.8729	.4388	.7712	.6060	.6472
5	.7615	.7371	.7918	1.2622	1.0808	.9376	.8302	.7520	.6522
6	.7585	1.0609	.7265	.8980	.6629	.6506	1.0461	.7159	.5969
7	1.0490	.5013	.5968	.5864	.6622	.5689	.5633	.6605	.6016
8	.8293	.7829	.2983	.4914	.8192	.3559	.6830	.5228	.5148
9	.8387	.3965	.3649	.2877	1.0165	.5290	.5551	.4729	.6774
10	.4230	.4164	.2004	.3515	.4635	.6408	.5700	.2513	.5611
11	.4409	.2438	.2840	.3934	.8159	.2100	.6304	.4384	.3087
12	.3427	.2797	.2410	.5160	.3479	.4649	.2884	.4904	.9808
13	.4688	.2107	.1328	.1964	.4378	.2911	.3844	.1816	.3813
14	.3429	.4298	.2649	.2712	.3231	.3874	.5738	.2666	.1081
15	.5233	.3352	.1951	.3772	.3652	.4002	.4372	.5914	.6220
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6	.5865	.8039	.8149	.9795	.7686	.5606	.7413	.6108	.5953

AGE	1992
0	.0011
1	.0019
2	.0546
3	.3530
4	.7268
5	.6456
6	.6502
7	.6446
8	.6806
9	.7392
10	.7419
11	.7371
12	.7397
13	.7356
14	.7385
15	.7382
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6	.5939

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

Continued

Table 4.3.1.c Continued

STOCK NUMBERS SAITHE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	480217.	189974.	120884.	128113.	117905.	256793.	159794.	197750.	338106.
2	266144.	389869.	155472.	98721.	96204.	96152.	209260.	129453.	157112.
3	184041.	204639.	272831.	105780.	69138.	67923.	61463.	149393.	89699.
4	87464.	96146.	114351.	106863.	72179.	43409.	45147.	38173.	104859.
5	44580.	43030.	36324.	41879.	50272.	34295.	23670.	27429.	22995.
6	50205.	25327.	17517.	11901.	13173.	23314.	17359.	10912.	16122.
7	32388.	22598.	12156.	7133.	4853.	7008.	13101.	7875.	5046.
8	13889.	13485.	10842.	5587.	4038.	2985.	3662.	6314.	3607.
9	4547.	6853.	6481.	4875.	2871.	2502.	1650.	2059.	2277.
10	2891.	2441.	4203.	3565.	2808.	1798.	1634.	859.	1078.
11	1546.	1640.	1529.	2248.	2207.	1775.	1229.	946.	451.
12	805.	895.	1093.	810.	1478.	1380.	1139.	707.	447.
13	293.	460.	505.	541.	409.	926.	865.	730.	284.
14	124.	121.	249.	261.	305.	191.	649.	529.	346.
15	121.	189.	169.	258.	269.	472.	283.	753.	436.
TOTAL STOCK BIOMASS ON 1. JANUARY	796562.	745712.	702195.	493710.	410862.	368127.	364239.	386393.	409849.
SPAWNING STOCK BIOMASS ON 1. JANUARY	445529.	359001.	295398.	237388.	218637.	212543.	199521.	174449.	161254.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	475766.	358416.	128399.	145551.	90397.	177635.	200293.	108905.	141561.
2	275392.	389371.	293379.	104822.	119091.	71918.	145422.	159222.	88913.
3	106029.	195488.	287557.	236244.	80499.	75163.	55810.	110144.	127248.
4	50610.	64144.	87724.	131095.	149174.	41705.	49601.	33250.	62334.
5	53505.	24545.	23213.	22605.	23998.	51022.	22018.	18781.	14851.
6	9274.	20456.	9616.	8610.	5238.	6667.	16358.	7859.	7249.
7	7384.	3556.	5797.	3807.	2872.	2210.	2848.	4705.	3145.
8	2448.	2118.	1764.	2613.	1734.	1213.	1024.	1327.	1990.
9	1711.	875.	792.	1071.	1309.	626.	695.	424.	644.
10	956.	605.	482.	450.	658.	388.	302.	327.	216.
11	604.	513.	327.	323.	260.	339.	167.	140.	208.
12	269.	318.	329.	201.	178.	94.	225.	73.	74.
13	251.	156.	197.	212.	98.	103.	48.	138.	37.
14	145.	129.	104.	141.	142.	52.	63.	27.	94.
15	301.	204.	210.	148.	204.	187.	61.	53.	30.
TOTAL STOCK BIOMASS ON 1. JANUARY	413696.	473046.	524393.	497375.	387118.	277046.	257563.	255288.	283132.
SPAWNING STOCK BIOMASS ON 1. JANUARY	170832.	137860.	118274.	120443.	111797.	119408.	105205.	82305.	79126.

AGE	1992
0	0.
1	186128.
2	115558.
3	61175.
4	64148.
5	26717.
6	6334.
7	3267.
8	1411.
9	974.
10	268.
11	101.
12	125.
13	23.
14	20.
15	114.
TOTAL STOCK BIOMASS ON 1. JANUARY	259715.
SPAWNING STOCK BIOMASS ON 1. JANUARY	92896.

Table 4.3.1.d MACKEREL

FISHING MORTALITY MACKEREL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0064	.0244	.0101	.0074	.0000	.0223	.0207	.0211	.0154
2	.1097	.0264	.1931	.0873	.0637	.0171	.0667	.0547	.0960
3	.0773	.1253	.2388	.2195	.2108	.1116	.0922	.1774	.1860
4	.1822	.1855	.1414	.2783	.2194	.1826	.1929	.0535	.2122
5	.2353	.1784	.2069	.1326	.2120	.2652	.3019	.2395	.1208
6	.2200	.2870	.1715	.2347	.1056	.1518	.3248	.3552	.2166
7	.1028	.1759	.2677	.4314	.0290	.0951	.2306	.3621	.2454
8	.2421	.4229	.3154	.4726	.3831	.1357	.2670	.2281	.2697
9	.0901	.3785	.2713	.5571	.2931	.0699	.3009	.2555	.1638
10	.0457	.1914	.3590	.4699	.5174	.2668	.1614	.2426	.2091
11	.0395	.0593	.2143	.6721	.0867	.3302	.2967	.1346	.1670
12	.1426	.0620	.0764	.3752	.1338	.2380	.4097	.5412	.1839
13	.1280	.1005	.0324	.1536	.4120	.4075	.2347	.3196	.4367
14	.0280	.0890	.0895	.0337	.1582	.2897	.6391	.7945	.5504
15	.6790	.3602	.2535	.4059	.5713	.2927	.2914	1.4402	.4108
MEAN F (UNWEIGHTED) FOR AGES 4 TO 8									
	.1965	.2499	.2206	.3099	.1898	.1661	.2634	.2477	.2129

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0048	.0006	.1229	.1924	.0149	.0342	.0303	.0095	.0038
2	.1076	.1034	.0247	1.0827	.0371	.1149	.1196	.0769	.1040
3	.2654	.6672	.3587	.0895	.0408	.3510	.4535	.4809	.3221
4	.2947	.6208	1.1846	.4712	.0086	.2042	.4124	.6215	.2389
5	.2146	.6412	.8891	.8162	.0536	.0202	.2003	.5329	.2844
6	.0822	.5078	1.1835	.3946	.1005	.3076	.0172	.1960	.3147
7	.2249	.2981	.6188	.7271	.0537	.2484	.3412	.0139	.4149
8	.3247	.3493	.3257	.2922	.1618	.1937	.2613	.4021	.0000
9	.2398	.4342	.7913	.4117	.2180	.0238	.1861	.2683	.4105
10	.1844	.4075	.7073	.9595	.0428	.2402	.0282	.1852	.5489
11	.1771	.1876	.5485	.8202	.1465	.0651	.2512	.0172	.1901
12	.2091	.2605	.3004	1.0233	.0798	.0169	.0582	.2560	.1902
13	.1318	.1753	.5666	.2747	.1573	.1500	.1849	.0423	.2210
14	.8826	.1255	.2706	.9047	.0186	.0899	.0823	.0016	.0761
15	.7472	.6811	2.0661	.3660	.7412	.0198	.2066	.2227	.1792
MEAN F (UNWEIGHTED) FOR AGES 4 TO 8									
	.2282	.4835	.8404	.5402	.0756	.1948	.2465	.3533	.2506

AGE	1992
0	.0000
1	.1050
2	.1604
3	.1454
4	.1069
5	.0945
6	.1679
7	.1987
8	.0553
9	.0001
10	.0013
11	.1248
12	.1251
13	.1248
14	.0019
15	.1255
MEAN F (UNWEIGHTED) FOR AGES 4 TO 8	
	.1247

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

Continued

Table 4.3.1.d

STOCK NUMBERS MACKEREL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	505680.	551393.	297859.	170363.	41411.	114307.	146261.	204133.	215867.
2	198957.	432482.	463158.	253781.	145545.	35643.	96211.	123309.	172029.
3	350778.	153458.	362541.	328640.	200162.	117535.	30158.	77464.	100479.
4	264678.	279468.	116525.	245757.	227109.	139539.	90478.	23670.	55837.
5	1269717.	189865.	199822.	87071.	160132.	156974.	100060.	64216.	19311.
6	256380.	863747.	136722.	139840.	65638.	111499.	103637.	63680.	43501.
7	84956.	177094.	557940.	99131.	95183.	50836.	82452.	64462.	38423.
8	82761.	65976.	127838.	367441.	55427.	79582.	39785.	56353.	38628.
9	40921.	55917.	37202.	80265.	197154.	32523.	59803.	26221.	38612.
10	12335.	32186.	32961.	24411.	39576.	126584.	26103.	38096.	17479.
11	8908.	10143.	22876.	19814.	13133.	20305.	83439.	19119.	25727.
12	7752.	7371.	8228.	15892.	8708.	10365.	12561.	53380.	14383.
13	8578.	5786.	5962.	6561.	9399.	6557.	7032.	7178.	26741.
14	37346.	6496.	4503.	4968.	4843.	5358.	3755.	4786.	4488.
15	48613.	78213.	15406.	8312.	8045.	9948.	9672.	2142.	4336.
TOTAL STOCK BIOMASS ON 1. JANUARY									
	985228.	892661.	751527.	617458.	454499.	365085.	309609.	256841.	230757.
SPAWNING STOCK BIOMASS ON 1. JANUARY									
	810129.	715375.	533170.	463196.	367472.	317495.	269324.	193711.	150186.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	39353.	45087.	63316.	21734.	38113.	97225.	77924.	152891.	141072.
2	182958.	33707.	38782.	48193.	15433.	32321.	80867.	65068.	130346.
3	134520.	141408.	26163.	32567.	14049.	12799.	24798.	61758.	51860.
4	71803.	88792.	62455.	15732.	25631.	11608.	7755.	13561.	32861.
5	38870.	46029.	41078.	16442.	8453.	21871.	8146.	4419.	6269.
6	14731.	26993.	20865.	14533.	6257.	6896.	18449.	5739.	2232.
7	30149.	11678.	13982.	5499.	8430.	4871.	4363.	15608.	4060.
8	25874.	20723.	7460.	6482.	2288.	6876.	3270.	2670.	13248.
9	25389.	16095.	12577.	4636.	4165.	1675.	4876.	2167.	1537.
10	28213.	17193.	8974.	4907.	2644.	2883.	1408.	3484.	1426.
11	12206.	20194.	9845.	3808.	1618.	2180.	1951.	1178.	2492.
12	18737.	8800.	14408.	4896.	1443.	1203.	1758.	1306.	996.
13	10300.	13085.	5837.	9183.	1515.	1147.	1018.	1428.	870.
14	14873.	7770.	9451.	2851.	6005.	1114.	850.	728.	1178.
15	3761.	9383.	6621.	15397.	1683.	32479.	2922.	2165.	2231.
TOTAL STOCK BIOMASS ON 1. JANUARY									
	209760.	171463.	111485.	70541.	39521.	65191.	54667.	66080.	80905.
SPAWNING STOCK BIOMASS ON 1. JANUARY									
	132045.	123575.	91230.	49912.	29475.	47112.	24552.	23684.	28013.

AGE	1992
0	0.
1	41979.
2	120961.
3	101107.
4	32346.
5	22273.
6	4061.
7	1403.
8	2308.
9	11402.
10	878.
11	709.
12	1773.
13	709.
14	601.
15	3903.
TOTAL STOCK BIOMASS ON 1. JANUARY	
	89022.
SPAWNING STOCK BIOMASS ON 1. JANUARY	
	33177.

Table 4.3.1.e HADDOCK

FISHING MORTALITY HADDOCK

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0259	.0316	.0391	.0304	.0423	.0662	.0942	.1028	.0637
1	.4268	.4035	.3803	.3664	.5696	.1918	.2536	.2266	.2494
2	.9315	1.0379	.8511	.9997	.8340	1.0159	.8112	.4704	.4593
3	.9396	1.2923	1.4218	1.0459	1.0651	1.4394	1.2123	.9254	.8237
4	.9849	1.1264	.8007	1.2832	1.1172	.9981	1.0992	.9884	.8779
5	.7007	1.0243	1.3781	1.0559	1.1157	.9754	.7104	.6326	.5996
6	.9445	.6716	1.1567	1.0552	1.0418	1.0519	.9540	.3060	.4947
7	1.1369	1.3393	.3565	.9248	1.1366	.5698	1.0123	.8919	.3858
8	.7418	1.1622	.6443	.4003	.6845	1.0224	.6238	.6712	.9329
9	.2758	.8873	1.2244	.4800	.6746	.5594	1.5070	.9143	.2543
10	1.1548	2.5651	3.0570	1.0046	.2421	.3850	.8787	.9086	.5853
11	.9000	.9000	.9000	.9000	1.0643	.9522	1.0033	.8952	.8874
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6	.9002	1.0305	1.1217	1.0880	1.0348	1.0962	.9575	.6646	.6510

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.0628	.0195	.0345	.0048	.0122	.0106	.0135	.0173	.0268
1	.2264	.1848	.3623	.2235	.1608	.2399	.2138	.3265	.2884
2	.6663	.6639	.6520	1.1335	.8716	.8472	.8227	1.1828	.9091
3	1.0492	.9373	.9456	1.3174	1.0306	1.3072	1.1354	1.2441	1.1667
4	1.1464	1.0859	1.1011	1.2757	1.0283	1.1540	1.3653	1.1712	1.0211
5	1.2295	1.1556	.9858	1.0373	.7886	1.1491	.7907	.9744	.9388
6	.7885	1.0159	.9895	.7294	1.1282	.6779	.8457	.5446	.7391
7	.3685	.6849	.8272	.9890	.8418	.8352	.5437	.6386	.5399
8	.1402	.1700	.5408	.7635	1.3360	.6354	.6321	.3428	.7248
9	.5377	.0945	.1727	.5822	.7311	1.0850	.8768	.4988	.4511
10	.9710	.6036	.0849	.4241	.5476	.9110	.6759	1.1792	.7686
11	.9354	.9522	.9343	.9713	1.0653	1.6004	.7002	.6135	.6297
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6	.9760	.9717	.9348	1.0986	.9695	1.0271	.9919	1.0234	.9550

AGE	1992
0	.0131
1	.1214
2	.8846
3	1.5537
4	1.5923
5	1.2825
6	1.2954
7	.9883
8	1.0937
9	.9281
10	1.1450
11	1.0942
MEAN F (UNWEIGHTED) FOR AGES 2 TO 6	1.3217

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

Continued

Table 4.3.1.e Continued

STOCK NUMBERS HADDOCK

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	7229721.	11868523.	1057833.	1550147.	3057923.	3714840.	6189837.	1630335.	2709604.
2	343175.	1259930.	2176277.	195429.	303006.	441732.	817869.	1361178.	287990.
3	596608.	91019.	306257.	640827.	49522.	90357.	110158.	250745.	576109.
4	93563.	179522.	19250.	56965.	172550.	13217.	16365.	25213.	76011.
5	3984.	27824.	46457.	6928.	12705.	45464.	3929.	4401.	7534.
6	2359.	1595.	8068.	9475.	1958.	3383.	13949.	1571.	1897.
7	16911.	745.	662.	2067.	2687.	562.	962.	4380.	941.
8	491.	4442.	160.	380.	671.	706.	260.	286.	1470.
9	99.	192.	1138.	69.	208.	277.	208.	114.	120.
10	51.	62.	65.	274.	35.	87.	130.	38.	37.
11	15.	20.	6.	4.	114.	33.	69.	66.	19.
TOTAL STOCK BIOMASS ON 1. JANUARY	759862.	1055607.	642857.	407121.	355152.	369101.	564904.	466399.	468243.
SPAWNING STOCK BIOMASS ON 1. JANUARY	251319.	222201.	266886.	224811.	131252.	97184.	108605.	172189.	216286.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	1698059.	5678517.	1861345.	2267891.	4572780.	381608.	652507.	655886.	1897465.
2	589296.	399834.	1493494.	360372.	485788.	1151726.	84072.	165654.	150396.
3	124089.	208521.	143755.	542100.	80814.	143067.	347013.	26087.	35968.
4	192678.	33634.	63023.	43263.	111773.	22554.	29908.	87052.	5884.
5	25393.	49340.	9170.	16952.	9766.	32435.	5771.	6203.	21901.
6	3362.	6044.	12656.	2788.	4894.	3621.	8389.	2136.	1910.
7	940.	1243.	1782.	3836.	1095.	1292.	1500.	2939.	1011.
8	524.	533.	513.	638.	1168.	387.	459.	713.	1271.
9	473.	373.	368.	245.	243.	251.	168.	200.	414.
10	76.	226.	278.	253.	112.	96.	70.	57.	99.
11	25.	34.	149.	303.	189.	63.	53.	52.	26.
TOTAL STOCK BIOMASS ON 1. JANUARY	382427.	530176.	498574.	438836.	451419.	336696.	211220.	136873.	171930.
SPAWNING STOCK BIOMASS ON 1. JANUARY	185540.	142601.	183114.	207128.	122405.	148275.	125491.	70433.	44007.

AGE	1992
0	0.
1	3226927.
2	475230.
3	43089.
4	8724.
5	1721.
6	6989.
7	744.
8	482.
9	504.
10	216.
11	52.
TOTAL STOCK BIOMASS ON 1. JANUARY	299975.
SPAWNING STOCK BIOMASS ON 1. JANUARY	57273.

Continued

Table 4.3.1.e Continued

PREDATION MORTALITY HADDOCK

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.8911	1.0746	1.0913	1.0776	1.0833	.9267	1.1695	1.1604	.9762
1	.6004	.5729	.5886	.5461	.6453	.6018	.5410	.7870	.5562
2	.0857	.0665	.0615	.0631	.0660	.0629	.0610	.0794	.0726
3	.0314	.0313	.0302	.0362	.0258	.0392	.0322	.0381	.0416
4	.0278	.0254	.0212	.0173	.0166	.0151	.0140	.0195	.0185
5	.0148	.0136	.0118	.0079	.0076	.0061	.0060	.0092	.0072
6	.0081	.0073	.0052	.0051	.0057	.0052	.0044	.0066	.0069
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.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

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.7933	1.0720	1.3515	1.2838	1.4267	1.0937	.9804	.9829	.7898
1	.4997	.4308	.5597	.5973	.4981	.5527	.4371	.4262	.3760
2	.0626	.0491	.0515	.0515	.0408	.0425	.0376	.0345	.0309
3	.0262	.0293	.0252	.0316	.0156	.0280	.0175	.0152	.0198
4	.0159	.0137	.0120	.0127	.0089	.0091	.0078	.0087	.0084
5	.0060	.0050	.0048	.0051	.0037	.0032	.0030	.0034	.0034
6	.0062	.0055	.0043	.0048	.0034	.0035	.0030	.0035	.0031
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.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

AGE	1992
0	.5438
1	.2898
2	.0255
3	.0101
4	.0061
5	.0025
6	.0022
7	.0000
8	.0000
9	.0000
10	.0000
11	.0000

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

Table 4.3.1.f HERRING

FISHING MORTALITY HERRING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0747	.1170	.1222	.0921	.0494	.1000	.1012	.5497	.4334
1	.4748	.6352	.2120	.2037	.1479	.1328	.0632	.1665	.2121
2	.9314	1.2117	1.2263	.1348	.0171	.0758	.2526	.2762	.2060
3	.8637	1.3968	1.3984	.9373	.0302	.0543	.3449	.2501	.4506
4	.9242	1.2260	1.5818	.3980	.0660	.0723	.2437	.2589	.2243
5	1.1072	1.7830	1.2764	.9248	.0184	.0347	.2094	.3515	.1296
6	1.0050	1.2190	1.0719	.4036	.0557	.0139	.0470	.3554	.1210
7	.7642	2.0489	1.5734	.7310	.0300	.3154	.1250	.6210	.1802
8	.7802	2.0003	2.3972	1.0526	.1731	.1151	.2301	.8495	.1946
9	1.0001	1.0003	.3602	.0010	.0003	.0120	.0022	.3000	.0387
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6									
	.9750	1.4062	1.3321	.6659	.0426	.0438	.2113	.3040	.2314

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.4896	.1322	.0430	.0163	.1012	.0963	.1209	.0569	.2141
1	.1553	.0744	.2086	.1423	.2188	.2356	.3375	.2150	.1712
2	.2696	.2457	.3319	.3544	.3215	.2759	.2151	.2198	.2116
3	.3079	.3750	.6054	.4494	.4326	.3761	.3544	.3118	.3612
4	.4108	.4812	.6754	.5320	.5390	.5012	.5054	.3858	.3795
5	.2607	.5606	.6236	.5099	.5990	.6133	.5612	.4264	.3804
6	.2930	.3290	.6622	.6803	.6160	.6790	.6890	.3810	.3951
7	.3191	.5300	.5187	.7064	.5828	.6567	.8101	.6382	.2927
8	.3796	.4217	.5396	.7030	.5924	.7857	.8539	.9646	.6027
9	.3302	.3146	.4608	.4702	.1864	.5794	.2729	.3970	.3113
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6									
	.3181	.4365	.6416	.5429	.5467	.5424	.5275	.3762	.3790

AGE	1992
0	.2574
1	.1840
2	.2275
3	.1801
4	.3797
5	.4042
6	.4862
7	.4984
8	.4555
9	.4581
MEAN F (UNWEIGHTED) FOR AGES 3 TO 6	
	.3625

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

Continued

Table 4.3.1.f Continued

STOCK NUMBERS HERRING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	4007648.	6841518.	1169259.	1057303.	1720244.	1724782.	3943580.	5187954.	7391870.
2	1679906.	992951.	1677874.	429579.	408578.	675856.	711820.	1715542.	1905867.
3	811263.	432017.	195830.	324226.	249086.	257191.	406513.	358026.	783679.
4	238642.	224867.	73284.	34315.	90422.	169437.	172144.	208523.	190677.
5	92476.	74339.	52235.	12141.	18689.	67894.	128155.	110666.	129045.
6	38770.	25453.	10457.	12332.	4096.	15508.	55861.	89118.	65820.
7	10024.	10928.	5861.	2924.	6858.	3216.	12824.	44038.	50670.
8	3687.	4224.	1274.	1099.	1274.	6022.	2123.	10241.	21415.
9	1678.	2291.	1402.	1092.	3639.	9150.	50000.	4629.	30599.
TOTAL STOCK BIOMASS ON 1. JANUARY	326687.	258181.	184780.	92635.	99123.	142474.	215668.	305638.	401739.
SPAWNING STOCK BIOMASS ON 1. JANUARY	231978.	148529.	124188.	68026.	67142.	103021.	148592.	195776.	260149.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	12551854.	11577276.	11453743.	20157845.	25302618.	14478899.	9985310.	11622383.	11587775.
2	3086648.	5710587.	5878891.	4985261.	9741533.	10903980.	6084649.	3929626.	4996954.
3	1026287.	1587114.	3054929.	2787733.	2317484.	4668792.	5510762.	3382028.	2159359.
4	353755.	553495.	816067.	1227941.	1272828.	1116537.	2327949.	2945759.	1916313.
5	124760.	194175.	284207.	340708.	588673.	605682.	552380.	1169231.	1677649.
6	97427.	83210.	95900.	130911.	176128.	277306.	281374.	273498.	664223.
7	49502.	61925.	51601.	41946.	57007.	82158.	121071.	122234.	161599.
8	38290.	32554.	32981.	27795.	18727.	28800.	38549.	48731.	58427.
9	45626.	69834.	45010.	40033.	50004.	19005.	38165.	37921.	49834.
TOTAL STOCK BIOMASS ON 1. JANUARY	614487.	908414.	1137568.	1212695.	1632469.	1862190.	1721543.	1516568.	1465030.
SPAWNING STOCK BIOMASS ON 1. JANUARY	378211.	611018.	836984.	832459.	1058510.	1385858.	1432870.	1268052.	1187311.

AGE	1992
0	0.
1	5381950.
2	5752261.
3	2889343.
4	1162812.
5	1100837.
6	1000694.
7	392302.
8	109118.
9	67650.
TOTAL STOCK BIOMASS ON 1. JANUARY	1446494.
SPAWNING STOCK BIOMASS ON 1. JANUARY	1222285.

Continued

Table 4.3.1.f Continued

PREDATION MORTALITY HERRING

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.6954	.6108	.5196	.4619	.4106	.3561	.3792	.2517	.2385
1	.6005	.4503	.4693	.4272	.4664	.4323	.4492	.5149	.3412
2	.2166	.2017	.2075	.2003	.2358	.2226	.2247	.2972	.2030
3	.2694	.2274	.1933	.1897	.2051	.1973	.1727	.2299	.1948
4	.1122	.1038	.0860	.0797	.0905	.0770	.0681	.0910	.0699
5	.0730	.0684	.0572	.0517	.0582	.0504	.0439	.0581	.0415
6	.1613	.1496	.1024	.0831	.0862	.0762	.0908	.1092	.0640
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.1917	.1965	.1371	.1334	.1625	.1575	.1759	.1459	.1195
1	.3123	.2833	.3032	.2649	.3030	.3113	.2751	.3091	.2092
2	.1856	.1698	.2042	.2016	.2040	.1965	.1622	.1689	.1262
3	.1595	.1401	.1560	.1846	.1476	.1698	.1220	.1063	.1078
4	.0590	.0553	.0681	.0732	.0737	.0726	.0532	.0472	.0448
5	.0343	.0349	.0416	.0400	.0437	.0434	.0318	.0291	.0263
6	.0602	.0488	.0647	.0510	.0466	.0498	.0448	.0452	.0315
7	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

AGE	1992
0	.1253
1	.1882
2	.1131
3	.0839
4	.0350
5	.0196
6	.0261
7	.0000
8	.0000
9	.0000

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

Table 4.3.1.g SPRAT

FISHING MORTALITY SPRAT

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0096	.0029	.0269	.0093	.0034	.0047	.0092	.0106	.0035
1	.1456	.3294	.3684	.2656	.7007	.5431	.5201	.5868	.8401
2	.5547	.8653	.8158	.7731	.7731	1.0654	1.1501	1.7175	1.4656
3	.8082	1.5204	3.0991	.5625	2.3361	1.9583	1.9643	.8075	1.8569
4	2.8330	1.8613	2.5472	4.3794	1.4234	1.8015	1.9906	.4648	.5693
MEAN F (UNWEIGHTED) FOR AGES 1 TO 3									
	.5028	.9050	1.4278	.5338	1.2700	1.1889	1.2115	1.0373	1.3876

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.0040	.0071	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	1.1184	.4735	.3116	.0320	.0809	.7980	.6428	.7633	.4535
2	1.3199	1.8766	.7836	.2703	.1848	.3493	.3270	.9300	.4641
3	1.7546	2.2947	.7718	.5715	.2242	.2680	.3645	.7869	.5656
4	2.0327	2.2005	1.0542	.6994	.3371	.5749	.6652	1.1203	.6431
MEAN F (UNWEIGHTED) FOR AGES 1 TO 3									
	1.3976	1.5483	.6223	.2913	.1633	.4717	.4448	.8267	.4944

AGE	1992
0	.0000
1	.3163
2	.2487
3	.2229
4	.4031
MEAN F (UNWEIGHTED) FOR AGES 1 TO 3	
	.2626

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

STOCK NUMBERS SPRAT

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	239493751.	147798359.	208976203.	93626901.	106331651.	170469152.	81999359.	51282797.	27075423.
2	41405525.	81240918.	39096859.	56012207.	28006249.	20636022.	38158549.	17612340.	11136150.
3	3154286.	8203443.	11313273.	5564276.	8406373.	4051993.	2188321.	3240828.	849756.
4	393462.	514594.	641717.	165540.	1210717.	293692.	202279.	122959.	507329.
TOTAL STOCK BIOMASS ON 1. JANUARY									
	1039171.	1194658.	1069134.	795790.	669798.	696222.	568592.	333713.	187452.
SPAWNING STOCK BIOMASS ON 1. JANUARY									
	392538.	795603.	504898.	542998.	382702.	235955.	347194.	195249.	114349.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	13548159.	31496377.	11654732.	13620622.	56052841.	15793908.	16750685.	16707207.	54397517.
2	4973361.	1955024.	8514908.	3764196.	5592994.	21935013.	3024795.	3589350.	3310794.
3	886156.	497022.	113846.	1435544.	1048775.	1589959.	5126175.	708690.	460293.
4	54414.	63917.	25020.	26616.	512020.	437361.	601689.	1698030.	157417.
TOTAL STOCK BIOMASS ON 1. JANUARY									
	91697.	109923.	102737.	89953.	223959.	254337.	161788.	122114.	184211.
SPAWNING STOCK BIOMASS ON 1. JANUARY									
	55117.	24883.	71269.	53178.	72616.	211693.	116561.	77005.	37338.

AGE	1992
0	0.
1	73668891.
2	15980188.
3	835943.
4	176771.

TOTAL STOCK BIOMASS ON 1. JANUARY

Continued

Table 4.3.1.g Continued

345073.
SPAWNING STOCK BIOMASS ON 1. JANUARY
146167.

PREDATION MORTALITY SPRAT

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0906	.0956	.0881	.0894	.0924	.0938	.1187	.0660	.0594
1	.3255	.3905	.3383	.3313	.3288	.3438	.4081	.3304	.2444
2	.5042	.5462	.5739	.5636	.6002	.6187	.7560	.7540	.5055
3	.5685	.5578	.6302	.5575	.5807	.5887	.6299	.7818	.4468
4	.4278	.4270	.4752	.4976	.4797	.5033	.5397	.6780	.4945

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.0502	.0621	.0590	.0633	.0825	.0717	.0845	.0618	.0421
1	.2075	.2246	.2086	.2481	.2473	.2448	.2877	.2454	.1615
2	.4234	.4067	.4367	.4476	.5130	.5445	.5642	.5639	.3523
3	.4232	.3556	.4163	.3438	.4063	.4568	.3868	.4917	.2840
4	.3874	.3495	.3495	.3646	.3050	.4135	.3328	.3734	.2850

AGE	1992
0	.0397
1	.1676
2	.3096
3	.2412
4	.2217

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

Table 4.3.1.h NORWAY POUT

FISHING MORTALITY N. POUT

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0365	.0492	.0362	.0195	.0110	.0100	.0116	.2084	.0086
1	.8693	.6186	.5219	.4964	.4214	.4373	.5232	.4987	.4847
2	2.7814	1.1970	1.7485	.7230	1.1266	1.7048	1.6682	1.1197	1.6951
3	2.2484	.9807	.8720	1.7382	.7879	.8797	1.4294	.8854	.8697
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2	1.8253	.9078	1.1352	.6097	.7740	1.0711	1.0957	.8092	1.0899

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.0263	.0259	.0107	.0586	.0090	.0494	.0923	.0322	.0267
1	.4589	.6057	.5883	.5685	.4731	.3002	.4289	.4039	.3112
2	1.2419	2.0006	1.5846	1.5830	2.6972	1.6231	1.1525	.8669	1.4673
3	1.1095	1.1928	1.5993	.7304	.3001	1.8983	.2913	1.4347	.4035
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2	.8504	1.3032	1.0865	1.0758	1.5851	.9616	.7907	.6354	.8892

AGE	1992
0	.0116
1	.3027
2	.9933
3	1.1503
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2	.6480

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
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	190937464.	125546431.	154919667.	124485173.	62957669.	96904168.	114430581.	41773217.	121746621.
2	3626699.	10071438.	7737063.	11156709.	10812638.	5467364.	11041466.	12860619.	3163852.
3	624537.	43183.	565782.	233439.	1237037.	756197.	249176.	606272.	827720.
TOTAL STOCK BIOMASS ON 1. JANUARY	1563671.	1195667.	1385294.	1221421.	787775.	898355.	1142925.	649023.	1035338.
SPAWNING STOCK BIOMASS ON 1. JANUARY	257658.	336929.	325644.	369943.	357144.	235531.	360220.	363294.	202591.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	106924544.	83994608.	64594558.	43987073.	65410904.	18171039.	43891509.	37456376.	37817141.
2	12674878.	13532422.	8127706.	4349196.	2579835.	4845180.	1783866.	5420021.	4672692.
3	140834.	1014954.	434934.	276569.	130648.	30282.	222634.	146520.	666967.
TOTAL STOCK BIOMASS ON 1. JANUARY	1120204.	1003059.	702625.	449429.	564010.	254687.	385382.	419819.	426633.
SPAWNING STOCK BIOMASS ON 1. JANUARY	388840.	428536.	260799.	148557.	116600.	130397.	85164.	163617.	167964.

AGE	1992
0	0.
1	78407029.
2	5296818.
3	273915.
TOTAL STOCK BIOMASS ON 1. JANUARY	733462.
SPAWNING STOCK BIOMASS ON 1. JANUARY	197158.

Continued

Table 4.3.1.h Continued

PREDATION MORTALITY N. POUT

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.5953	.6371	.6176	.6420	.5608	.4777	.5770	.4689	.4407
1	1.3234	1.4185	1.3593	1.1976	1.2727	.9855	.9130	1.3318	1.0277
2	1.1013	1.1484	1.1628	.9610	1.0195	.8265	.7018	1.1129	.8873
3	.8291	.8124	.7850	.6364	.7195	.6162	.4671	.7568	.5999

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.3856	.5232	.7058	.6689	.6821	.5454	.4665	.4675	.3985
1	.8582	.9799	1.3599	1.5177	1.3796	1.2708	.9127	.9275	.9045
2	.7422	.8473	1.2535	1.5008	1.1456	1.0719	.7841	.8094	.8495
3	.5089	.5261	.7778	1.0068	.6881	.7560	.5610	.5258	.5740

AGE	1992
0	.2880
1	.6071
2	.5440
3	.3884

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

Table 4.3.1.i SANDEEL

FISHING MORTALITY SANDEEL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0114	.0153	.0162	.0306	.1066	.1026	.0752	.1147	.1673
1	.1730	.1393	.2218	.3180	.4411	.2380	.4981	.4102	.3656
2	.1627	.2857	.4990	.4266	.7089	.8950	.7735	.9040	.9049
3	.0708	.4247	.3269	.7493	.3695	.7141	1.0017	.5658	1.2845
4	.4056	.2063	.4882	.4175	.5040	.6199	.5945	.9633	1.4169
5	.4074	.4961	.1553	.7574	.2246	.8367	.4606	1.0879	.8766
6	.6761	.4944	.6472	.9363	.9183	.9203	1.1418	.9465	.9719
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2	.1679	.2125	.3604	.3723	.5750	.5665	.6358	.6571	.6353

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.0423	.0368	.0274	.0285	.0120	.0408	.0244	.0419	.0727
1	.2372	.5442	.3154	.1457	.3704	.3604	.9812	.4942	.7260
2	.8146	.2830	1.6075	.5538	.4918	1.3390	.2320	1.2534	.9598
3	.7313	1.7349	1.2651	.5621	.3493	.9058	1.0825	.8339	.6511
4	.4236	.6202	.6788	.2709	.1710	1.7345	.4684	.4457	.5004
5	.5607	.5623	1.7674	.1217	.1390	.8990	.2066	1.3652	.1991
6	.9255	1.1324	1.3110	.3377	.0300	.7771	.0278	.0384	.0000
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2	.5259	.4136	.9614	.3498	.4311	.8497	.6066	.8738	.8429

AGE	1992
0	.0235
1	.5665
2	.4896
3	.4959
4	.5277
5	.3342
6	.3451
MEAN F (UNWEIGHTED) FOR AGES 1 TO 2	.5280

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

STOCK NUMBERS SANDEEL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	576497555.	543953458.	337322359.	415356938.	426634556.	294592781.	282118204.	121782815.	371126743.
2	53890031.	49467767.	72322398.	41263288.	57435814.	63915622.	57417570.	45313489.	22121644.
3	17842825.	17123315.	14535297.	16911660.	10838318.	12234239.	11450284.	11279830.	7936897.
4	9004398.	8292767.	5300207.	5008671.	3927765.	3904093.	3168302.	2139770.	3378754.
5	1125504.	2252108.	2493021.	1242561.	1364293.	1085050.	1002789.	800659.	393348.
6	292019.	335660.	575369.	904751.	270800.	573093.	248410.	323267.	154055.
TOTAL STOCK BIOMASS ON 1. JANUARY	3263460.	3093153.	2423443.	2428449.	2510351.	2079415.	1931840.	1160080.	1865922.
SPAWNING STOCK BIOMASS ON 1. JANUARY	1015119.	971734.	1107886.	808557.	846476.	930504.	831579.	685127.	418527.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	102667889.	340611240.	83640952.	359418352.	197085101.	66330720.	244378361.	92395673.	205637247.
2	95372991.	27884020.	73939739.	23311576.	134781599.	60692865.	19338020.	39766828.	23913903.
3	4403635.	20931248.	10680287.	7603462.	7066051.	43580553.	8118021.	7870571.	5796168.
4	1234430.	1215151.	2147607.	1762635.	2577592.	2965954.	10294898.	1613021.	2021566.
5	429877.	436426.	361154.	617609.	789955.	1283032.	303160.	3735327.	600169.
6	104216.	157113.	158217.	61295.	822829.	540859.	753547.	336447.	1464116.
TOTAL STOCK BIOMASS ON 1. JANUARY	1447263.	1955745.	1273127.	1797309.	2294224.	1612124.	1496949.	993774.	1207265.
SPAWNING STOCK BIOMASS ON 1. JANUARY	1046858.	627361.	946927.	395577.	1525592.	1353434.	543873.	633431.	405280.

Continued

Table 4.3.1.i Continued

AGE	1992
0	0.
1	244926592.
2	46587011.
3	5025895.
4	1853490.
5	743326.
6	524017.

TOTAL STOCK BIOMASS ON 1. JANUARY
1555747.
SPAWNING STOCK BIOMASS ON 1. JANUARY
600533.

PREDATION MORTALITY SANDEEL

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.6510	.6515	.5461	.5422	.5586	.5503	.5995	.3428	.3438
1	1.7928	1.3886	1.3895	1.1707	.9678	.9075	.8408	.8055	.5031
2	.5338	.4892	.5042	.4604	.3878	.3747	.4039	.3881	.2592
3	.3054	.3581	.3486	.3207	.2617	.2471	.2857	.2497	.1864
4	.6203	.6357	.6025	.5231	.4226	.3795	.4211	.3705	.2848
5	.6977	.7420	.6874	.6112	.5142	.4641	.5463	.4413	.3542
6	.8025	.7285	.6619	.5847	.5204	.3982	.3942	.3575	.3057

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.3094	.4041	.3798	.4062	.4321	.3587	.3368	.2452	.2420
1	.5762	.4933	.4722	.3451	.3174	.3822	.3445	.3674	.2688
2	.2519	.2267	.2172	.1899	.1872	.2227	.2170	.2224	.1501
3	.1663	.1520	.1465	.1297	.1288	.1471	.1435	.1353	.0990
4	.2561	.2331	.2075	.1717	.1667	.1862	.1854	.1829	.1401
5	.3076	.2884	.2551	.2236	.2338	.2438	.2701	.2331	.1794
6	.2698	.2277	.1725	.1319	.1052	.1417	.1208	.1294	.1177

AGE	1992
0	.2735
1	.3112
2	.1549
3	.0961
4	.1424
5	.1843
6	.1320

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

Table 4.3.1.j PLAICE

FISHING MORTALITY PLAICE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0037	.0030	.0091	.0072	.0028	.0031	.0016	.0006	.0034
2	.0448	.0746	.1230	.2280	.1617	.1693	.1863	.1952	.1404
3	.4768	.1669	.2696	.2059	.3706	.4789	.6346	.5557	.6795
4	.6220	.4334	.3770	.3435	.3815	.4932	.5848	.5481	.6293
5	.5229	.5113	.3069	.5786	.4213	.6020	.4454	.5191	.5130
6	.3789	.5105	.3389	.3056	.4579	.6190	.4196	.3685	.4337
7	.2916	.3895	.3811	.3094	.2967	.5761	.3952	.3660	.3582
8	.3605	.3271	.3331	.3317	.2578	.3111	.3575	.3783	.3276
9	.3614	.3711	.2392	.3252	.2350	.3176	.1993	.3198	.3305
10	.3691	.3275	.2801	.2173	.2582	.3318	.2172	.2031	.3809
11	.4302	.2313	.3160	.2615	.1736	.3238	.1953	.2507	.2241
12	.3315	.4980	.1631	.3065	.1662	.2277	.3122	.2330	.2287
13	.3123	.2834	.5151	.1110	.2248	.2669	.1165	.3213	.2242
14	.2417	.3303	.1394	.4794	.0916	.3366	.1460	.1597	.3188
15	.4400	.4380	.3310	.2910	.2530	.3822	.2611	.3231	.3642
MEAN F (UNWEIGHTED) FOR AGES 3 TO 8	.4421	.3898	.3344	.3458	.3643	.5134	.4729	.4559	.4902

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0022	.0002	.0002	.0013	.0000	.0000	.0033	.0036	.0026
2	.1457	.1339	.1514	.1544	.0932	.0365	.0992	.1104	.1233
3	.5127	.5060	.4480	.5141	.4000	.3462	.2737	.3090	.3754
4	.7127	.4226	.6765	.5209	.6393	.4651	.4587	.5183	.6140
5	.5258	.5700	.4353	.6684	.6377	.7001	.5293	.6540	.6636
6	.4059	.4397	.4343	.5901	.5013	.6399	.5143	.5549	.6775
7	.3493	.3246	.3667	.4457	.4597	.5482	.4578	.4266	.6099
8	.3052	.3736	.2735	.3855	.2954	.4979	.3926	.3356	.4701
9	.2692	.2955	.2792	.3015	.2556	.4352	.2808	.3186	.3854
10	.3349	.2699	.2428	.3110	.2345	.3724	.3327	.2395	.3328
11	.3515	.2169	.1850	.2637	.1991	.2279	.2776	.2340	.2997
12	.3544	.2853	.2474	.2697	.1821	.3162	.1887	.2198	.2822
13	.2636	.1930	.2640	.2661	.1654	.2332	.1938	.1328	.2388
14	.1818	.1958	.2129	.3403	.1188	.2615	.1873	.1443	.1727
15	.4112	.3401	.3532	.4882	.3762	.6534	.7074	.4772	.6247
MEAN F (UNWEIGHTED) FOR AGES 3 TO 8	.4686	.4394	.4391	.5208	.4889	.5329	.4377	.4664	.5684

AGE	1992
0	.0000
1	.0042
2	.0824
3	.2826
4	.4957
5	.7550
6	.5756
7	.4769
8	.5205
9	.4934
10	.4571
11	.3337
12	.4257
13	.3883
14	.5956
15	1.7937
MEAN F (UNWEIGHTED) FOR AGES 3 TO 8	.5177

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

Continued

Table 4.3.1.j Continued

STOCK NUMBERS PLAICE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	453903.	337082.	325937.	472326.	431777.	442751.	658950.	421742.	1023781.
2	484500.	409177.	304076.	292251.	424331.	389606.	399371.	595316.	381368.
3	165497.	419193.	343623.	243301.	210529.	326623.	297613.	299945.	443154.
4	136695.	92960.	320986.	237444.	179182.	131503.	183075.	142758.	155691.
5	103318.	66402.	54533.	199225.	152384.	110712.	72662.	92306.	74671.
6	62131.	55417.	36033.	36305.	101070.	90475.	54870.	42117.	49701.
7	32848.	38489.	30096.	23232.	24199.	57852.	44085.	32634.	26363.
8	21952.	22205.	23592.	18602.	15427.	16276.	29424.	26869.	20478.
9	19820.	13851.	14487.	15299.	12080.	10787.	10789.	18620.	16655.
10	14097.	12495.	8647.	10320.	10001.	8641.	7104.	7999.	12236.
11	35944.	8819.	8149.	5913.	7514.	6990.	5611.	5173.	5907.
12	7046.	21153.	6332.	5376.	4119.	5715.	4575.	4176.	3643.
13	7996.	4576.	11632.	4867.	3580.	3156.	4118.	3030.	2994.
14	7223.	5294.	3119.	6288.	3941.	2587.	2187.	3317.	1988.
15	11024.	12334.	9833.	7586.	11845.	8506.	5516.	4957.	6889.
TOTAL STOCK BIOMASS ON 1. JANUARY									
	461893.	441454.	438348.	451618.	453919.	453389.	457630.	447417.	526313.
SPAWNING STOCK BIOMASS ON 1. JANUARY									
	324505.	297156.	315754.	320888.	320193.	306862.	281351.	286831.	278772.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	584806.	605360.	542513.	1360669.	562894.	565267.	404985.	474392.	610055.
2	923200.	528006.	547650.	490772.	1229600.	509328.	511474.	365253.	427722.
3	299863.	722073.	417901.	425929.	380545.	1013610.	444348.	419109.	295958.
4	203243.	162486.	393909.	241580.	230492.	230804.	648775.	305794.	278415.
5	75079.	90169.	96355.	181205.	129840.	110043.	131168.	371050.	164774.
6	40452.	40156.	46138.	56415.	84036.	62088.	49443.	69905.	174574.
7	29145.	24391.	23408.	27040.	28293.	46059.	29627.	26749.	36317.
8	16673.	18597.	15952.	14679.	15668.	16166.	24087.	16961.	15798.
9	13353.	11119.	11581.	10980.	9034.	10551.	8891.	14718.	10971.
10	10829.	9231.	7487.	7926.	7349.	6331.	6178.	6075.	9684.
11	7565.	7010.	6377.	5314.	5255.	5260.	3947.	4008.	4327.
12	4272.	4816.	5106.	4796.	3694.	3896.	3789.	2706.	2870.
13	2623.	2712.	3277.	3607.	3313.	2786.	2570.	2839.	1965.
14	2165.	1823.	2023.	2277.	2501.	2541.	1996.	1916.	2249.
15	3268.	4586.	3722.	3327.	3869.	3797.	3195.	3416.	2910.
TOTAL STOCK BIOMASS ON 1. JANUARY									
	536775.	556723.	551484.	656203.	660191.	667741.	630833.	602339.	565202.
SPAWNING STOCK BIOMASS ON 1. JANUARY									
	318951.	322137.	362687.	349358.	404849.	404303.	462950.	441847.	393631.

AGE	1992
0	0.
1	800332.
2	550569.
3	342122.
4	183970.
5	136329.
6	76782.
7	80228.
8	17856.
9	8933.
10	6752.
11	6282.
12	2901.
13	1959.
14	1400.
15	2016.
TOTAL STOCK BIOMASS ON 1. JANUARY	
	561825.
SPAWNING STOCK BIOMASS ON 1. JANUARY	
	343611.

Table 4.3.1.k SOLE

FISHING MORTALITY SOLE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0010	.0066	.0096	.0131	.0006	.0008	.0043	.0030	.0184
2	.1845	.2748	.1032	.2586	.2339	.2202	.1261	.2490	.2305
3	.5718	.5367	.5549	.5263	.5584	.6520	.5386	.5115	.6717
4	.5940	.6231	.4869	.5954	.4920	.6037	.5777	.5670	.5402
5	.4491	.4173	.4994	.4590	.4944	.4206	.5381	.5103	.5696
6	.4430	.4153	.3076	.3069	.4585	.4201	.3281	.5029	.5597
7	.3905	.2922	.3335	.1409	.4907	.3069	.5000	.3293	.4021
8	.2713	.3602	.3028	.2942	.3862	.3991	.3859	.3412	.3279
9	.1642	.3091	.2540	.2004	.2480	.2311	.2791	.3326	.3666
10	.2671	.1223	.1753	.1728	.2032	.2097	.0663	.2119	.3567
11	.3134	.1508	.1276	.1026	.2641	.2228	.3179	.1626	.2198
12	.0760	.3972	.0990	.0988	.1700	.1819	.0978	.1737	.1449
13	.0241	.0212	.4675	.0988	.1051	.1881	.1031	.2242	.3057
14	.2072	.0733	.0376	.5535	.0750	.0881	.0737	.0497	.0369
15	.3840	.3060	.2840	.3120	.4160	.4942	.3652	.5102	.4202
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8	.4149	.4171	.3698	.3688	.4449	.4318	.4278	.4302	.4717

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0028	.0028	.0021	.0024	.0013	.0000	.0012	.0065	.0035
2	.3075	.2849	.3025	.1415	.2328	.2243	.1257	.1517	.1339
3	.5949	.7092	.7178	.5939	.4938	.6302	.4822	.4093	.5585
4	.6736	.6724	.7484	.6450	.5913	.6846	.6230	.4585	.6531
5	.3127	.5813	.5831	.6347	.4694	.5547	.4058	.5117	.6928
6	.4014	.6557	.4345	.7209	.5047	.4924	.3771	.6108	.4081
7	.4117	.4129	.3409	.4850	.3899	.4461	.3037	.4358	.6454
8	.3844	.3583	.2886	.2695	.3159	.3709	.3021	.4290	.5494
9	.3136	.3247	.3437	.3218	.3455	.2772	.2971	.4514	.4722
10	.2791	.2961	.1766	.5819	.1858	.2038	.1740	.2492	.4743
11	.4783	.2837	.3580	.4760	.2846	.0697	.3508	.3396	.5164
12	.0582	.2666	.3972	.5597	.3141	.1958	.0882	.9504	.8732
13	.0332	.0662	.2451	.4452	.4015	.1285	.1432	.0848	.7302
14	.4277	.0660	.0869	.4198	.3222	.0739	.1025	.2515	.0601
15	.3191	.3431	.4052	.7814	.7114	.3912	.5512	1.0673	.5785
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8	.4409	.5250	.4880	.4986	.4283	.4862	.3742	.4295	.5202

AGE	1992
0	.0000
1	.0023
2	.2400
3	.6414
4	.6153
5	.5600
6	.4500
7	.5108
8	.4994
9	.5624
10	.5039
11	.4047
12	.7269
13	.7598
14	.6484
15	3.5533
MEAN F (UNWEIGHTED) FOR AGES 2 TO 8	.5024

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

Continued

Table 4.3.1.k Continued

STOCK NUMBERS SOLE

AGE	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	110510.	42055.	114328.	140529.	47857.	11802.	153873.	148884.	152993.
2	95491.	99898.	37803.	102463.	125502.	43277.	10670.	138627.	134315.
3	51721.	71849.	68670.	30853.	71583.	89872.	31418.	8511.	97787.
4	12810.	26420.	38012.	35675.	16494.	37057.	42369.	16590.	4617.
5	20408.	6400.	12820.	21136.	17798.	9125.	18335.	21514.	8515.
6	5619.	11785.	3815.	7040.	12085.	9823.	5422.	9686.	11686.
7	5127.	3265.	7039.	2538.	4687.	6914.	5839.	3534.	5300.
8	2896.	3140.	2206.	4563.	1994.	2596.	4602.	3205.	2300.
9	2770.	1998.	1982.	1474.	3076.	1226.	1576.	2831.	2061.
10	2717.	2127.	1327.	1391.	1092.	2172.	881.	1079.	1837.
11	9189.	1882.	1703.	1008.	1059.	806.	1594.	746.	790.
12	1487.	6078.	1465.	1356.	823.	736.	584.	1049.	574.
13	1407.	1247.	3697.	1200.	1112.	628.	555.	479.	798.
14	1705.	1243.	1105.	2096.	984.	906.	471.	453.	346.
15	4602.	3757.	3278.	2851.	2705.	1844.	2017.	867.	962.
TOTAL STOCK BIOMASS ON 1. JANUARY	60838.	58456.	53678.	57640.	58784.	50295.	44566.	51559.	61771.
SPAWNING STOCK BIOMASS ON 1. JANUARY	41943.	42368.	42669.	36269.	38821.	43646.	35379.	24707.	35318.

AGE	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	143681.	71569.	82116.	162917.	75965.	450405.	100577.	137157.	36897.
2	135917.	129640.	64578.	74145.	147061.	68649.	407534.	90897.	123300.
3	96518.	90423.	88220.	43180.	58240.	105426.	49637.	325192.	70670.
4	45201.	48176.	40256.	38942.	21574.	32163.	50794.	27730.	195420.
5	2434.	20853.	22254.	17234.	18487.	10807.	14676.	24649.	15864.
6	4359.	1611.	10551.	11239.	8266.	10461.	5615.	8851.	13370.
7	6042.	2640.	757.	6182.	4946.	4515.	5785.	3485.	4348.
8	3208.	3622.	1581.	487.	3444.	3030.	2615.	3864.	2039.
9	1499.	1976.	2290.	1072.	336.	2272.	1892.	1749.	2276.
10	1293.	992.	1292.	1469.	703.	216.	1558.	1272.	1008.
11	1164.	885.	667.	980.	743.	528.	159.	1185.	897.
12	574.	653.	603.	422.	551.	506.	446.	101.	763.
13	449.	490.	452.	367.	218.	364.	376.	369.	35.
14	532.	393.	415.	320.	213.	132.	290.	295.	307.
15	882.	877.	839.	587.	343.	359.	232.	344.	421.
TOTAL STOCK BIOMASS ON 1. JANUARY	67411.	66267.	57529.	53658.	56696.	74689.	98868.	107813.	101591.
SPAWNING STOCK BIOMASS ON 1. JANUARY	41199.	44539.	44382.	35132.	32309.	42558.	36785.	88229.	82484.

AGE	1992
0	0.
1	423074.
2	33268.
3	97586.
4	36581.
5	92027.
6	7179.
7	8044.
8	2063.
9	1065.
10	1285.
11	567.
12	484.
13	288.
14	15.
15	268.
TOTAL STOCK BIOMASS ON 1. JANUARY	95378.
SPAWNING STOCK BIOMASS ON 1. JANUARY	69567.

Table 4.3.2 Total average mortality (Z) 1981-1991. Total mortality split into fishing mortality (F) and natural mortality. Non-fishing mortality further subdivided into predation mortality by MSVPA predators (M2), mortality due to "OTHER" predators, and all other mortality (M1). 0-group mortalities expressed on a half yearly basis.

		Res. M	Oth. pred.	M2	t. Nat. Mo	F	Z
Cod	0	0.1	0.36	0.518	0.978	0	0.978
	1	0.2	0.28	0.206	0.686	0.196	0.882
	2	0.2	0.07	0.076	0.346	0.918	1.264
	3	0.2		0.036	0.236	0.996	1.232
	4	0.2		0.004	0.204	0.93	1.134
	5	0.2			0.2	0.787	0.987
	6	0.2			0.2	0.835	1.035
	7	0.2			0.2	0.849	1.049
	8	0.2			0.2	0.801	1.001
	9	0.2			0.2	0.819	1.019
	10	0.2			0.2	0.907	1.107
	11	0.2			0.2	0.649	0.849
Whiting	0	0.1	0.28	0.896	1.276	0.085	1.361
	1	0.2	0.36	0.386	0.946	0.273	1.219
	2	0.2	0.12	0.096	0.416	0.513	0.929
	3	0.2	0.08	0.058	0.338	0.771	1.109
	4	0.2	0.03	0.055	0.285	1.098	1.383
	5	0.2	0.01	0.036	0.246	1.28	1.526
	6	0.2		0.051	0.251	1.354	1.605
	7	0.2			0.2	1.395	1.595
	8	0.2			0.2	2.094	2.294
	9	0.2			0.2	2.006	2.206
	10	0.2			0.2	1.596	1.796
Saithe	0	0.1			0.1	0	0.1
	1	0.2			0.2	0.011	0.211
	2	0.2			0.2	0.109	0.309
	3	0.2			0.2	0.351	0.551
	4	0.2			0.2	0.806	1.006
	5	0.2			0.2	0.919	1.119
	6	0.2			0.2	0.762	0.962
	7	0.2			0.2	0.607	0.807
	8	0.2			0.2	0.565	0.765
	9	0.2			0.2	0.59	0.79
	10	0.2			0.2	0.473	0.673
	11	0.2			0.2	0.466	0.666
	12	0.2			0.2	0.515	0.715
	13	0.2			0.2	0.312	0.512
	14	0.2			0.2	0.322	0.522
	15	0.2			0.2	0.466	0.666

Continued

Table 4.3.2 Continued

		Res. M	Oth. pred.	M2	t. Nat. Mo	F	Z
Haddock	0	0.1	0.52	1.093	1.713	0.014	1.727
	1	0.2	0.52	0.481	1.201	0.242	1.443
	2	0.2	0.11	0.04	0.35	0.961	1.311
	3	0.2	0.03	0.021	0.251	1.2	1.451
	4	0.2		0.009	0.209	1.169	1.378
	5	0.2		0.004	0.204	0.947	1.151
	6	0.2		0.004	0.204	0.777	0.981
	7	0.2			0.2	0.731	0.931
	8	0.2			0.2	0.739	0.939
	9	0.2			0.2	0.704	0.904
	10	0.2			0.2	0.751	0.951
	11	0.2			0.2	0.93	1.13
Mackerel	0	0.075			0.075	0	0.075
	1	0.15			0.15	0.048	0.198
	2	0.15				0.256	0.256
	3	0.15				0.29	0.29
	4	0.15				0.326	0.326
	5	0.15				0.318	0.318
	6	0.15				0.222	0.222
	7	0.15				0.3	0.3
	8	0.15				0.219	0.219
	9	0.15				0.253	0.253
	10	0.15				0.334	0.334
	11	0.15				0.248	0.248
	12	0.15				0.271	0.271
	13	0.15				0.172	0.172
	14	0.15				0.196	0.196
	15	0.15				0.289	0.289
Herring	0	0.05	0.17	0.149	0.369	0.101	0.47
	1	0.1	0.22	0.279	0.599	0.22	0.819
	2	0.1	0.11	0.177	0.387	0.266	0.653
	3	0.1	0.05	0.14	0.29	0.381	0.671
	4	0.1	0.03	0.061	0.191	0.474	0.665
	5	0.1	0.01	0.036	0.146	0.515	0.661
	6	0.1		0.045	0.145	0.573	0.718
	7	0.1			0.1	0.614	0.714
	8	0.1			0.1	0.75	0.85
	9	0.1			0.1	0.37	0.47
Sprat	0	0.1	0.22	0.068	0.388	0	0.388
	1	0.2	0.41	0.239	0.849	0.462	1.311
	2	0.2	0.36	0.498	1.058	0.421	1.479
	3	0.2	0.3	0.395	0.895	0.463	1.358
	4	0.2	0.26	0.346	0.806	0.673	1.479
Norway pout	0	0.1	0.3	0.538	0.938	0.045	0.983
	1	0.2	0.55	1.152	1.902	0.141	2.043
	2	0.2	0.44	1.027	1.667	1.565	3.232
	3	0.2	0.34	0.685	1.225	0.843	2.068
Sandeel	0	0.1	0.16	0.337	0.597	0.037	0.634
	1	0.2	0.29	0.338	0.828	0.513	1.341
	2	0.2	0.25	0.198	0.648	0.805	1.453
	3	0.2	0.19	0.131	0.521	0.731	1.252
	4	0.2	0.16	0.172	0.532	0.598	1.13
	5	0.2	0.14	0.231	0.571	0.488	1.059
	6	0.2	0.11	0.124	0.434	0.202	0.636

Table 4.3.3a Total biomass consumed by all predators, compared to average stock biomass, total predator biomass and total yield in terms of biomass (1000 t), when all stomach data are used (keyrun). Second and third figure refers to deviation in percent of results from runs with 1981 or 1991 stomach data only.

Year	Average biomass	81	91	Total yield	Total VPA species eaten (TMSE)	81	91	Total oth. food eaten (TOFE)	81	91	Average predator biomass (APDB)	81	91
1974	9537	-16	-5	3158	6286	-2	-11	7969	-15	17	3391	-12	2
1975	8970	-15	-4	3272	5446	-6	-9	7400	-4	4	3531	-15	5
1976	7714	-12	-4	3277	4600	-3	-11	6129	-2	3	2967	-4	-2
1977	6643	-10	-5	2635	3846	2	-15	5251	-8	2	2292	-3	-3
1978	6218	-9	-4	2668	3299	8	-17	4702	-13	6	2095	-5	-4
1979	6239	-9	-5	2577	3137	7	-21	4850	-14	8	2014	-4	-3
1980	5645	-10	-5	2740	2611	-3	-24	4823	-8	-1	2191	-6	-2
1981	5181	-9	-3	2558	2437	3	-19	4214	-13	8	2060	-4	-5
1982	5783	-8	-1	2540	2243	-3	-10	3549	-9	1	1854	-5	-2
1983	5794	-5	-2	2511	2072	5	-14	3541	-21	10	1648	-5	-2
1984	6035	-5	-1	2770	1927	8	-13	3536	-18	4	1727	-14	2
1985	5421	-6	-2	2700	1973	16	-16	3414	-20	9	1675	-9	-1
1986	6664	-6	-2	2151	2066	13	-16	3457	-18	8	1564	-10	-1
1987	7009	-4	-1	2614	1559	5	-12	2716	-7	-1	1478	-11	0
1988	5869	-4	-2	2765	1337	12	-18	2381	-10	4	1248	-1	-3
1989	5383	-5	-1	2554	1119	-3	-11	2031	-6	-2	1049	-2	-4
1990	4857	-6	-1	2090	1066	1	-9	2065	-13	4	940	-3	-4
1991	5438	-5	0	2255	1191	4	-11	2308	-13	9	903	-8	1
1992	6355	-2	0	2255	1345	5	-16	3778	-3	7	1025	-6	2

Table 4.3.3b

Year	Yield/ av. biom.	81	91	TMSE/ av. biom.	81	91	TOFE/ av. biom.	81	91	TMSE/ APDB	81	91	TMSE/ Yield	81	91
1974	0.33	19	5	0.66	16	-6	0.84	1	23	1.85	11	-13	1.99	-2	-11
1975	0.36	18	4	0.61	11	-6	0.83	14	8	1.54	11	-14	1.66	-6	-9
1976	0.42	13	5	0.60	10	-6	0.79	11	8	1.55	1	-9	1.40	-3	-11
1977	0.40	11	5	0.58	13	-11	0.79	1	7	1.68	6	-12	1.46	2	-15
1978	0.43	10	5	0.53	19	-14	0.76	-4	11	1.57	14	-14	1.24	8	-17
1979	0.41	10	5	0.50	18	-17	0.78	-6	14	1.56	12	-19	1.22	7	-21
1980	0.49	11	5	0.46	7	-20	0.85	2	4	1.19	3	-22	0.95	-3	-24
1981	0.49	10	4	0.47	14	-16	0.81	-5	12	1.18	7	-14	0.95	3	-19
1982	0.44	8	1	0.39	5	-9	0.61	-1	2	1.21	3	-8	0.88	-3	-10
1983	0.43	5	2	0.36	11	-12	0.61	-17	13	1.26	10	-12	0.83	5	-14
1984	0.46	6	1	0.32	14	-12	0.59	-13	6	1.12	25	-14	0.70	8	-13
1985	0.50	7	2	0.36	24	-14	0.63	-15	12	1.18	27	-15	0.73	16	-16
1986	0.32	6	2	0.31	20	-14	0.52	-13	10	1.32	26	-15	0.96	13	-16
1987	0.37	4	1	0.22	9	-11	0.39	-3	0	1.06	18	-12	0.60	5	-12
1988	0.47	4	2	0.23	17	-16	0.41	-6	6	1.07	14	-15	0.48	12	-18
1989	0.47	5	1	0.21	2	-10	0.38	-1	-1	1.07	-1	-7	0.44	-3	-11
1990	0.43	6	1	0.22	7	-9	0.43	-8	5	1.13	4	-6	0.51	1	-9
1991	0.41	5	0	0.22	9	-11	0.42	-8	9	1.32	12	-12	0.53	4	-11
1992	0.35	2	0	0.21	7	-16	0.59	-1	7	1.31	12	-18	0.60	5	-16

Table 4.4.1 Total Biomasses consumed by predators, compared to average stock biomass of predator, for Western Mackerel stock.

PREDATOR W_MACKEREL

PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING	SPRAT	N. POUT	SANDEEL
1974	678.	0.	0.	0.	53924.	1644.	221.	407664.	651778.
1975	652.	0.	0.	0.	11567.	500.	617.	1061084.	1003165.
1976	501.	0.	0.	0.	3733.	148.	65.	195924.	190355.
1977	100.	0.	0.	0.	2490.	203.	25.	67336.	64304.
1978	213.	0.	0.	0.	6318.	220.	82.	113814.	102268.
1979	857.	0.	0.	0.	20488.	857.	86.	291343.	253717.
1980	530.	0.	0.	0.	9770.	2126.	79.	266938.	291083.
1981	567.	0.	0.	0.	12150.	3189.	31.	486867.	377609.
1982	371.	0.	0.	0.	8537.	23223.	2951.	567477.	331248.
1983	670.	0.	0.	0.	25041.	22751.	1713.	535652.	512666.
1984	226.	0.	0.	0.	13982.	13775.	1158.	585251.	400047.
1985	598.	0.	0.	0.	14766.	55029.	4058.	313728.	537344.
1986	229.	0.	0.	0.	21549.	114920.	6979.	528502.	432501.
1987	283.	0.	0.	0.	3513.	42154.	7867.	425433.	294979.
1988	219.	0.	0.	0.	2675.	34914.	5108.	378424.	307946.
1989	106.	0.	0.	0.	2387.	38616.	2908.	387590.	220531.
1990	196.	0.	0.	0.	11099.	31520.	3557.	558433.	417330.
1991	360.	0.	0.	0.	10300.	18933.	14545.	561656.	359798.
1992	186.	0.	0.	0.	39830.	61524.	13299.	364826.	308310.

PREDATOR W_MACKEREL

PREY	PLAICE	SOLE	TOTAL	OTH. FOOD	AV.BIOM.
1974	0.	0.	1115909.	1390734.	442769.
1975	0.	0.	2077584.	2714150.	841922.
1976	0.	0.	390726.	674363.	195792.
1977	0.	0.	134459.	301874.	89983.
1978	0.	0.	222914.	519030.	141257.
1979	0.	0.	567347.	1073650.	305261.
1980	0.	0.	570525.	2033406.	491198.
1981	0.	0.	880414.	1779266.	513514.
1982	0.	0.	933806.	2861799.	697052.
1983	0.	0.	1098494.	3109695.	778934.
1984	0.	0.	1014440.	3379139.	837532.
1985	0.	0.	925523.	3856459.	849438.
1986	0.	0.	1104679.	4403981.	1033217.
1987	0.	0.	774230.	4652948.	1072346.
1988	0.	0.	729287.	4057478.	921879.
1989	0.	0.	652137.	3781730.	854968.
1990	0.	0.	1022134.	4405044.	1072346.
1991	0.	0.	965592.	3821174.	921879.
1992	0.	0.	787975.	3645893.	854968.

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

YEAR	MSVPA SPECIES						OTHER PREDATORS		
	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	10120473.	9724282.	3157578.	6142107.	4562431.	8336000.	442769.	1115909.	1390734.
1975	9845996.	9280808.	3272390.	5405429.	4320782.	7513462.	841922.	2077584.	2714150.
1976	8558841.	7808917.	3276641.	4408573.	3519112.	6400067.	195792.	390726.	674363.
1977	7365143.	6691459.	2634517.	3673955.	3029056.	5520020.	89983.	134459.	301874.
1978	6687470.	6267144.	2667601.	3170237.	2888252.	4942071.	141257.	222914.	519030.
1979	6356185.	6408124.	2577154.	3065793.	3112275.	5027087.	305261.	567347.	1073650.
1980	6744874.	5817838.	2740116.	2573834.	2662506.	4908579.	491198.	570525.	2033406.
1981	5089200.	5421223.	2558072.	2395558.	2390943.	4311292.	513514.	880414.	1779266.
1982	6171740.	6067095.	2539891.	2213494.	2716410.	3605349.	697052.	933806.	2861799.
1983	5679182.	6144986.	2510925.	2072912.	2723373.	3584109.	778934.	1098494.	3109695.
1984	6620689.	6314606.	2769585.	1929783.	2656103.	3560431.	837532.	1014440.	3379139.
1985	5594168.	5645048.	2699711.	1955562.	2151669.	3472038.	849438.	925523.	3856459.
1986	5991207.	6982600.	2150906.	2070740.	2858586.	3455068.	1033217.	1104679.	4403981.
1987	7138423.	7256407.	2613730.	1592706.	2767202.	2675204.	1072346.	774230.	4652948.
1988	6037529.	6080022.	2765214.	1346272.	2046252.	2370793.	921879.	729287.	4057478.
1989	5699963.	5617929.	2553965.	1131037.	1932026.	2013173.	854968.	652137.	3781730.
1990	4853203.	5178662.	2090187.	1100643.	1809010.	2029350.	1072346.	1022134.	4405044.
1991	5040357.	5759269.	2254693.	1200133.	2241987.	2312321.	921879.	965592.	3821174.
1992	5954924.	6500369.	2254968.	1314697.	2729506.	3884807.	854968.	787975.	3645893.

Continued

Table 4.4.1 Continued

Mortality of 0-group is for 3rd and 4th quarter only
1 NORTH SEA DATA 1974 - 1992 (MULTISPECIES WORKING GROUP 1993)
WITH STOMACH CONTENT DATA FOR COD, WHITING, MACKEREL,SAITHE AND HADDOCK

MULTISPECIES VPA

BIOMASS OF OTHER FOOD ASSUMED TO REMAIN CONSTANT

COD MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1986 - 1991

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.00000	589170.	223352.	.58971
1	.19653	227470.	38289.	.20378
2	.91831	91487.	4846.	.07534
3	.99657	33393.	686.	.03546
4	.93026	8970.	23.	.00432
5	.78699	3477.	0.	.00000
6	.83457	1343.	0.	.00000
7	.84854	553.	0.	.00000
8	.80113	229.	0.	.00000
9	.81894	84.	0.	.00000
10	.90669	37.	0.	.00000
11	.64938	28.	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 : 1986 - 1991

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.08534	9540870.	4872920.	.88308
1	.27350	2745279.	746510.	.38284
2	.51360	837798.	61323.	.09552
3	.77167	354660.	15321.	.05735
4	1.09828	105748.	3661.	.05508
5	1.27984	27938.	581.	.03583
6	1.35457	5748.	155.	.05015
7	1.39510	1848.	0.	.00000
8	2.09393	491.	0.	.00000
9	2.00570	67.	0.	.00000
10	1.59567	14.	0.	.00000

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

HADDOCK MEAN VALUES OVER YEARS BY AGE GROUP
RANGE OF YEARS : 1986 - 1991

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.01439	11389367.	6555700.	1.16690
1	.24252	1717479.	553951.	.47018
2	.96137	399543.	11790.	.03926
3	1.20050	195796.	2230.	.02081
4	1.16931	50069.	315.	.00920
5	.94652	15504.	38.	.00360
6	.77749	3956.	12.	.00352
7	.73137	1946.	0.	.00000
8	.73910	773.	0.	.00000
9	.70417	254.	0.	.00000
10	.75105	115.	0.	.00000
11	.93007	114.	0.	.00000

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

Continued

Table 4.4.1 Continued

HERRING MEAN VALUES OVER YEARS BY AGE GROUP

RANGE OF YEARS : 1986 - 1991

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.09016	25671359.	7308507.	.38190
1	.22152	15361516.	3187608.	.27251
2	.26757	6730899.	992423.	.17318
3	.38208	3455875.	381661.	.13649
4	.47489	1796507.	75364.	.05851
5	.51593	821121.	18184.	.03407
6	.57374	300247.	8139.	.04334
7	.61446	97669.	0.	.00000
8	.75037	36838.	0.	.00000
9	.36951	39160.	0.	.00000

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

SPRAT MEAN VALUES OVER YEARS BY AGE GROUP

RANGE OF YEARS : 1986 - 1991

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.00000	59347583.	3306012.	.07480
1	.45900	29995944.	5469955.	.27923
2	.42134	6854809.	2163681.	.50254
3	.46621	1712048.	436018.	.38956
4	.67385	568166.	139671.	.33945

*) 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 : 1986 - 1991

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.03171	216838341.	106375456.	.93756
1	.31670	50131217.	25372164.	1.46708
2	1.58094	3886578.	1674065.	1.00930
3	.84457	243706.	92091.	.67525

*) 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 : 1986 - 1991

AGE	MEAN F	MEAN N *)	MEAN D	MEAN M2
0	.02685	535382936.	248241076.	.72383
1	.49771	220163475.	64525281.	.48938
2	.80621	50187989.	4997599.	.19681
3	.73345	13303566.	819142.	.12908
4	.60225	3521512.	307830.	.16855
5	.49211	1215588.	112938.	.22642
6	.20207	661608.	58172.	.12183

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

Table 6.6.1 ANOVA of 1981 and 1991 estimates of suitability.

cause	Sum Of Squares and % of Total Variance Explained				
	cod	whiting	saithe	mackerel	haddock
mean	120.16 100%	96.41 100%	90.81 100%	119.18 100%	118.34 100%
" + basic model"	49.00 41%	42.10 44%	69.40 76%	60.12 50%	40.81 34%
" + predator size	11.30 9%	11.90 12%	0.70 1%	5.70 5%	29.50 25%
" + skewness of size preference	0.03 0%	0.10 0%	0.00 0%	0.00 0%	0.00 0%
" + scalings nested under year.	5.00 4%	7.90 8%	3.40 4%	4.30 4%	11.80 10%
" + years.size suitability nested under year.	0.90 1%	2.20 2%	1.50 2%	1.20 1%	0.40 0%
Residual	53.93	32.37	15.85	47.79	35.77

cause	Degrees of Freedom				
	cod	whiting	saithe	mackerel	haddock
mean	1518	962	748	614	557
" + basic model"	29	28	25	17	18
" + predator size	1	1	1	1	1
" + skewness of size preference	1	1	1	1	1
" + scalings nested under year.	28	25	19	13	12
" + years.size suitability nested under year.	4	4	4	4	4
Residual	1455	903	698	578	521

cause	Mean Squares				
	cod	whiting	saithe	mackerel	haddock
mean	0.08	0.10	0.12	0.19	0.21
" + basic model"	1.69	1.50	2.78	3.54	2.27
" + predator size	11.30	11.90	0.70	5.70	29.50
" + skewness of size preference	0.03	0.10	0.00	0.00	0.00
" + scalings nested under year.	0.18	0.32	0.18	0.33	0.98
" + years.size suitability nested under year.	0.23	0.55	0.38	0.30	0.10
Residual	0.04	0.04	0.02	0.08	0.07

cause	F ratio and P levels				
	cod	whiting	saithe	mackerel	haddock
mean					
" + basic model"	45.59 0.000	41.94 0.000	122.25 0.000	42.77 0.000	33.02 0.000
" + predator size	304.87 0.000	331.96 0.000	30.83 0.000	68.94 0.000	429.68 0.000
" + skewness of size preference	0.81 0.368	2.79 0.095	0.00 1.000	0.00 1.000	0.00 1.000
" + scalings nested under year.	4.82 0.000	8.82 0.000	7.88 0.000	4.00 0.000	14.32 0.000
" + years.size suitability nested under year.	6.07 0.000	15.34 0.000	16.51 0.000	3.63 0.006	1.46 0.214
Residual	1.00	1.00	1.00	1.00	1.00

Table 6.6.2 Canonical Parameter Estimates of fit of Suits from 1981 and 1991 stomach samples. Note that comparisons of mackerel and haddock are not possible due to the extreme forms of size preference the model has fitted.

	cod 1981 estimate	cod 1981 s.e.	cod 1991 estimate	cod 1991 s.e.	whiting 1981 estimate	whiting 1981 s.e.	whiting 1991 estimate	whiting 1991 s.e.	saithe 1981 estimate	saithe 1981 s.e.	saithe 1991 estimate	saithe 1991 s.e.	mackerel 1981 estimate	mackerel 1981 s.e.	mackerel 1991 estimate	mackerel 1991 s.e.	haddock 1981 estimate	haddock 1981 s.e.	haddock 1991 estimate	haddock 1991 s.e.
Size Preference terms																				
μ	4.30	0.37	4.14	0.38	3.97	0.40	3.52	0.33	5.03	0.46	4.43	0.46	5.45		7.68		22.28		11.41	
σ2	1.40	0.06	1.75	0.08	0.87	0.04	1.16	0.06	0.84	0.04	0.92	0.04	1.59		1.90		3.69		2.20	
Prefered prey ratio	73.68	27.12	62.82	23.61	53.19	21.18	33.62	11.19	153.50	69.95	84.12	38.50	233.82	0.37	2167.13	0.44	4755695054.47	0.41	90018.19	0.34
ω (power)	-0.47	0.04	-0.59	0.04	-0.77	0.04	0.81	0.04	0.52	0.04	-0.49	0.04	1.23	0.21	-0.99	0.15	-1.33	0.10	1.62	0.09
correction	7.69	1.36	6.09	1.14	9.93	2.05	6.32	1.24	15.88	2.96	11.60	2.46	10.51		16.74		68.92		30.85	
Prey * Quarter																				
cod * 1	0.70	0.32	0.54	0.23	0.03	0.03	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased
cod * 2	1.61	0.69	1.80	0.61	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased
cod * 3	0.91	0.40	1.04	0.37	0.00	0.01	0.16	0.07	0.98	1.05	0.00	aliased	10.19	7.16	1936.94	1588.29	0.00	aliased	0.00	aliased
cod * 4	0.38	0.19	0.48	0.20	0.07	0.05	0.09	0.04	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased
whiting * 1	0.54	0.23	0.88	0.28	0.46	0.32	0.35	0.15	0.07	0.10	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased
whiting * 2	0.28	0.13	0.58	0.19	0.34	0.24	0.14	0.06	0.18	0.21	0.01	0.02	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased
whiting * 3	0.25	0.11	0.23	0.08	0.31	0.22	0.12	0.05	0.08	0.10	0.45	0.38	0.00	aliased	154.29	194.41	#############	########	0.00	aliased
whiting * 4	0.25	0.12	0.86	0.27	0.15	0.11	0.12	0.05	0.05	0.07	0.11	0.10	0.00	aliased	0.00	aliased	#############	########	0.00	aliased
haddock * 1	0.32	0.15	0.35	0.14	0.19	0.13	0.10	0.05	0.89	0.97	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased
haddock * 2	0.40	0.18	0.13	0.07	0.17	0.13	0.00	aliased	0.98	1.08	0.06	0.07	0.00	aliased	0.00	aliased	0.00	aliased	0.00	aliased
haddock * 3	0.31	0.14	0.06	0.03	0.14	0.10	0.11	0.05	0.81	0.87	0.37	0.33	0.00	aliased	0.00	aliased	#############	########	########	########
haddock * 4	0.48	0.21	0.52	0.18	0.21	0.15	0.22	0.09	0.36	0.41	0.50	0.46	0.00	aliased	0.00	aliased	#############	########	########	########
herring * 1	0.18	0.09	0.06	0.03	0.23	0.17	0.01	0.01	0.04	0.05	0.25	0.21	18.76	15.25	0.00	aliased	#############	########	########	########
herring * 2	0.07	0.04	0.07	0.04	0.06	0.05	0.00	0.01	0.04	0.05	0.10	0.10	4.58	4.72	419.42	851.42	0.00	aliased	0.00	aliased
herring * 3	0.38	0.17	0.46	0.16	0.14	0.10	0.09	0.04	0.01	0.01	0.08	0.08	3.57	2.78	1272.66	1154.30	0.00	aliased	0.00	aliased
herring * 4	0.13	0.06	0.06	0.03	0.06	0.05	0.04	0.02	0.03	0.04	0.25	0.22	33.17	22.06	7397.26	6043.56	#############	########	########	########
sprat * 1	0.31	0.14	0.21	0.08	0.10	0.07	0.09	0.04	0.02	0.03'	0.00	aliased	0.00	aliased	0.00	aliased	#############	########	0.00	aliased
sprat * 2	0.08	0.05	0.04	0.03	0.02	0.02	0.09	0.04	0.00	aliased	0.00	aliased	0.30	0.39	3161.70	2655.83	0.00	aliased	########	########
sprat * 3	0.01	0.01	0.19	0.08	0.07	0.05	0.04	0.02	0.00	0.01	0.00	0.00	0.61	0.53	28.19	45.38	#############	########	0.00	aliased
sprat * 4	0.06	0.03	0.02	0.01	0.11	0.08	0.02	0.01	0.08	0.09	0.00	aliased	2.25	1.87	1449.34	1265.27	0.00	aliased	0.00	aliased
n. pout * 1	0.04	0.03	0.08	0.04	0.11	0.08	0.06	0.03	0.98	1.07	0.91	0.83	0.00	aliased	0.00	aliased	#############	########	########	########
n. pout * 2	0.03	0.02	0.11	0.05	0.13	0.09	0.05	0.02	1.09	1.18	1.35	1.21	0.00	aliased	28.19	100.06	#############	########	########	########
n. pout * 3	0.11	0.06	0.06	0.03	0.01	0.01	0.03	0.01	0.60	0.64	0.67	0.60	0.50	0.52	625.70	514.32	#############	########	########	########
n. pout * 4	0.13	0.06	0.09	0.04	0.01	0.01	0.10	0.04	1.09	1.17	0.55	0.49	12.33	8.48	3323.80	2758.76	#############	########	########	########
sandeel * 1	0.04	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.03	0.00	0.00	6.83	4.88	3037.73	2454.48	#############	########	########	########
sandeel * 2	0.21	0.10	0.11	0.04	0.11	0.08	0.09	0.04	0.01	0.01	0.02	0.02	11.49	7.94	2183.89	1786.42	#############	########	########	########
sandeel * 3	0.01	0.01	0.01	0.01	0.02	0.01	0.05	0.02	0.07	0.08	0.00	0.00	7.04	4.61	971.52	744.19	#############	########	########	########
sandeel * 4	0.13	0.06	0.00	0.00	0.02	0.02	0.07	0.03	0.01	0.02	0.00	0.00	0.75	0.64	512.28	469.25	#############	########	########	########
sum 1	2.13		2.14		1.15		0.63		2.03		1.15		25.59		3037.73		#############		########	
sum 2	2.69		2.84		0.83		0.37		2.30		1.55		16.38		5793.19		#############		########	
sum 3	1.98		2.05		0.69		0.61		2.55		1.57		21.92		4989.30		#############		########	
sum 4	1.56		2.02		0.64		0.65		1.62		1.41		48.50		12682.68		#############		########	

Note 1. This table shows the parameter estimates converted to the canonical form,

Note 2. The haddock results are unavailable due to the extreme size preference fitted.

$$Suit\ (pred\ ,prey\ ) = Scaling\ \ (pred\ ,prey\ ,quarter\ \ ,year\ )*(predwt\ \ )^{\omega}*\frac{1}{\sqrt{2\pi\sigma^2}}\exp\left(-.5\left(\frac{x-\mu}{\sigma}\right)^2\right)$$

Note 3. The s.e. are first order approximations.

Note 4. Sums are sums of suitability for each quarter

Table 6.6.3 Comparison of Canonical Parameter Estimates of fit of Suits from 1981 and 1991 stomach samples. Note that comparisons of mackerel and haddock are not possible due to the extreme forms of size preference the model has fitted.

Prey * Quarter	cod % change between estimates 1991/1981	whiting % change between estimates 1991/1981	saithe % change between estimates 1991/1981	mackerel % change between estimates 1991/1981	haddock % change between estimates 1991/1981
cod * 1	-23%	N.A.	N.A.	N.A.	N.A.
cod * 2	6%	N.A.	N.A.	N.A.	N.A.
cod * 3	10%	5697%	N.A.	-17%	N.A.
cod * 4	-4%	28%	N.A.	N.A.	N.A.
whiting * 1	64%	38%	N.A.	N.A.	N.A.
whiting * 2	94%	-12%	-89%	N.A.	N.A.
whiting * 3	-11%	-56%	802%	N.A.	N.A.
whiting * 4	162%	-26%	161%	N.A.	N.A.
haddock * 1	9%	-3%	N.A.	N.A.	N.A.
haddock * 2	-68%	N.A.	-91%	N.A.	N.A.
haddock * 3	-82%	-8%	-26%	N.A.	254%
haddock * 4	-16%	4%	59%	N.A.	1538%
herring * 1	-70%	-93%	1096%	N.A.	8716%
herring * 2	-14%	-84%	310%	-74%	N.A.
herring * 3	18%	-26%	1543%	57%	N.A.
herring * 4	-63%	-36%	859%	-15%	-65%
sprat * 1	-31%	51%	N.A.	N.A.	N.A.
sprat * 2	-50%	753%	N.A.	2833%	N.A.
sprat * 3	1291%	-27%	-39%	-80%	N.A.
sprat * 4	-72%	-84%	N.A.	146%	N.A.
n. pout * 1	75%	-1%	62%	N.A.	-72%
n. pout * 2	283%	-6%	84%	N.A.	-72%
n. pout * 3	-46%	225%	82%	447%	-97%
n. pout * 4	-48%	598%	-42%	3%	-94%
sandeel * 1	-39%	167%	-82%	275%	-81%
sandeel * 2	-52%	81%	271%	-46%	734%
sandeel * 3	30%	225%	-94%	-39%	5%
sandeel * 4	-99%	226%	-91%	161%	-88%

Note 1) This table shows the ratio between canonical estimates of suitability scaling for each prey species quarter.

Table 6.6.4 Comparison of Relative % change in Canonical Parameter Estimates of fit of Suits from 1981 and 1991 stomach samples (includes aliased terms as zeros).

Prey * Quarter	cod change between estimates %Suit(1991)-%Suit(1981)	whiting change between estimates %Suit(1991)-%Suit(1981)	saithe change between estimates %Suit(1991)-%Suit(1981)	mackerel change between estimates %Suit(1991)-%Suit(1981)	haddock change between estimates %Suit(1991)-%Suit(1981)
cod * 1	-8%	-3%	0%	0%	0%
cod * 2	3%	0%	0%	0%	0%
cod * 3	4%	26%	-39%	-8%	0%
cod * 4	-1%	3%	0%	0%	0%
whiting * 1	16%	15%	-4%	0%	0%
whiting * 2	10%	-5%	-7%	0%	0%
whiting * 3	-1%	-25%	25%	3%	-6%
whiting * 4	26%	-6%	5%	0%	-18%
haddock * 1	1%	0%	-44%	0%	0%
haddock * 2	-10%	-20%	-39%	0%	0%
haddock * 3	-13%	-2%	-8%	0%	62%
haddock * 4	-5%	1%	13%	0%	87%
herring * 1	-6%	-19%	20%	-73%	73%
herring * 2	0%	-6%	5%	-21%	0%
herring * 3	3%	-5%	5%	9%	0%
herring * 4	-5%	-4%	16%	-10%	-6%
sprat * 1	-5%	5%	-1%	0%	-5%
sprat * 2	-2%	21%	0%	53%	17%
sprat * 3	9%	-3%	0%	-2%	0%
sprat * 4	-3%	-15%	-5%	7%	0%
n. pout * 1	2%	0%	30%	0%	-63%
n. pout * 2	3%	-1%	40%	0%	-67%
n. pout * 3	-3%	3%	19%	10%	-56%
n. pout * 4	-4%	13%	-28%	1%	-58%
sandeel * 1	-1%	2%	-1%	73%	-6%
sandeel * 2	-4%	11%	1%	-32%	50%
sandeel * 3	0%	6%	-3%	-13%	1%
sandeel * 4	-8%	7%	-1%	2%	-6%

Note 1) this table shows the % difference between canonical forms of the suitability scalings.

Table 6.7.1. Comparison of extra explained sum of squares due to fitting either:-
1) terms for prey biomass.
or
2) nesting all terms under year.
in a fit including the basic model +predator size effects.
Percentages of the total terms (from table 6.3.1) are also shown.

	predator				
Cause	cod	whiting	saithe	mackerel	haddock
Biomass at prey age	2.5	2.4	0.9	4.2	8.2
	2%	2%	1%	4%	7%
Year effects on all terms	5.9	10.1	4.9	5.5	12.2
(from 6.3.1)	5%	10%	5%	5%	10%
Total (from 6.3.1)	120.2	96.4	90.8	119.2	118.3
	100%	100%	100%	100%	100%

Table 6.7.2 Comparison of log prey biomass coefficients estimated in a fit including the basic model +predator size effects.

	predator				
prey	cod	whiting	saithe	mackerel	haddock
cod	-0.25	-3.36	-1.85	-0.16	0.00
whiting	0.18	0.37	-0.30	-0.22	-0.21
haddock	0.32	0.19	0.05	0.00	-0.65
herring	-0.16	-0.42	1.16	0.35	3.38
sprat	0.16	-0.16	0.18	-0.49	0.36
nop	0.09	0.06	0.01	-0.19	0.23
sandeel	-0.22	-0.01	0.13	-0.32	0.70

Note 1) This table shows estimates of the coeficient of Ln(prey biomass) in a fit of suitability with this factor and the basic model. The model fitted is,

$$Suit(pred, prey, quarter) = \exp(a(pred, prey, quarter) + b(pred).x + c(pred).x^2 + d.\ln(predwt) + (\phi - 1).\ln(preybiomass)) + \varepsilon$$

Where x is the Ln(predwt/wt) and where the coefficient of LN(preybiomass) is the exponent of the supposed switching model (ϕ minus 1).

Table 6.8.1. Goodness of fit statistics for models to explain the differences in suitability estimates between 81-RUN and 91-RUN. Sum Squares are Type III for all individual model terms. Q=quarter, PD=predator species, PY=prey species. * means terms are crossed. () means preceeding term is nested under term in brackets.

Model 1: Main effects - Quarter, predator species, prey species
Interactions - All 2-way interactions
Covariates - None

SOURCE	DF	SUM SQUARE	MEAN SQUARE	F
MODEL	67	1264.3	18.87	10.71
ERROR	1593	2806.5	1.76	R^2=0.302 RMSE=1.327
INTERCEPT	1	18.45	18.45	10.47
Q	3	43.81	14.60	8.29
PD	4	25.79	6.45	3.66
PY	6	84.96	14.16	8.04
PD * PY	23	620.69	26.99	15.32
Q * PD	12	127.18	10.60	6.02
Q * PY	18	152.95	8.50	4.82

Model 2: Main Effects - Quarter
Interactions - None
Covariates - Change in predator biomass

MODEL	5	46.54	9.30	6.70
ERROR	944	1380.25	1.38	R^2=0.032 RMSE=1.178
INTERCEPT	1	8.51	8.51	6.13
Q	3	34.31	11.43	8.24
PDBIOM	1	11.64	11.64	8.38

continued....

Table 6.8.1 (ctd)

Model 3: Main Effects - Quarter
Interactions - None
Covariates - Change in prey biomass

MODEL	5	36.34	7.26	5.20
ERROR	994	1390.45	1.40	R^2=0.024 RMSE=1.183
INTERCEPT	1	0.51	0.51	0.37
Q	3	35.56	11.85	8.47
PYBIOM	1	1.44	1.44	1.03

Model 4: Main Effects - Quarter
Interactions - None
Covariates - Change in predator biomass nested under quarter

MODEL	8	49.39	6.17	4.44
ERROR	991	1377.39	1.39	R^2=0.034 RMSE=1.179
INTERCEPT	1	8.61	8.61	6.19
Q	3	9.91	3.30	2.38
PDBIOM (Q)	4	14.50	3.63	2.61

Model 5: Main Effects - Quarter
Interactions - None
Covariates - Change in prey biomass nested under quarter

MODEL	8	74.83	9.35	6.86
ERROR	991	1351.96	1.36	R^2=0.051 RMSE=1.168
INTERCEPT	1	0.01	0.01	0.00
Q	3	33.86	11.29	8.27
PYBIOM (Q)	4	39.93	9.98	7.32

continued..

Table 6.8.1 (ctd.)

Model 6: Main Effects - Quarter, Predator Species
Interactions - None
Covariates - Change in predator biomass nested under predator

MODEL	13	108.65	8.36	6.25
ERROR	986	1318.14	1.34	R^2=0.075 RMSE=1.156
INTERCEPT	1	6.49	6.49	4.85
Q	3	25.10	8.37	6.26
PD	4	23.55	5.89	4.40
PDBIOM(PD)	5	5.56	1.11	0.83

Model 7: Main Effects - Quarter, Prey species
Interactions - None
Covariates - Change in prey biomass nested under prey

MODEL	17	66.70	3.92	2.62
ERROR	982	1360.09	1.38	R^2=0.046 RMSE=1.173
INTERCEPT	1	0.02	0.02	0.01
Q	3	19.19	8.39	6.09
PY	6	10.10	1.65	1.03
PYBIOM(PY)	7	31.81	4.54	3.30

Model 8: Main Effects - Quarter, Predator Species
Interactions - None
Covariates - Change in predator biomass nested under predator species and quarter

MODEL	28	122.50	4.38	3.26
ERROR	971	1304.29	1.34	R^2=0.085 RMSE=1.159
INTERCEPT	1	6.94	6.94	5.17
Q	3	7.44	2.48	1.85
PD	4	24.12	6.03	4.49
PDBIOM (Q*PD)	20	19.42	0.97	0.72

continued...

Table 6.8.1 (ctd.)

Model 9: Main Effects - Quarter, Prey Species
Interactions - None
Covariates - Change in prey biomass nested under prey species and quarter

MODEL	38	164.16	4.32	3.32
ERROR	967	1262.63	1.31	R^2=0.115 RMSE=0.143
INTERCEPT	1	0.17	0.17	0.13
Q	3	11.07	3.69	2.94
PY	6	20.30	3.40	2.86
PYBIOM (Q*PY)	28	129.26	4.61	3.54

Table 6.8.2 Parameter estimates from the two best model fits to the change in suitabilities. Estimates are quasi-standardized, so they roughly approximate z-scores (i.e., parameter estimates greater than 1.96 have less than an 0.05 probability of actually being 0.0).

A: Model 1 - Main effects quarter, predator, and prey, and all two way interactions; no covariates. (N.A. means that combination of predator and prey were too uncommon to provide an estimate.)

PREDATOR PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK
COD	-0.46	0.26	-3.36	-2.54	-1.35
WHITING	0.71	0.47	N.A.	N.A.	1.77
HADDOCK	-0.30	-0.15	-0.54	N.A.	N.A.
HERRING	-0.49	1.04	3.29	-1.32	5.43
SPRAT	-2.84	-2.10	-2.16	1.16	-4.19
N. POUT	-1.23	-0.16	-0.17	0.22	ALIASED
SANDEEL	ALIASED	0.39	-1.09	-1.79	ALIASED

B: Model 9 - Main effects quarter and prey species; covariate is change in prey biomass nested under prey species and quarter.

PREDATOR PREY	COD	WHITING	SAITHE	MACKEREL	HADDOCK
COD	-2.17	-1.18	-4.30	-1.96	ALIASED
WHITING	-0.33	-0.07	-1.76	2.14	ALIASED
HADDOCK	-1.95	-2.11	-2.77	N.A.	N.A.
HERRING	-1.09	-2.16	-1.07	-1.68	ALIASED
SPRAT	-2.14	-1.20	-2.79	-1.27	ALIASED
N.POUT	-0.89	-0.55	-1.03	-.076	ALIASED
SANDEEL	ALIASED	ALIASED	ALIASED	ALIASED	ALIASED

C: Model 9 - parameter estimate for slope/s.e. of estimate.

QUARTER PREY	1	2	3	4
COD	1.457	-1.001	2.225	-0.831
WHITING	-0.171	0.030	-1.371	-1.556
HADDOCK	1.603	0.058	-1.214	-3.952
HERRING	0.047	0.455	-0.872	3.158
SPRAT	5.096	4.093	-1.41	1.661
N.POUT	0.443	-0.599	-2.680	0.247
SANDEEL	1.499	2.261	0.759	0.025

Table 6.10.1 North Sea data 1974-1992 (Multispecies Working Group 1993) with stomach content data for Cod, Whiting, Mackerel, Saithe and Haddock.

LONGTERM MULTI SPECIES PREDICTION, CONSTANT RECRUITMENT

Baseline
COMPARED TO
130 mm mesh size, 75 meshes in codend

SENSITIVITY TO CHANGES IN RECRUITMENT LEVEL
CHANGE IN % FROM BASELINE OF S.S.BIOM.

PERCENTAGE OF RUNS IN EACH INTERVAL
512 COMPARISONS IN TOTAL

SPECIES CHANGE	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING
> 100	24.6	0.0	0.0	0.0	36.1	0.0
90 - 100	12.9	0.0	100.0	0.0	11.9	0.0
80 - 90	27.1	0.0	0.0	0.0	9.6	0.0
70 - 80	22.9	0.0	0.0	0.0	5.5	0.0
60 - 70	12.3	0.0	0.0	0.0	7.2	0.0
50 - 60	0.2	7.0	0.0	0.0	4.7	0.0
40 - 50	0.0	28.7	0.0	0.0	0.4	0.0
30 - 40	0.0	51.0	0.0	0.0	2.1	0.0
20 - 30	0.0	13.3	0.0	0.0	5.7	0.0
10 - 20	0.0	0.0	0.0	0.0	8.8	0.0
.01 - 10	0.0	0.0	0.0	0.0	6.4	0.0
-.01 - .01	0.0	0.0	0.0	100.0	0.0	0.0
-10 - -.01	0.0	0.0	0.0	0.0	1.6	0.0
-20 - -10	0.0	0.0	0.0	0.0	0.0	54.1
-30 - -20	0.0	0.0	0.0	0.0	0.0	39.5
-40 - -30	0.0	0.0	0.0	0.0	0.0	6.4
-50 - -40	0.0	0.0	0.0	0.0	0.0	0.0
-60 - -50	0.0	0.0	0.0	0.0	0.0	0.0
-70 - -60	0.0	0.0	0.0	0.0	0.0	0.0
-80 - -70	0.0	0.0	0.0	0.0	0.0	0.0
-90 - -80	0.0	0.0	0.0	0.0	0.0	0.0
-100 - -90	0.0	0.0	0.0	0.0	0.0	0.0
< -100	0.0	0.0	0.0	0.0	0.0	0.0

SPECIES CHANGE	SPRAT	N. POUT	SANDEEL	PLAICE	SOLE	ALL SPECIES
> 100	0.0	0.0	0.0	0.0	0.0	0.0
90 - 100	0.0	0.0	0.0	0.0	0.0	0.0
80 - 90	0.0	0.0	0.0	0.0	0.0	0.0
70 - 80	0.0	0.0	0.0	0.0	0.0	0.0
60 - 70	0.0	0.0	0.0	0.0	0.0	0.0
50 - 60	0.0	0.0	0.0	0.0	0.0	0.0
40 - 50	0.0	0.0	0.0	0.0	0.0	0.0
30 - 40	0.0	0.0	0.0	0.0	0.0	0.0
20 - 30	0.0	0.0	0.0	0.0	0.0	0.0
10 - 20	0.0	0.0	0.0	0.0	0.0	1.8
.01 - 10	0.0	0.0	0.0	0.0	0.0	52.7
-.01 - .01	0.0	0.0	0.0	100.0	100.0	0.0
-10 - -.01	100.0	0.0	98.0	0.0	0.0	45.5
-20 - -10	0.0	1.8	2.0	0.0	0.0	0.0
-30 - -20	0.0	22.7	0.0	0.0	0.0	0.0
-40 - -30	0.0	25.6	0.0	0.0	0.0	0.0
-50 - -40	0.0	20.1	0.0	0.0	0.0	0.0
-60 - -50	0.0	5.7	0.0	0.0	0.0	0.0
-70 - -60	0.0	24.2	0.0	0.0	0.0	0.0
-80 - -70	0.0	0.0	0.0	0.0	0.0	0.0
-90 - -80	0.0	0.0	0.0	0.0	0.0	0.0
-100 - -90	0.0	0.0	0.0	0.0	0.0	0.0
< -100	0.0	0.0	0.0	0.0	0.0	0.0

Table 6.10.2 North Sea data 1974-1992 (Multispecies Working Group 1993) with stomach content data for Cod, Whiting, Mackerel, Saithe and Haddock.

LONGTERM MULTI SPECIES PREDICTION, CONSTANT RECRUITMENT

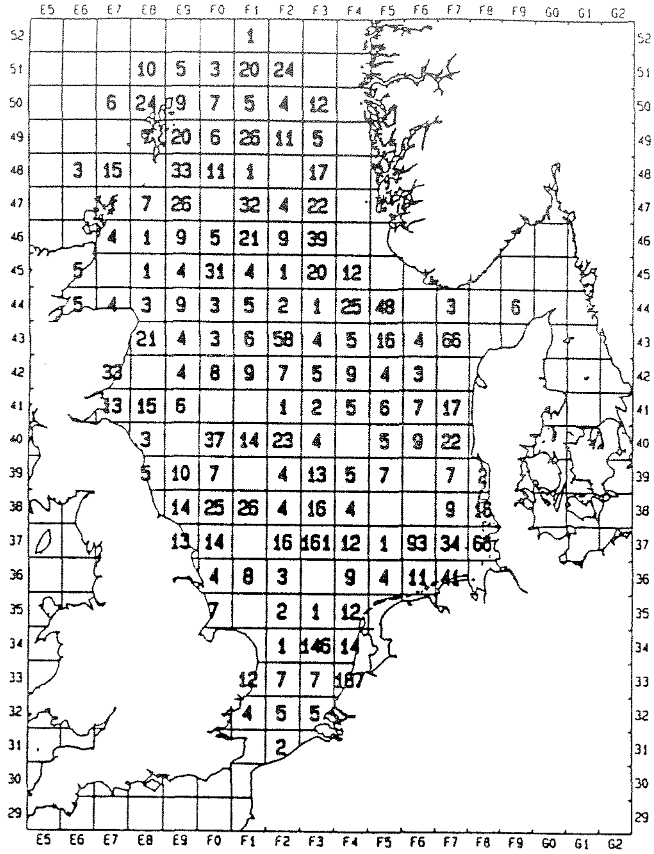
Baseline
COMPARED TO
130 mm mesh size, 75 meshes in codend

SENSITIVITY TO CHANGES IN RECRUITMENT LEVEL
CHANGE IN % FROM BASELINE OF YIELD

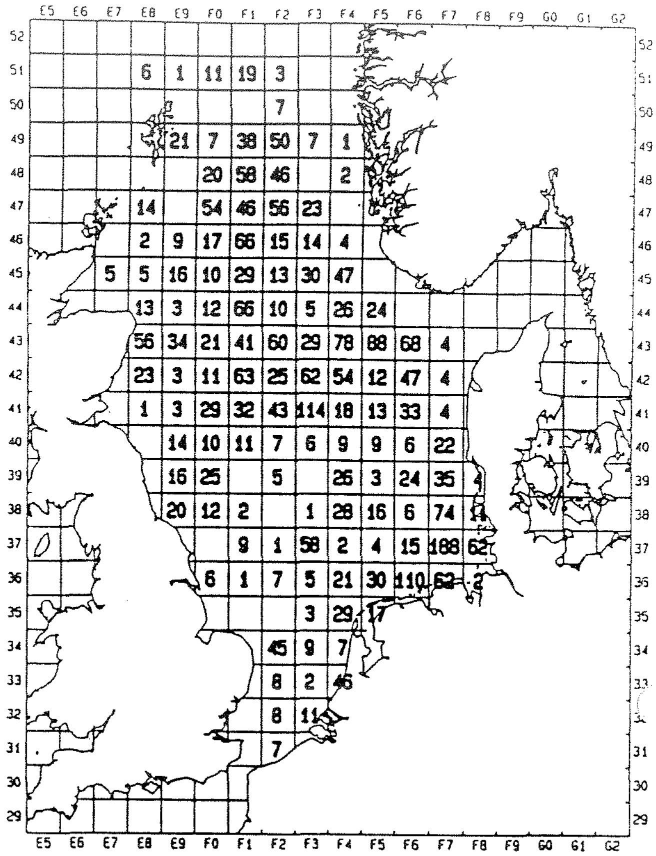
PERCENTAGE OF RUNS IN EACH INTERVAL
512 COMPARISONS IN TOTAL

SPECIES CHANGE	COD	WHITING	SAITHE	MACKEREL	HADDOCK	HERRING
> 100	0.0	0.0	0.0	0.0	0.0	0.0
90 - 100	0.0	0.0	0.0	0.0	0.0	0.0
80 - 90	0.0	0.0	0.0	0.0	0.0	0.0
70 - 80	0.0	0.0	0.0	0.0	0.0	0.0
60 - 70	0.0	0.0	0.0	0.0	0.0	0.0
50 - 60	0.0	0.0	0.0	0.0	0.0	0.0
40 - 50	0.0	0.0	0.0	0.0	0.0	0.0
30 - 40	0.0	0.0	0.0	0.0	0.0	0.0
20 - 30	0.0	0.0	0.0	0.0	0.0	0.0
10 - 20	11.3	0.0	100.0	0.0	0.0	0.0
.01 - 10	26.2	0.0	0.0	0.0	0.0	0.0
-.01 - .01	0.0	0.0	0.0	100.0	0.0	0.0
-10 - -.01	50.0	0.0	0.0	0.0	0.0	0.0
-20 - -10	12.5	0.0	0.0	0.0	10.0	47.1
-30 - -20	0.0	20.1	0.0	0.0	26.0	43.2
-40 - -30	0.0	79.9	0.0	0.0	26.8	9.8
-50 - -40	0.0	0.0	0.0	0.0	12.5	0.0
-60 - -50	0.0	0.0	0.0	0.0	13.3	0.0
-70 - -60	0.0	0.0	0.0	0.0	11.5	0.0
-80 - -70	0.0	0.0	0.0	0.0	0.0	0.0
-90 - -80	0.0	0.0	0.0	0.0	0.0	0.0
-100 - -90	0.0	0.0	0.0	0.0	0.0	0.0
< -100	0.0	0.0	0.0	0.0	0.0	0.0

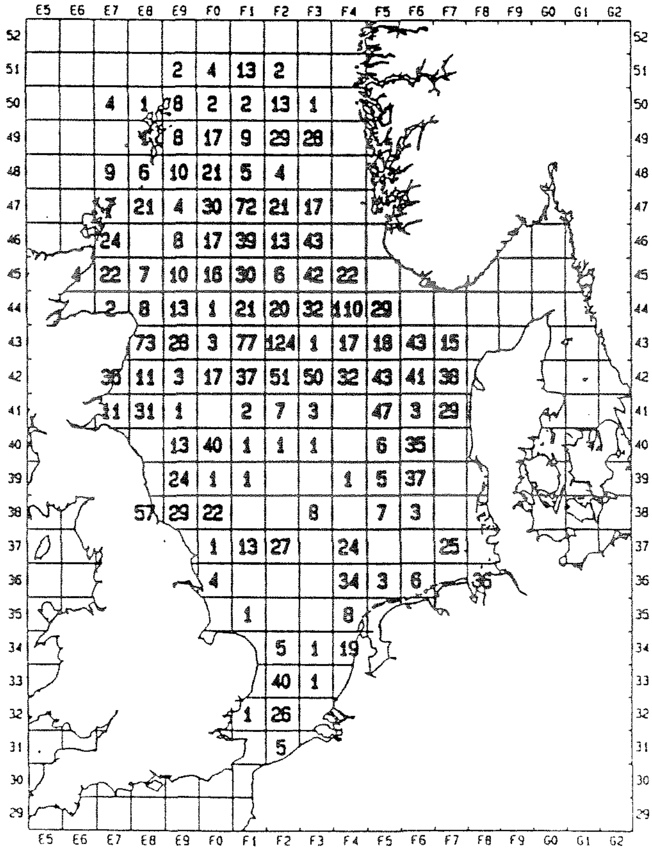
SPECIES CHANGE	SPRAT	N. POUT	SANDEEL	PLAICE	SOLE	ALL SPECIES
> 100	0.0	0.0	0.0	0.0	0.0	0.0
90 - 100	0.0	0.0	0.0	0.0	0.0	0.0
80 - 90	0.0	0.0	0.0	0.0	0.0	0.0
70 - 80	0.0	0.0	0.0	0.0	0.0	0.0
60 - 70	0.0	0.0	0.0	0.0	0.0	0.0
50 - 60	0.0	0.0	0.0	0.0	0.0	0.0
40 - 50	0.0	0.0	0.0	0.0	0.0	0.0
30 - 40	0.0	0.0	0.0	0.0	0.0	0.0
20 - 30	0.0	0.0	0.0	0.0	0.0	0.0
10 - 20	0.0	0.0	0.0	0.0	0.0	0.0
.01 - 10	0.0	0.0	2.0	0.0	0.0	0.0
-.01 - .01	0.0	0.0	0.0	100.0	100.0	0.0
-10 - -.01	100.0	0.0	98.0	0.0	0.0	9.2
-20 - -10	0.0	0.0	0.0	0.0	0.0	82.8
-30 - -20	0.0	22.5	0.0	0.0	0.0	8.0
-40 - -30	0.0	27.0	0.0	0.0	0.0	0.0
-50 - -40	0.0	20.1	0.0	0.0	0.0	0.0
-60 - -50	0.0	17.8	0.0	0.0	0.0	0.0
-70 - -60	0.0	12.7	0.0	0.0	0.0	0.0
-80 - -70	0.0	0.0	0.0	0.0	0.0	0.0
-90 - -80	0.0	0.0	0.0	0.0	0.0	0.0
-100 - -90	0.0	0.0	0.0	0.0	0.0	0.0
< -100	0.0	0.0	0.0	0.0	0.0	0.0



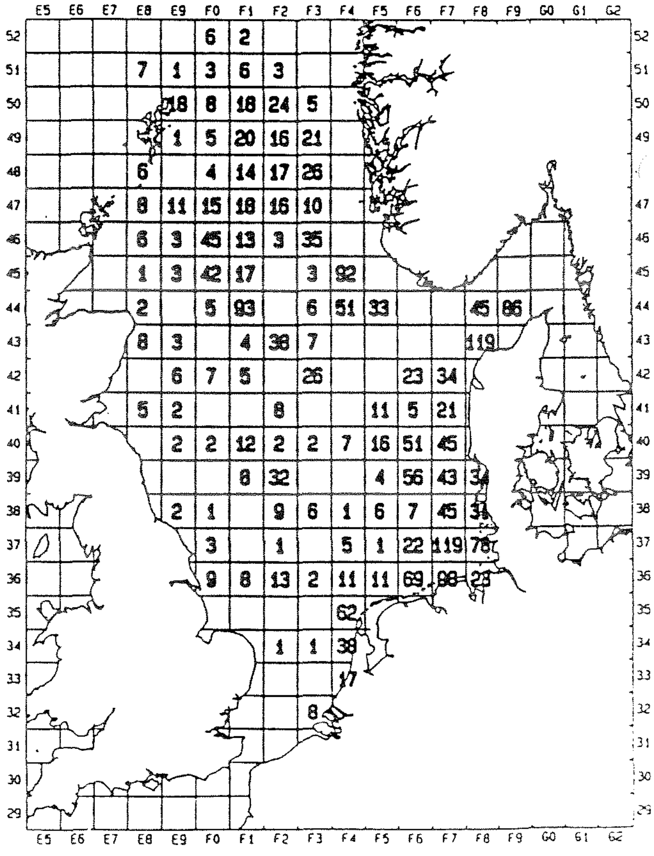
Quarter 1



Quarter 2

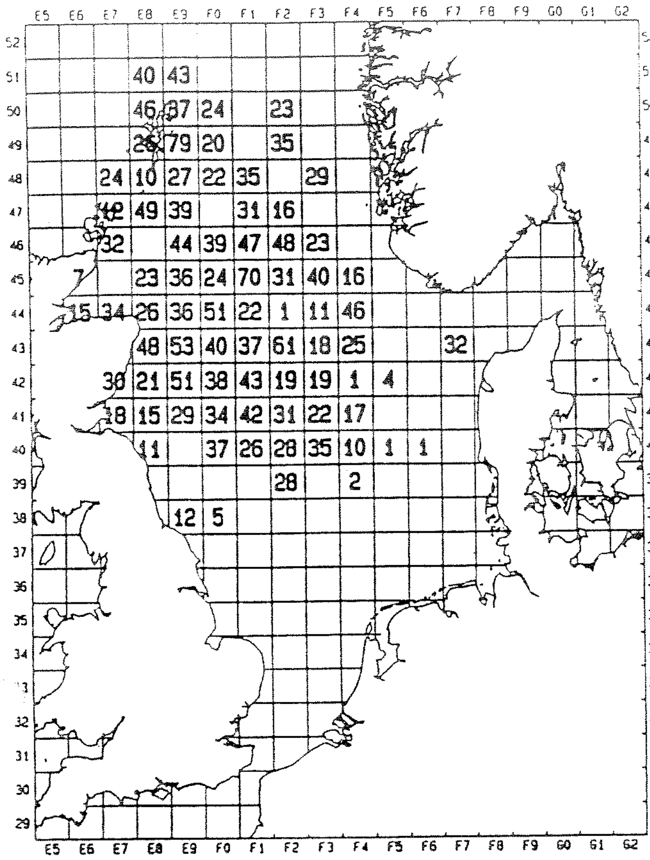


Quarter 3

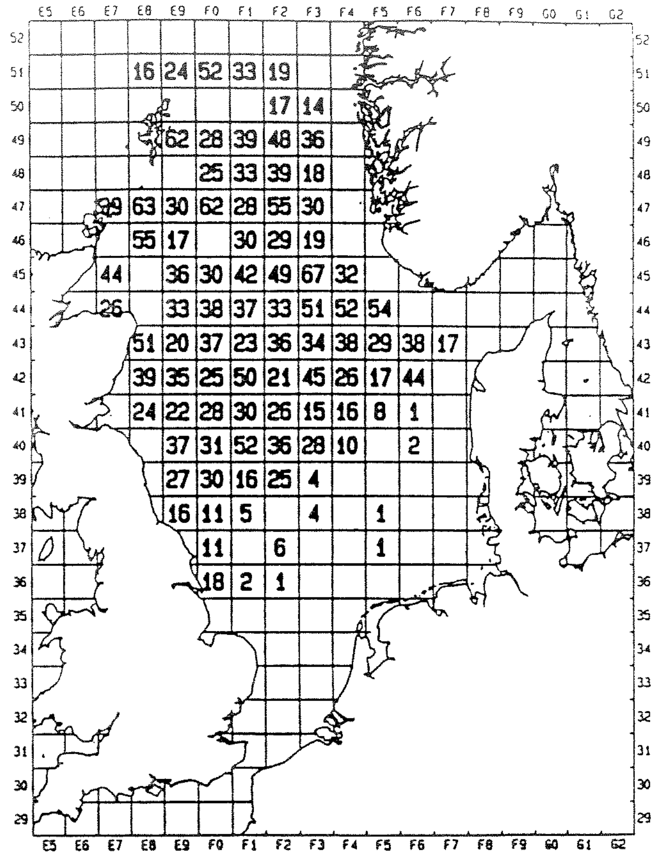


Quarter 4

Figure 3.2.1.1 Numbers of cod stomachs sampled in each rectangle in each quarter



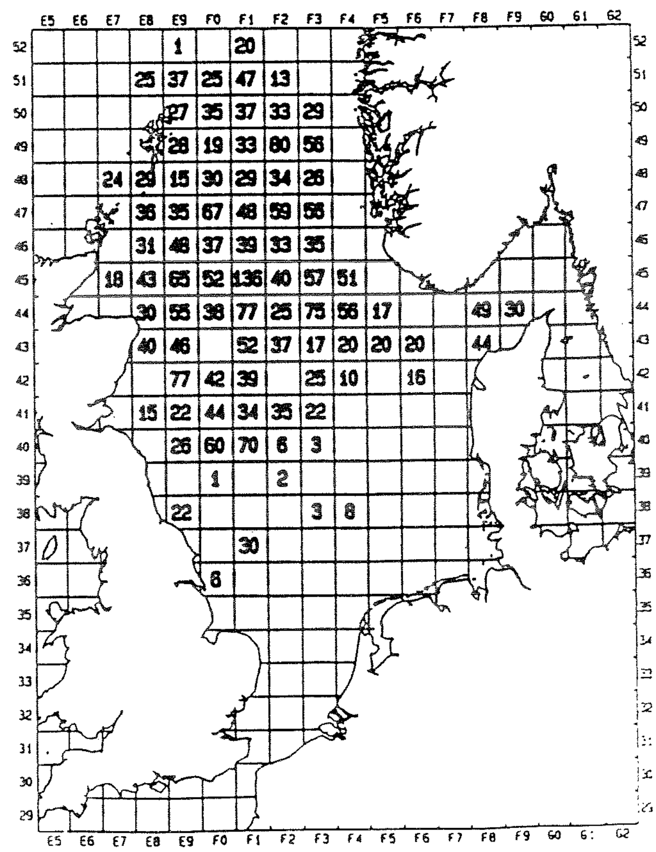
Quarter 1



Quarter 2

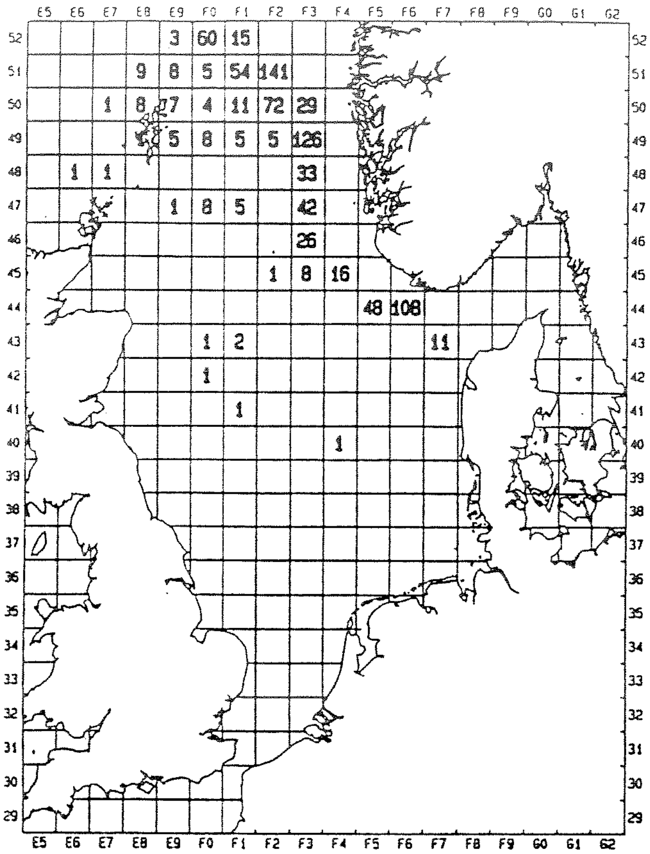
NOT YET AVAILABLE

Quarter 3

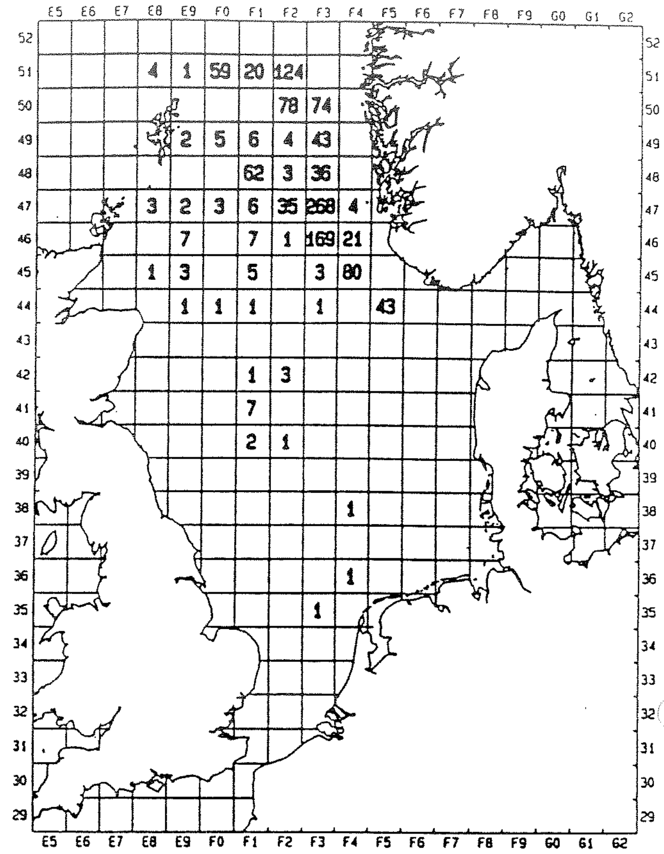


Quarter 4

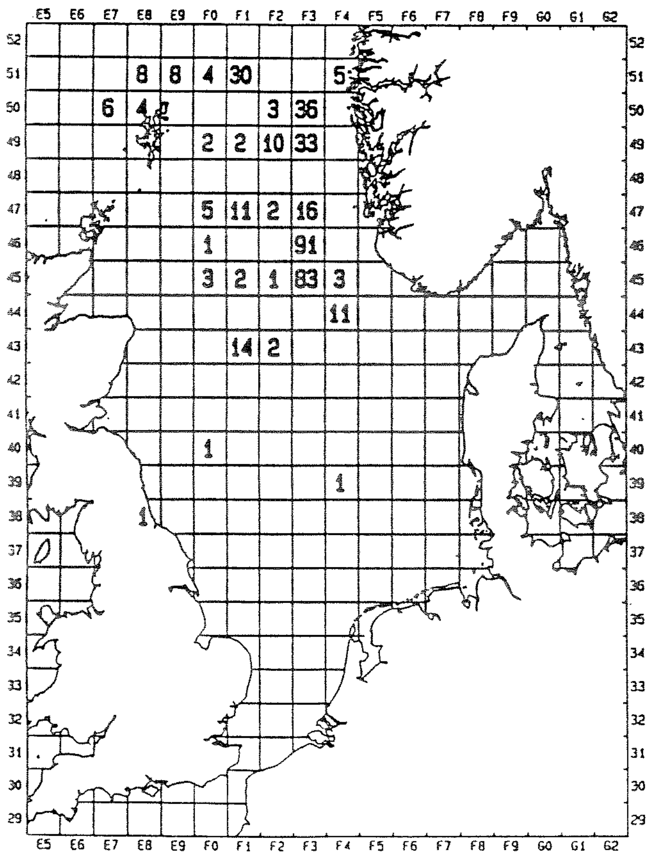
Figure 3.2.1.2 Numbers of haddock stomachs sampled in each rectangle in each quarter



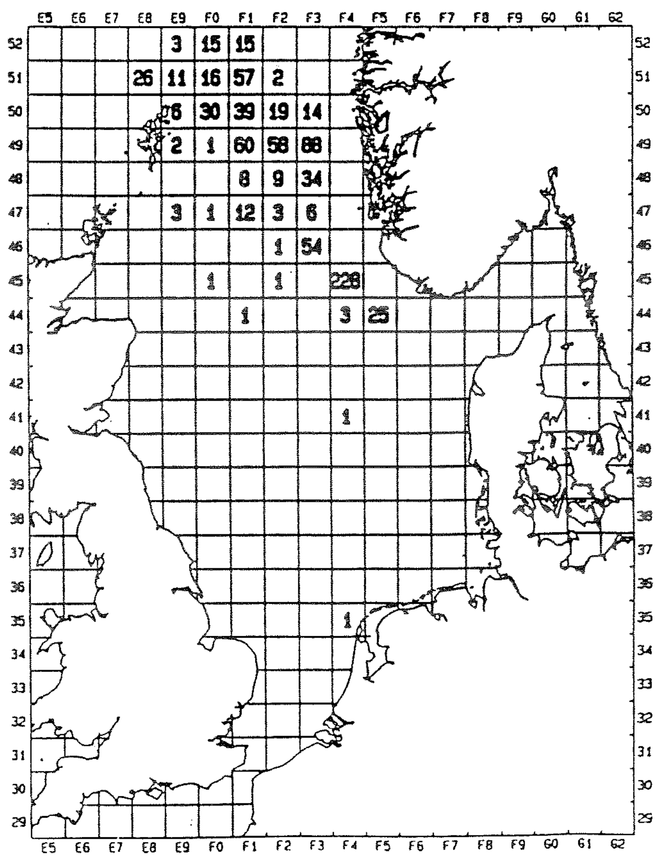
Quarter 1



Quarter 2



Quarter 3



Quarter 4

Figure 3.2.1.3 Numbers of whiting stomachs sampled in each rectangle in each quarter

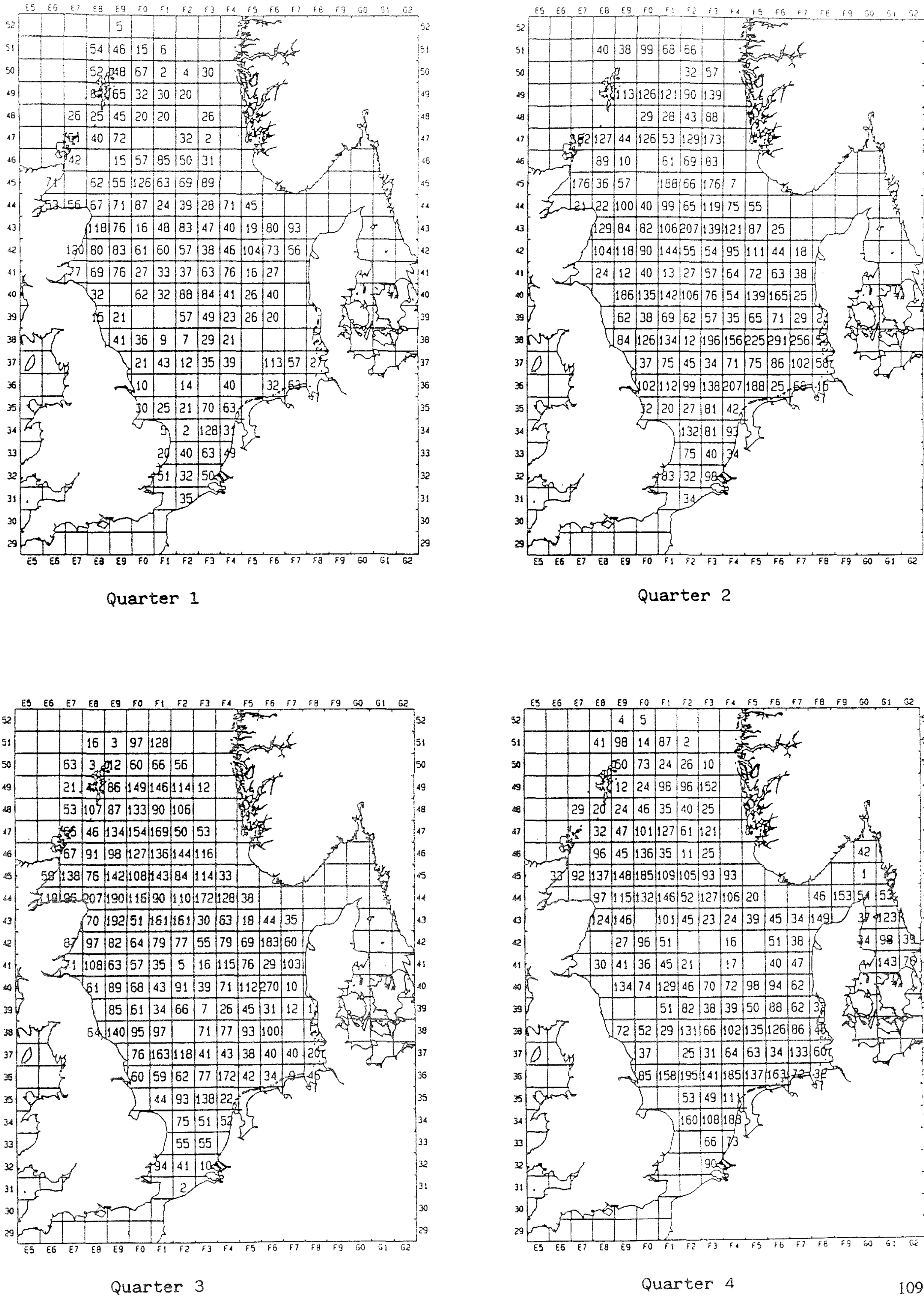


Figure 3.2.1.4 Numbers of saithe stomachs sampled in each rectangle in each quarter

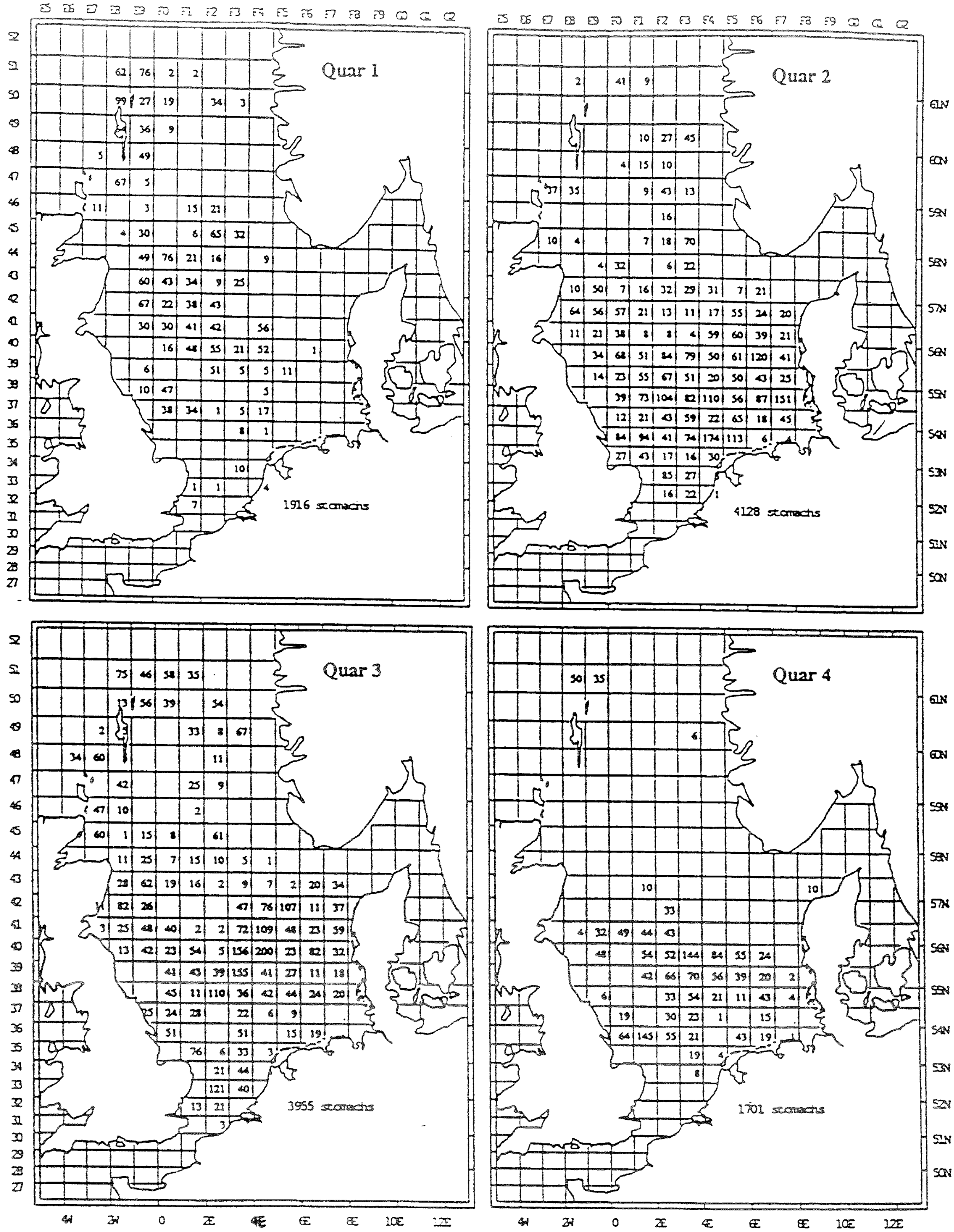


Figure 3.2.2.1 Numbers of Grey Gurnard stomachs sampled in each rectangle in each quar

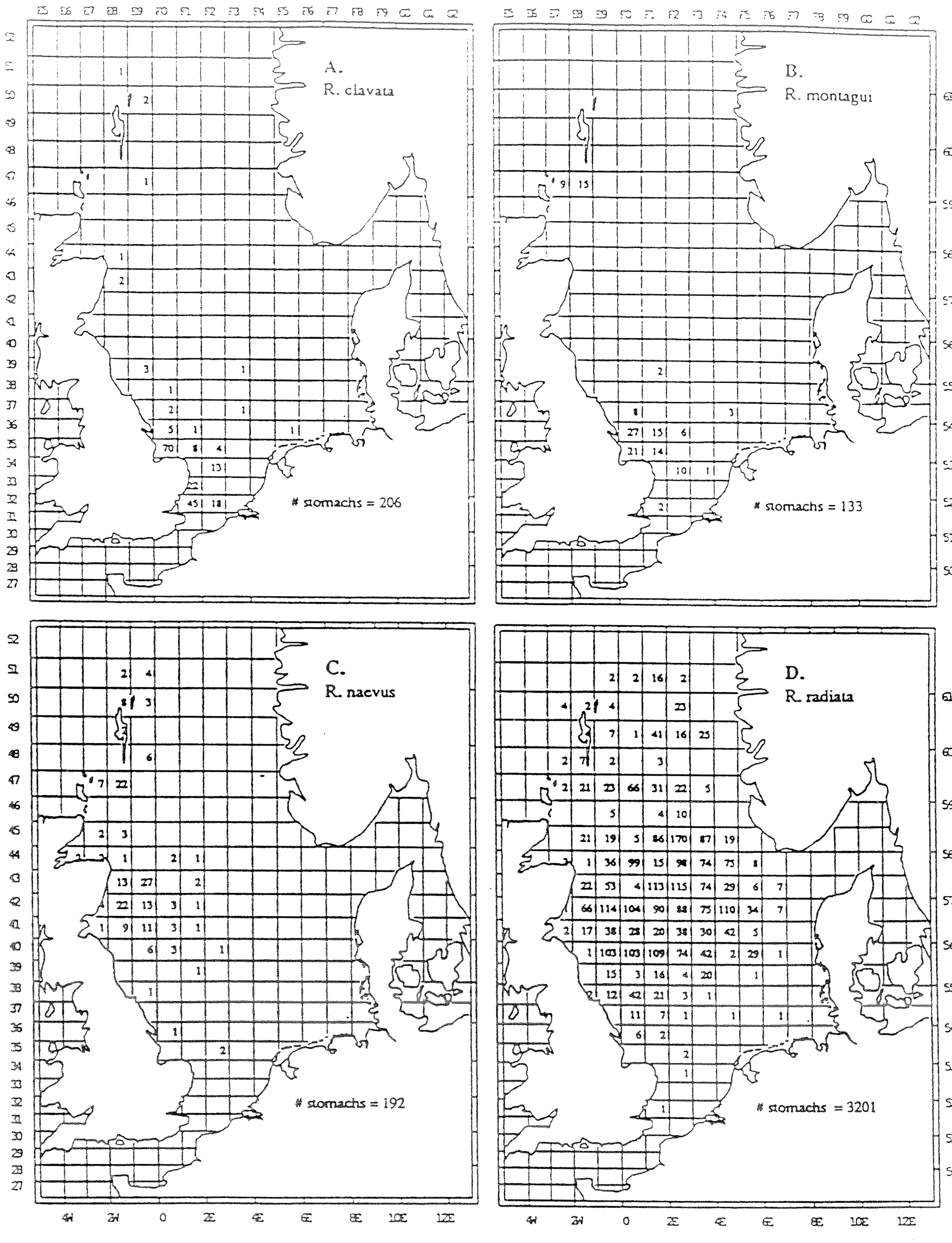


Figure 3.2.2.2 Numbers of Raja Sp. stomachs sampled in each rectangle

Figure 3.6.3.1

PREY OF 0-GROUP GADOIDS IN THE NORTHERN NORTH SEA IN JUNE 1991

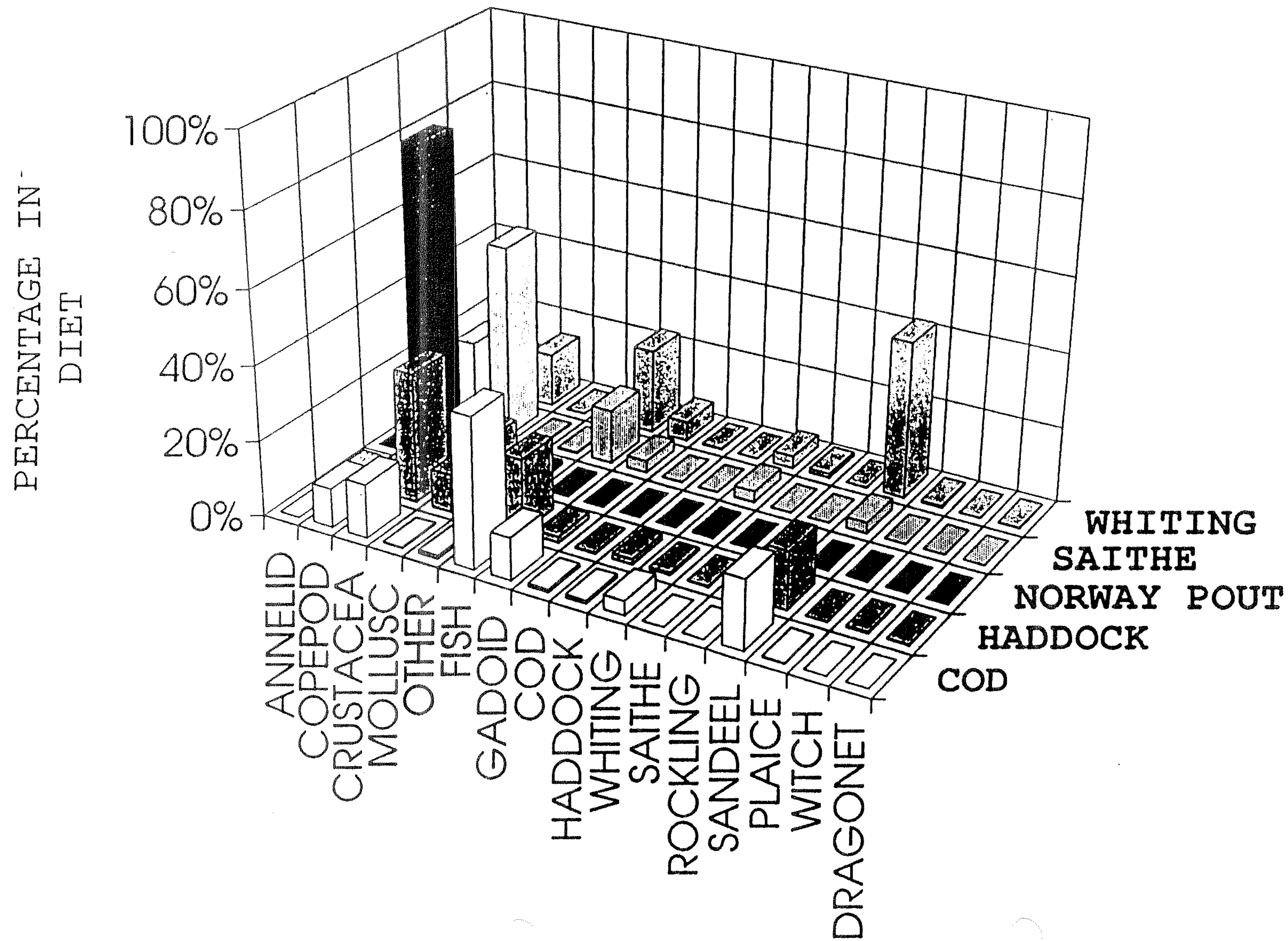


Figure 3.6.3.2

PERCENTAGE OF FISH PREY IN THE DIET OF 0-GROUP GADOIDS IN THE NORTHERN NORTH SEA IN JUNE 1991

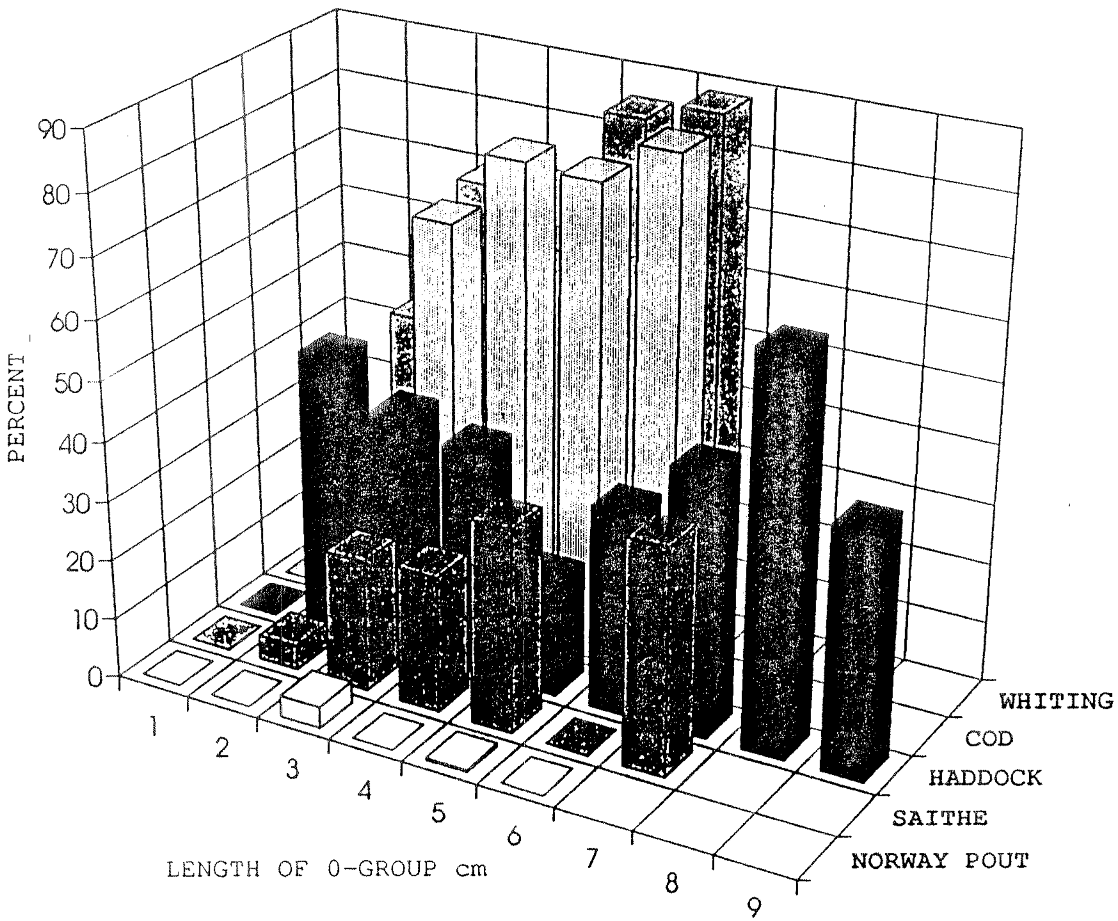


Figure 4.3.1.a

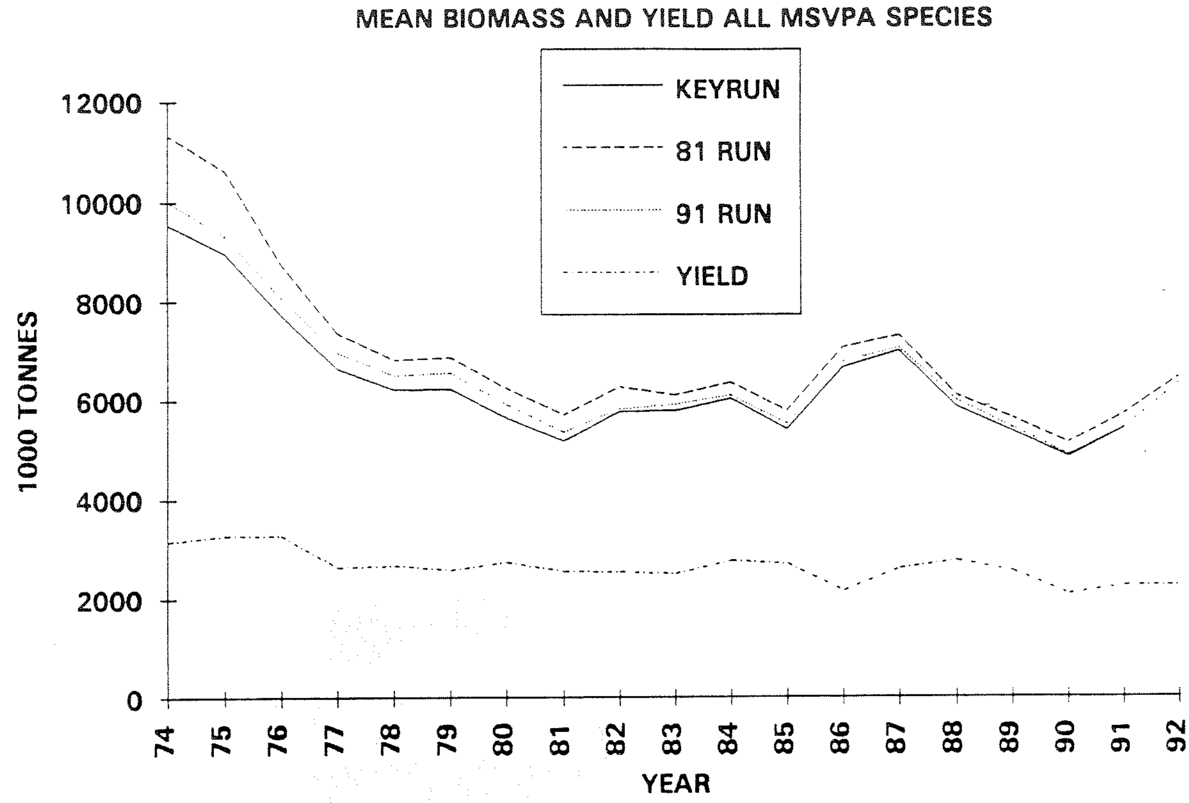


Figure 4.3.1.b

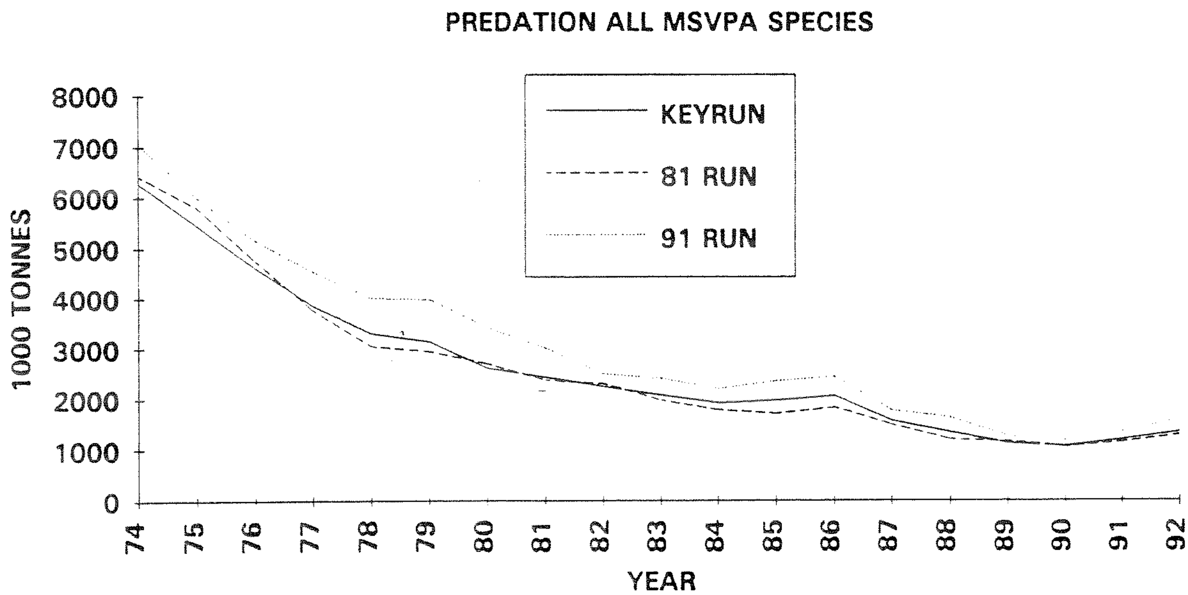


Figure 4.3.2.a

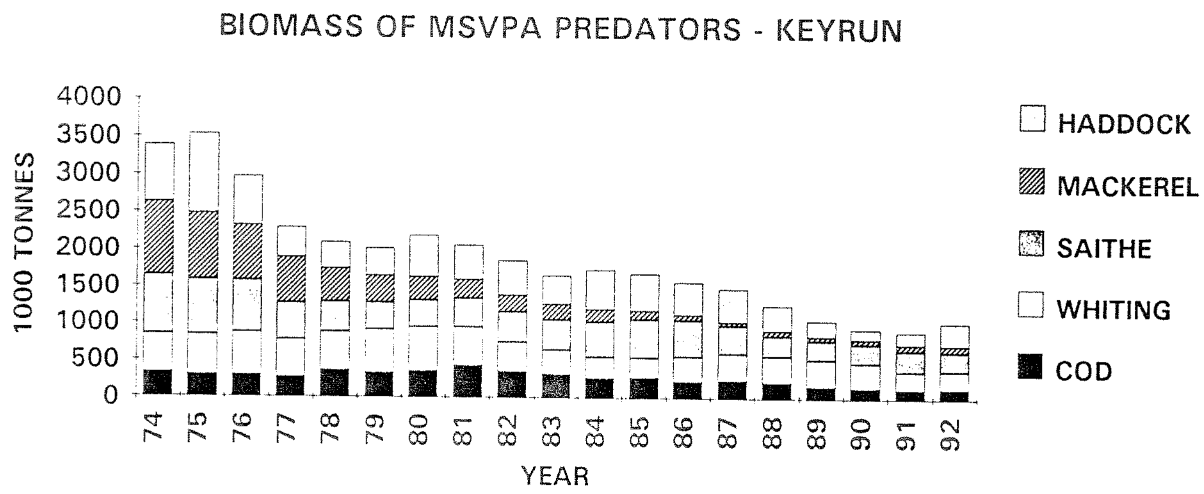


Figure 4.3.2.b

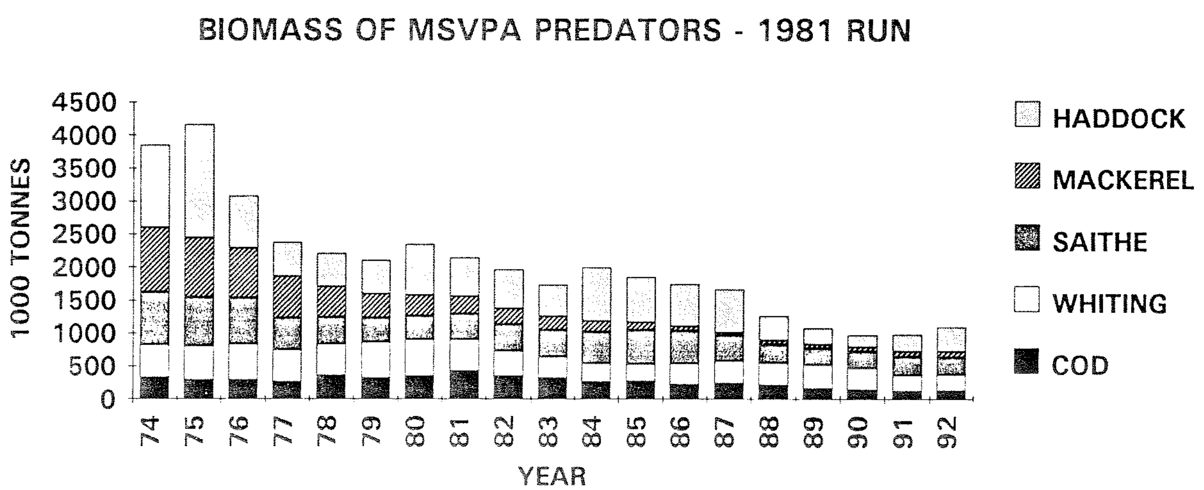


Figure 4.3.2.c

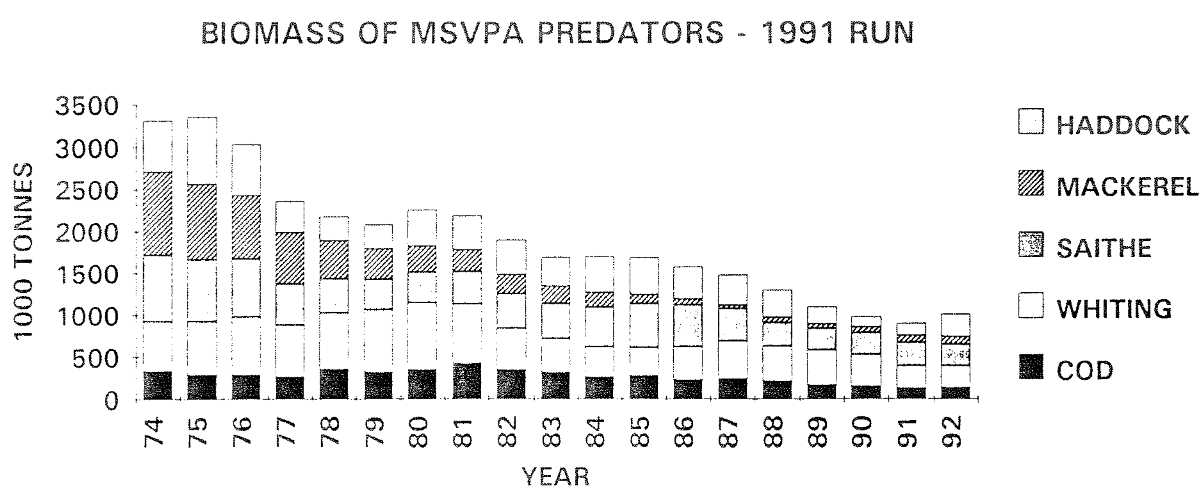


Figure 4.3.3.a

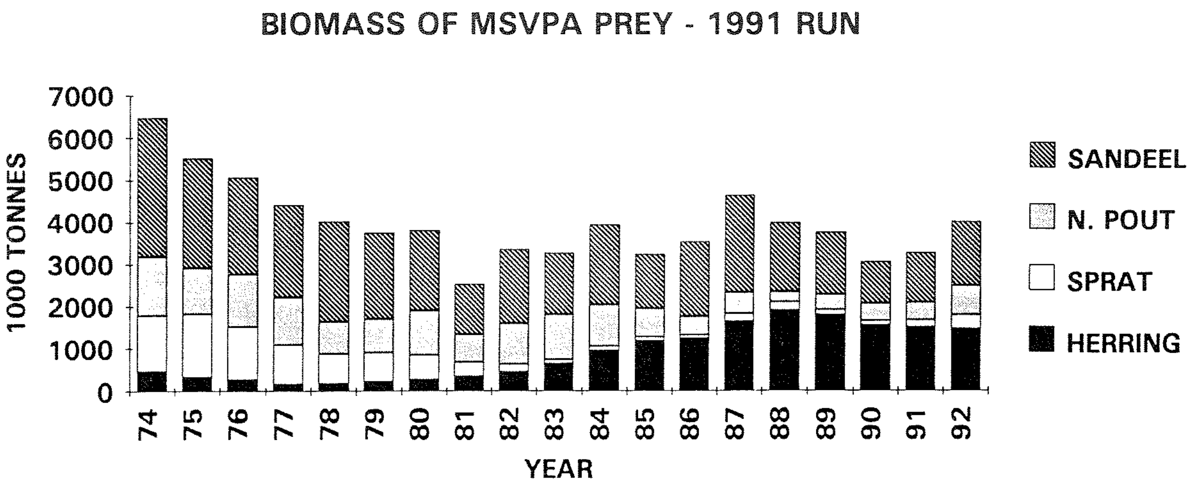


Figure 4.3.3.b

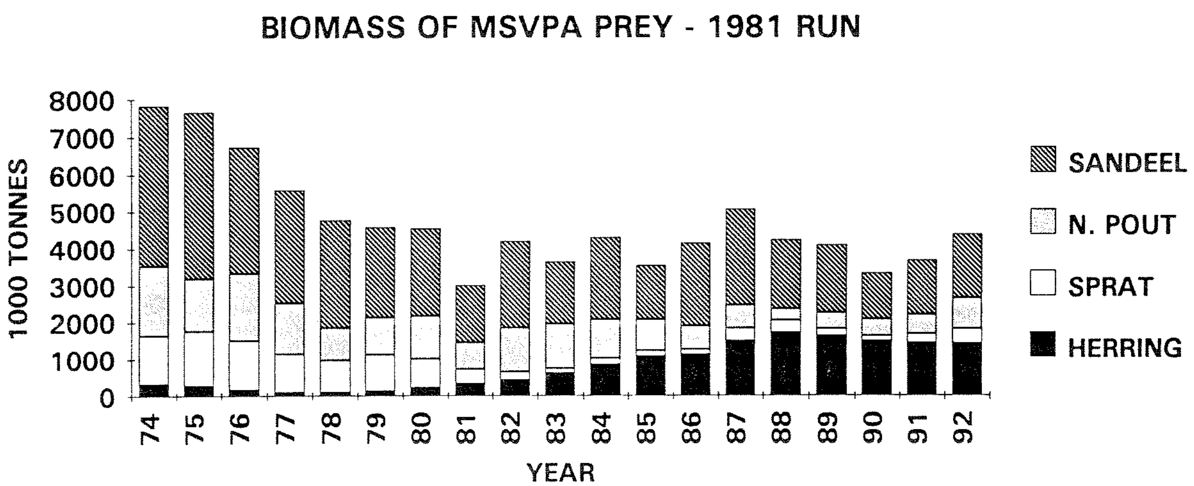


Figure 4.3.3.c

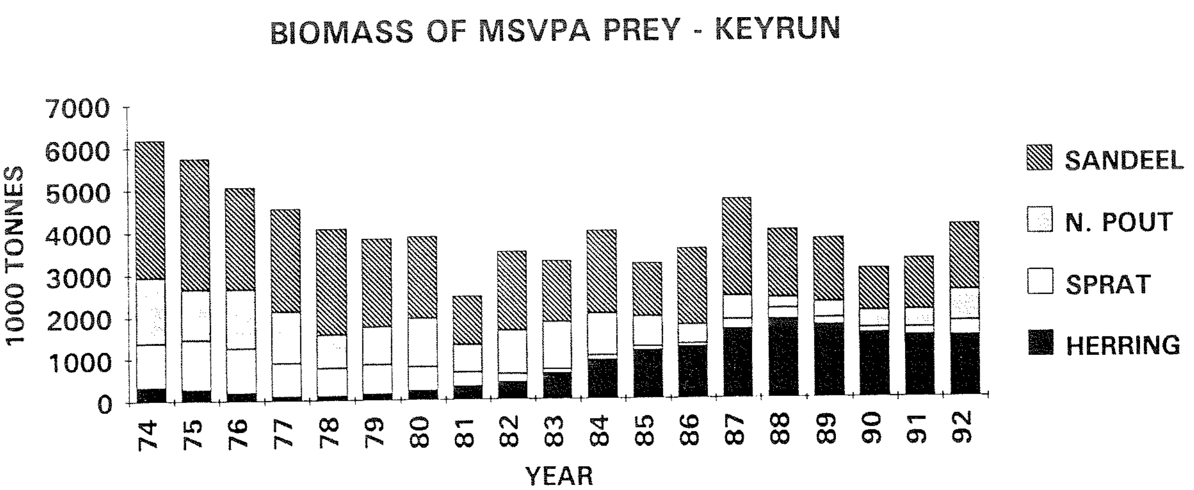


Figure 4.3.4

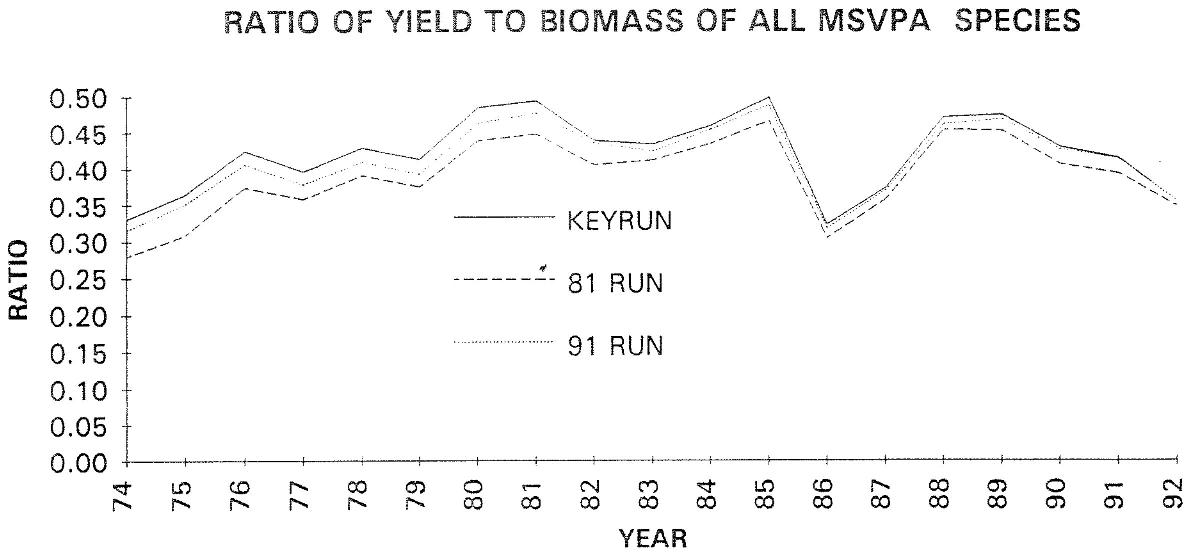


Figure 4.3.5

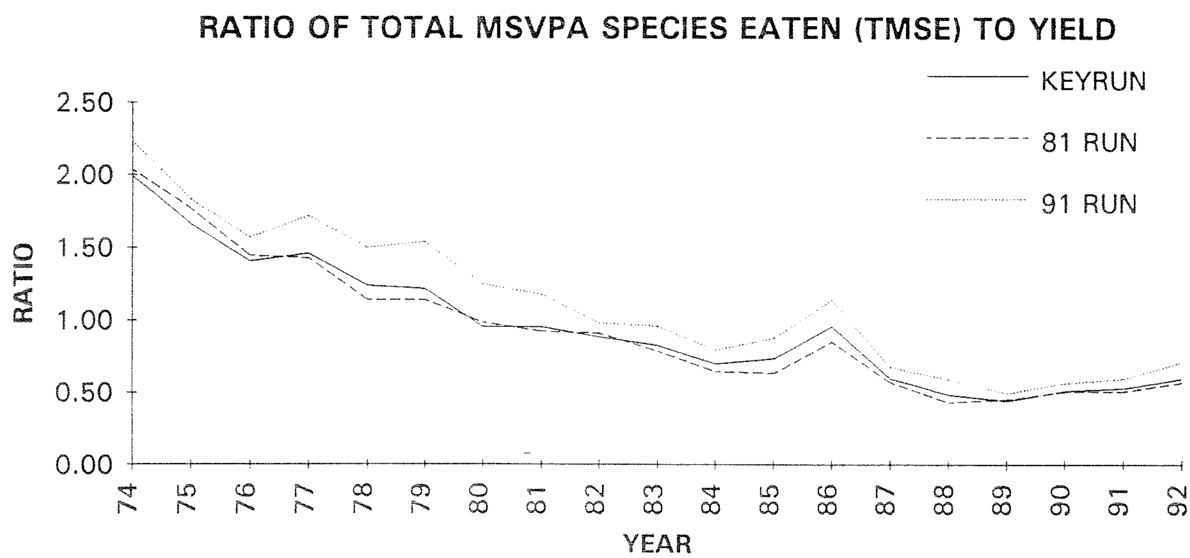


Figure 4.3.6

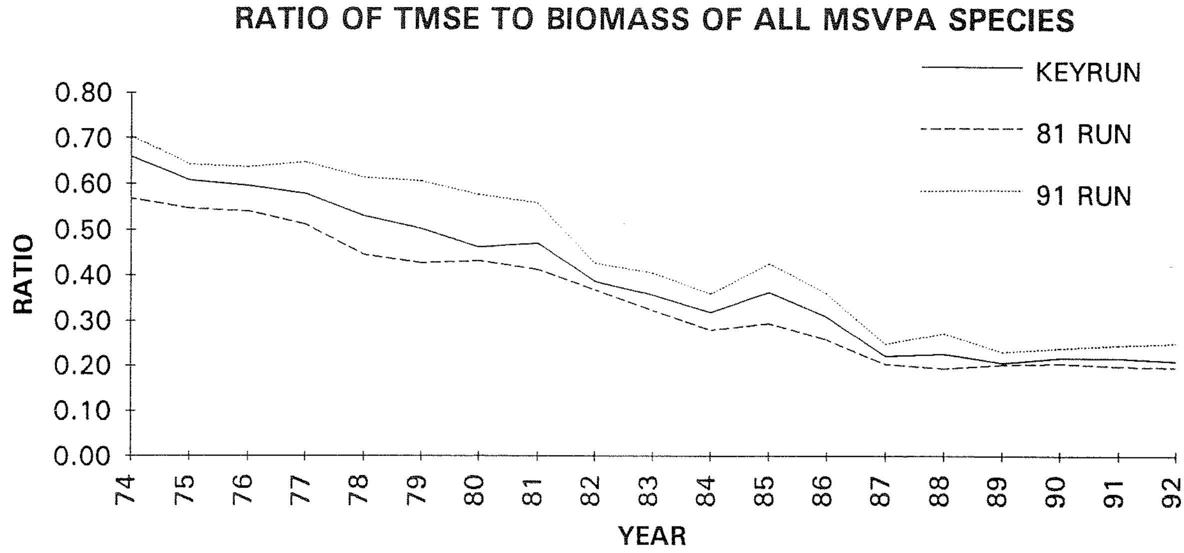


Figure 4.3.7

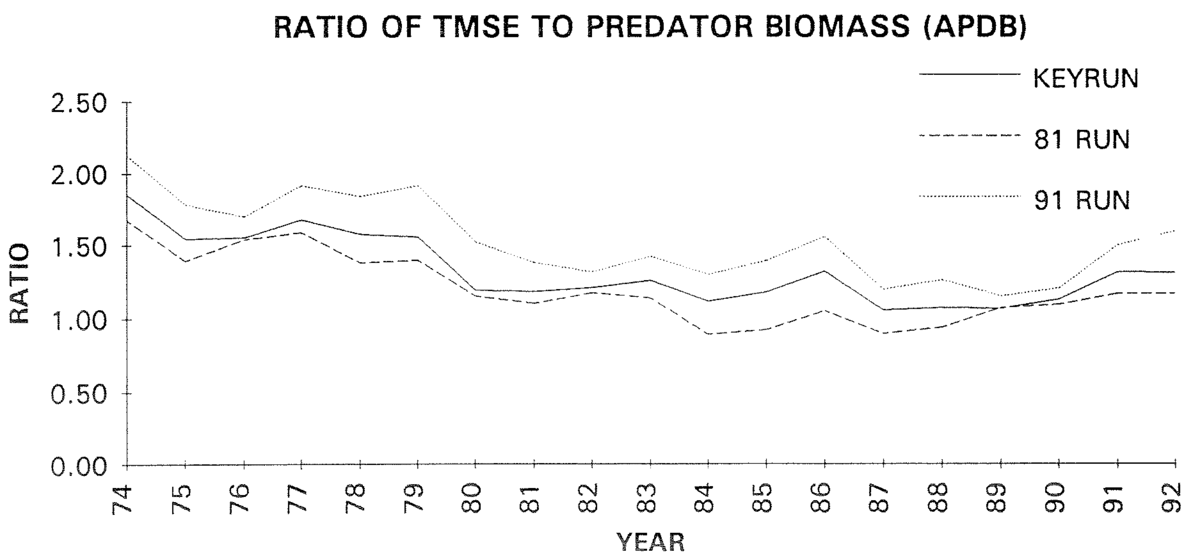
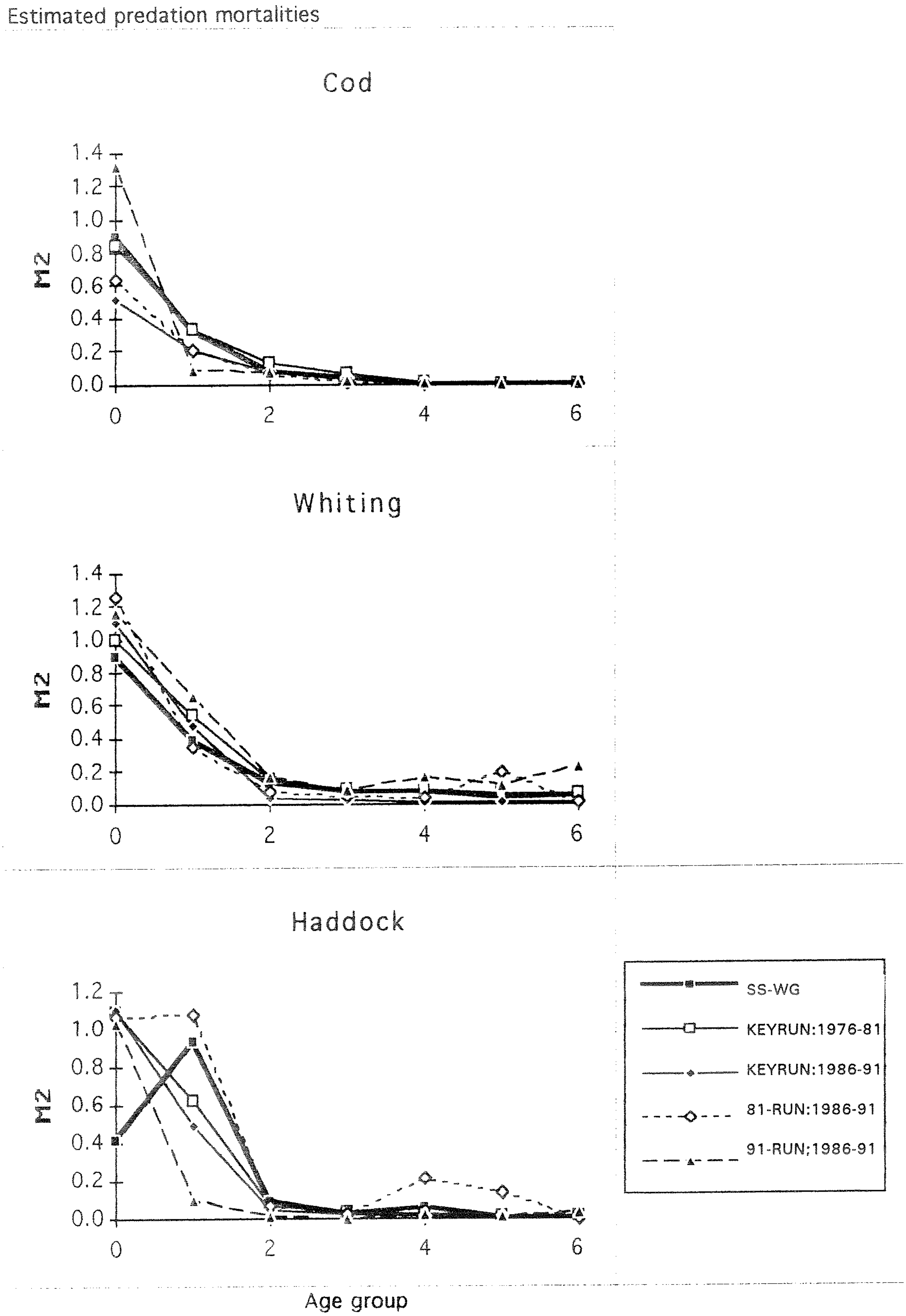
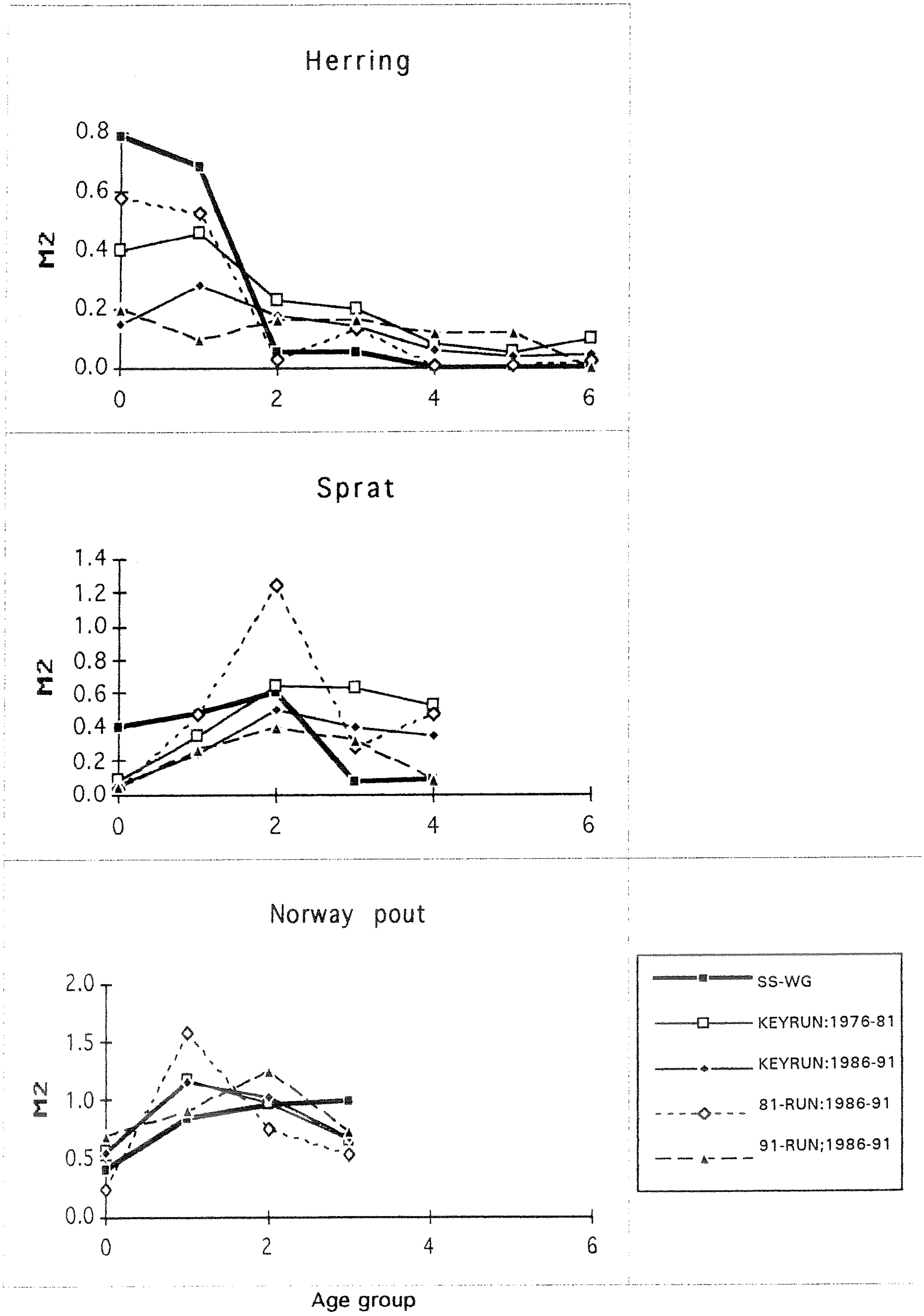


Figure 4.3.8



Continued

Figure 4.3.8 Continued



Continued

Figure 4.3.8 Continued

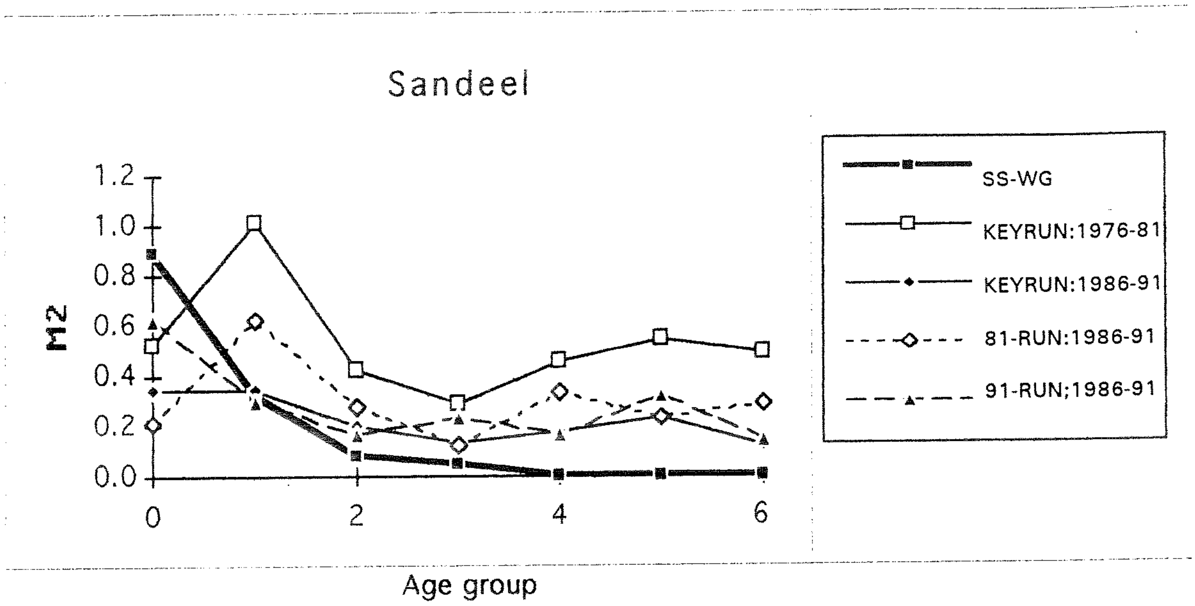
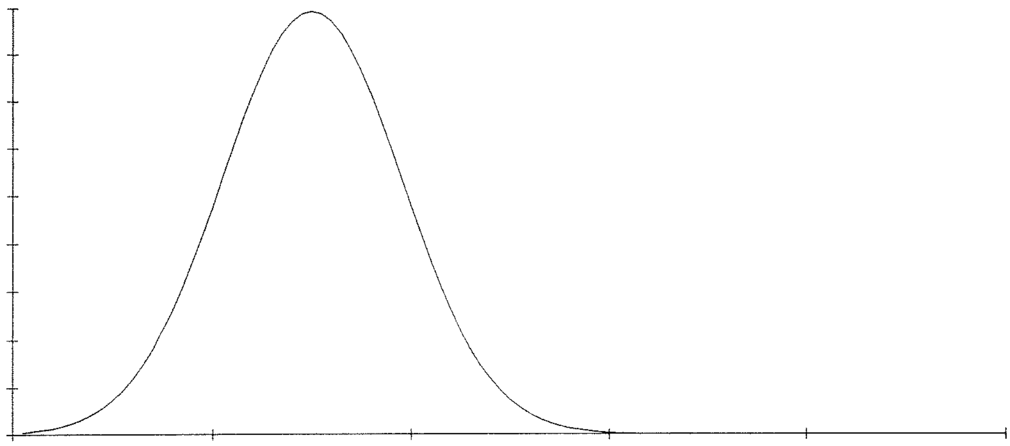
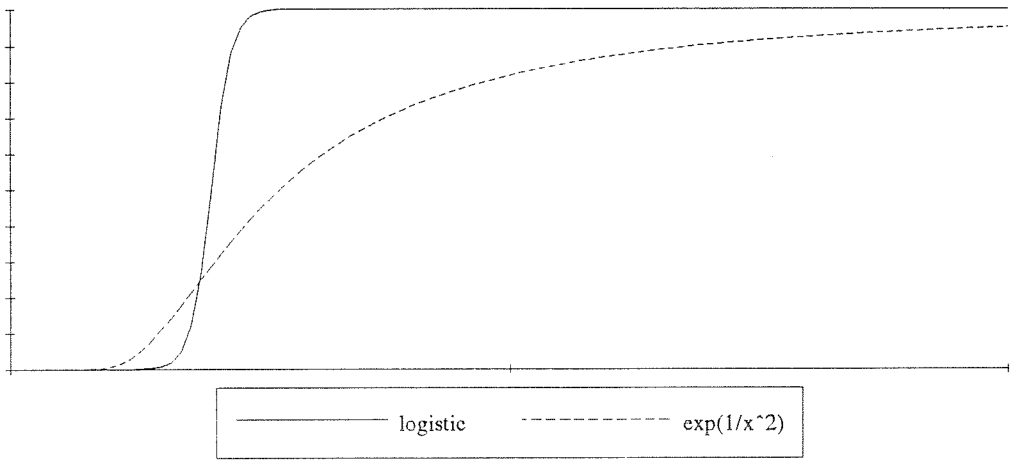


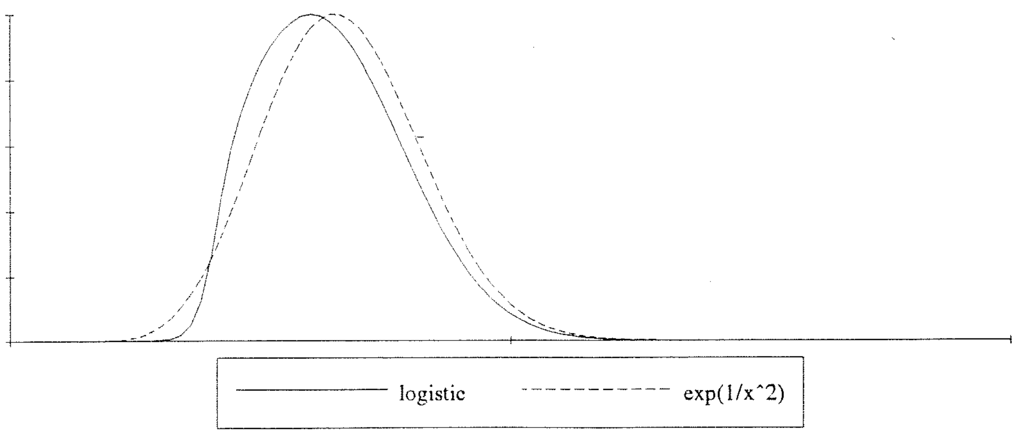
Figure 5.3.1 Comparison of the previously used size preference function (a), two multiplier functions, and the resulting size preference functions.



a: normal distribution



b: multipliers (logistic and series expansion model)



c: resulting size preference functions

Figure 6.2.1.a

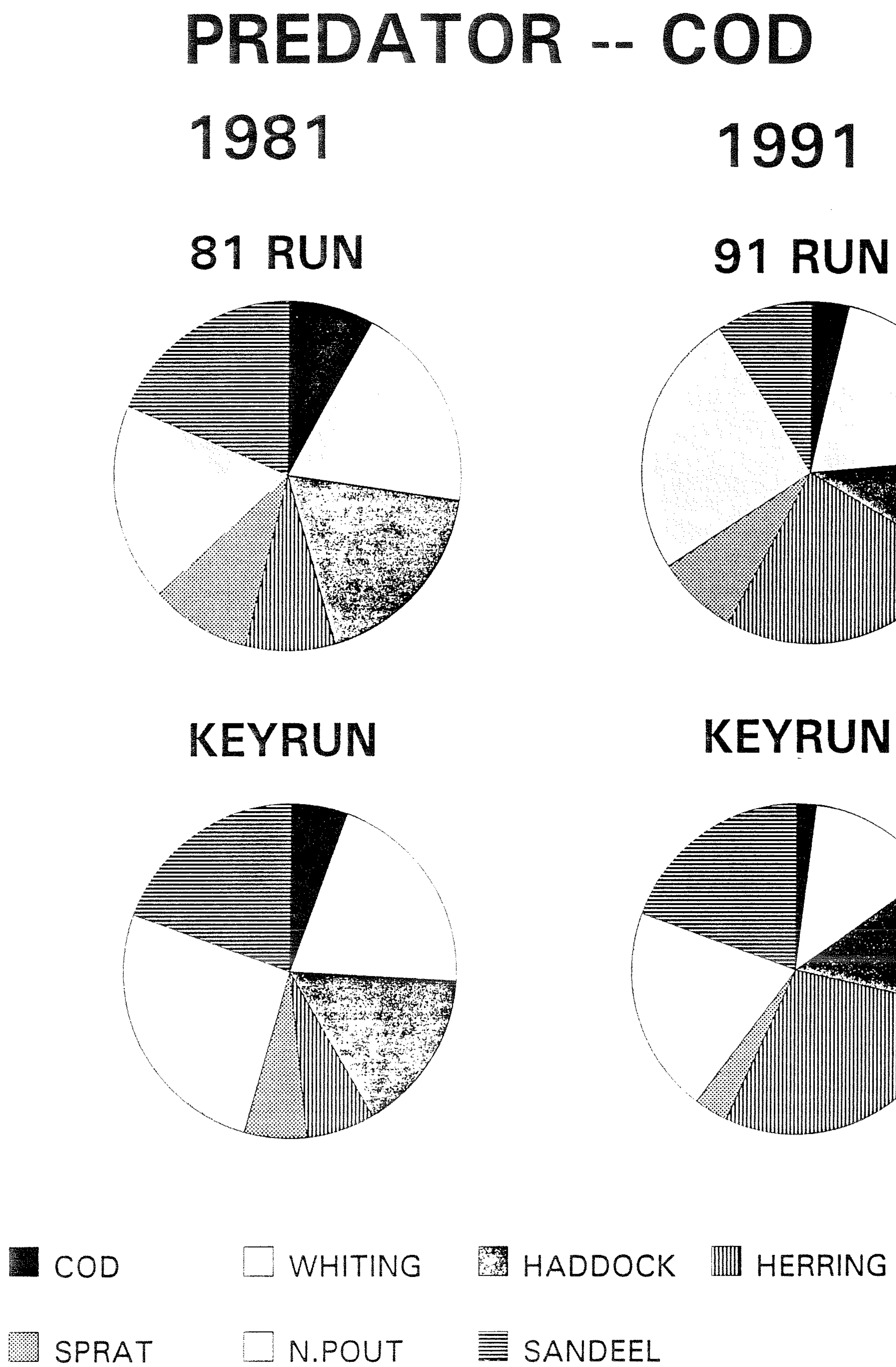

PREDATOR -- COD
1981
1991
81 RUN
91 RUN
KEYRUN
KEYRUN
COD
WHITING
HADDOCK
HERRING
SPRAT
N.POUT
SANDEEL

Figure 6.2.1.b

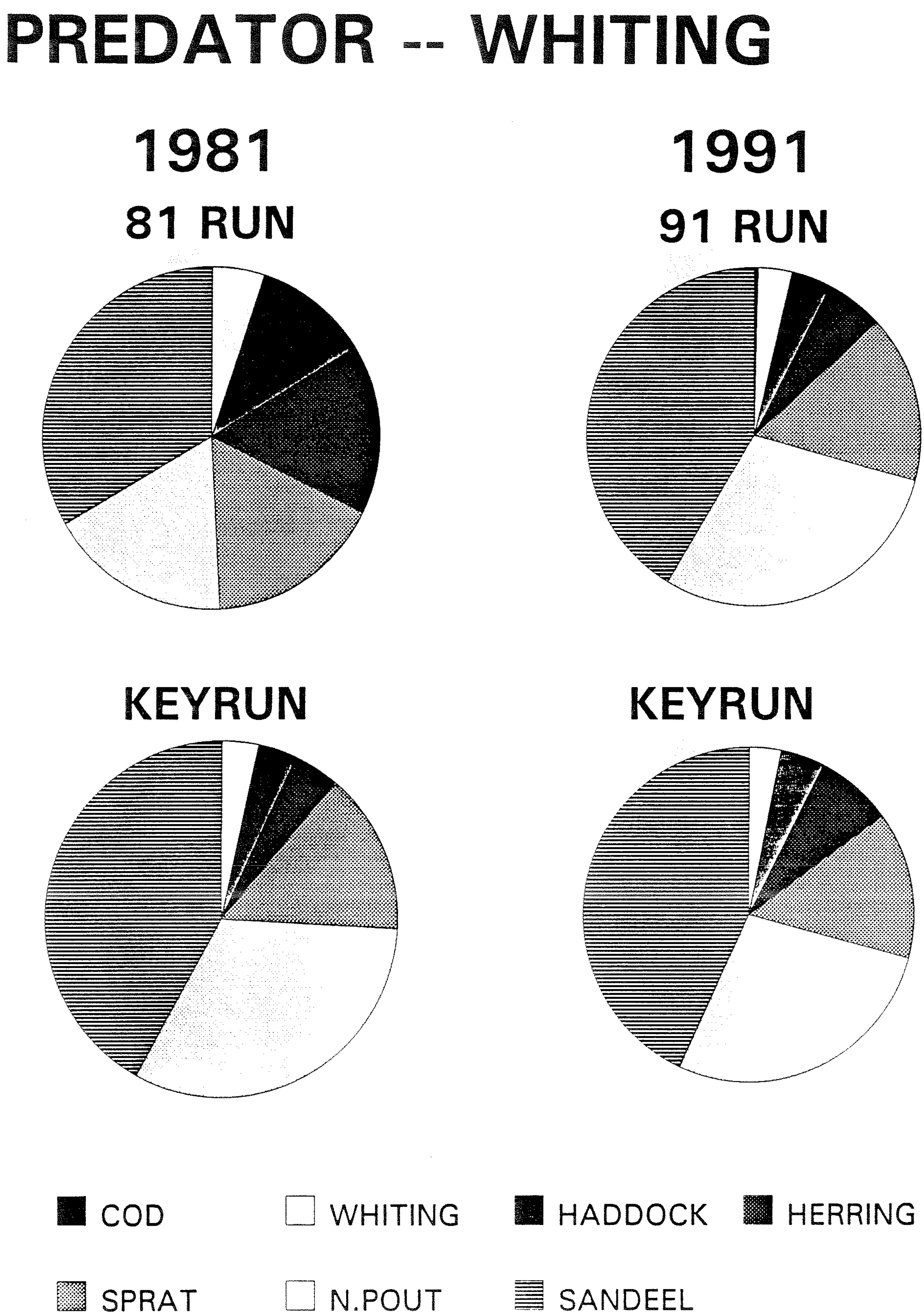
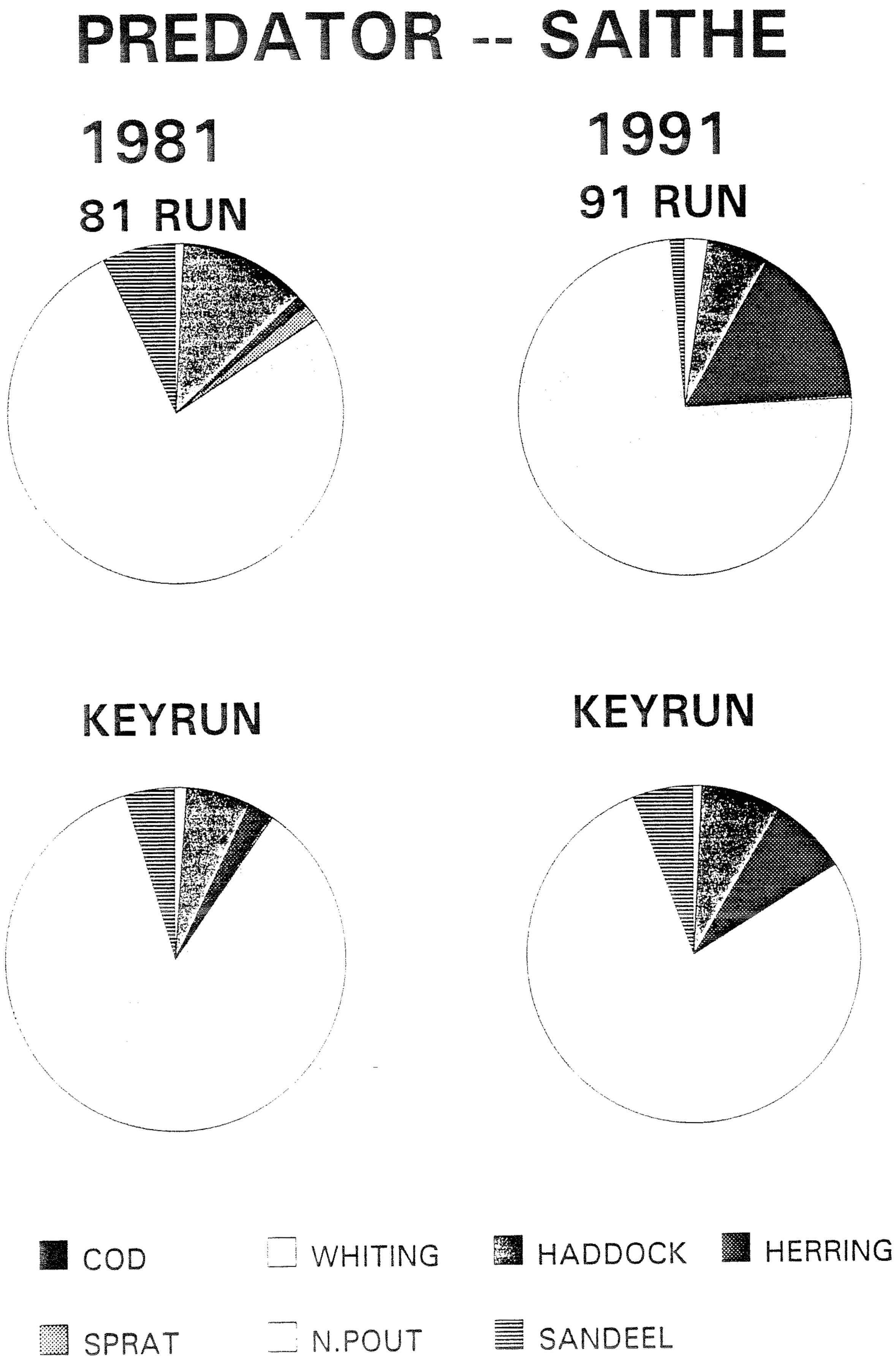
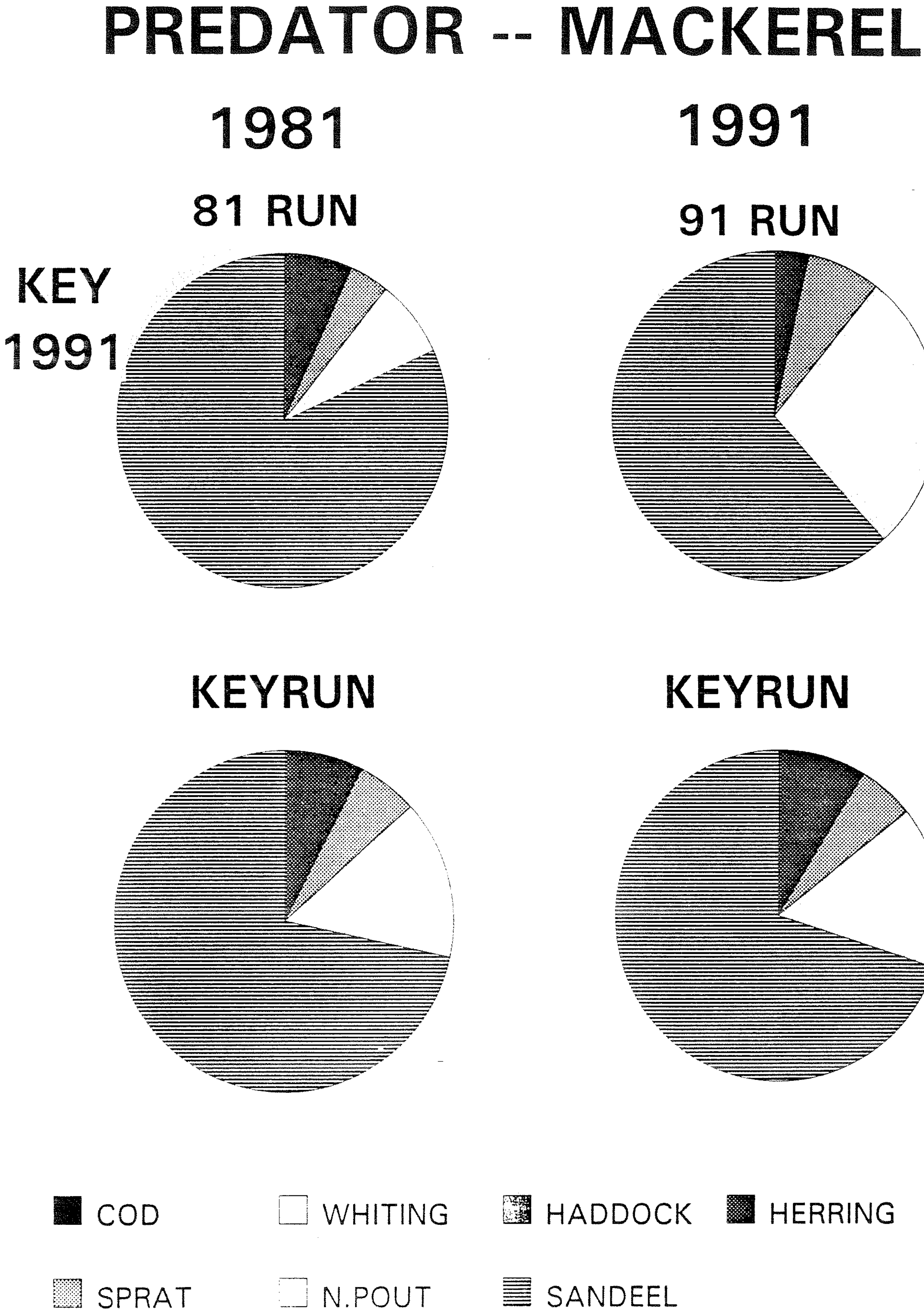

PREDATOR -- WHITING
1981
81 RUN
1991
91 RUN
KEYRUN
KEYRUN
COD
WHITING
HADDOCK
HERRING
SPRAT
N.POUT
SANDEEL

Figure 6.2.1.c



PREDATOR -- SAITHE
1981
81 RUN
1991
91 RUN
KEYRUN
KEYRUN
COD
WHITING
HADDOCK
HERRING
SPRAT
N.POUT
SANDEEL

Figure 6.2.1.d



PREDATOR -- MACKEREL
1981
1991
81 RUN
91 RUN
KEY
1991
KEYRUN
KEYRUN
COD
WHITING
HADDOCK
HERRING
SPRAT
N.POUT
SANDEEL

Figure 6.2.1.e

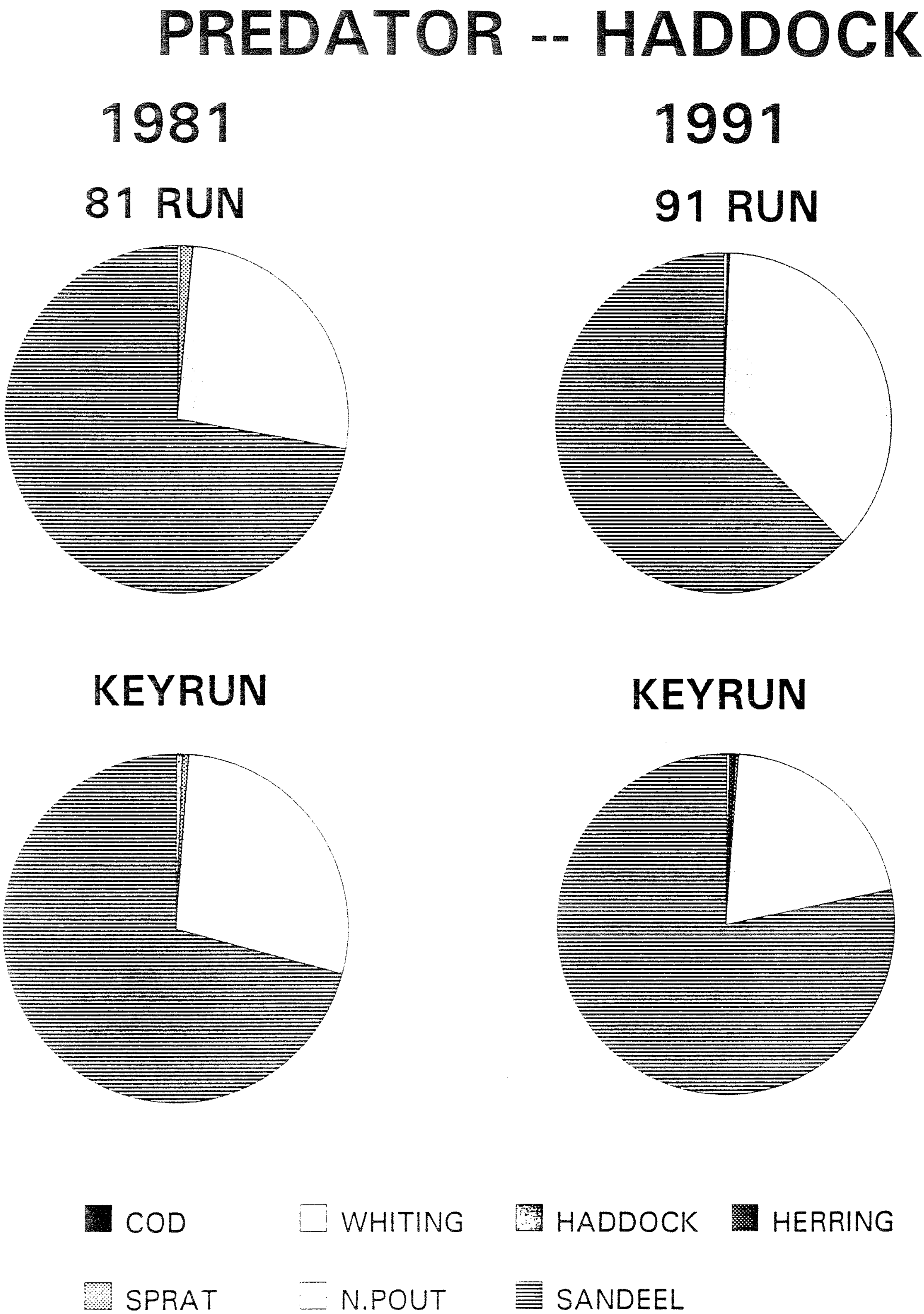
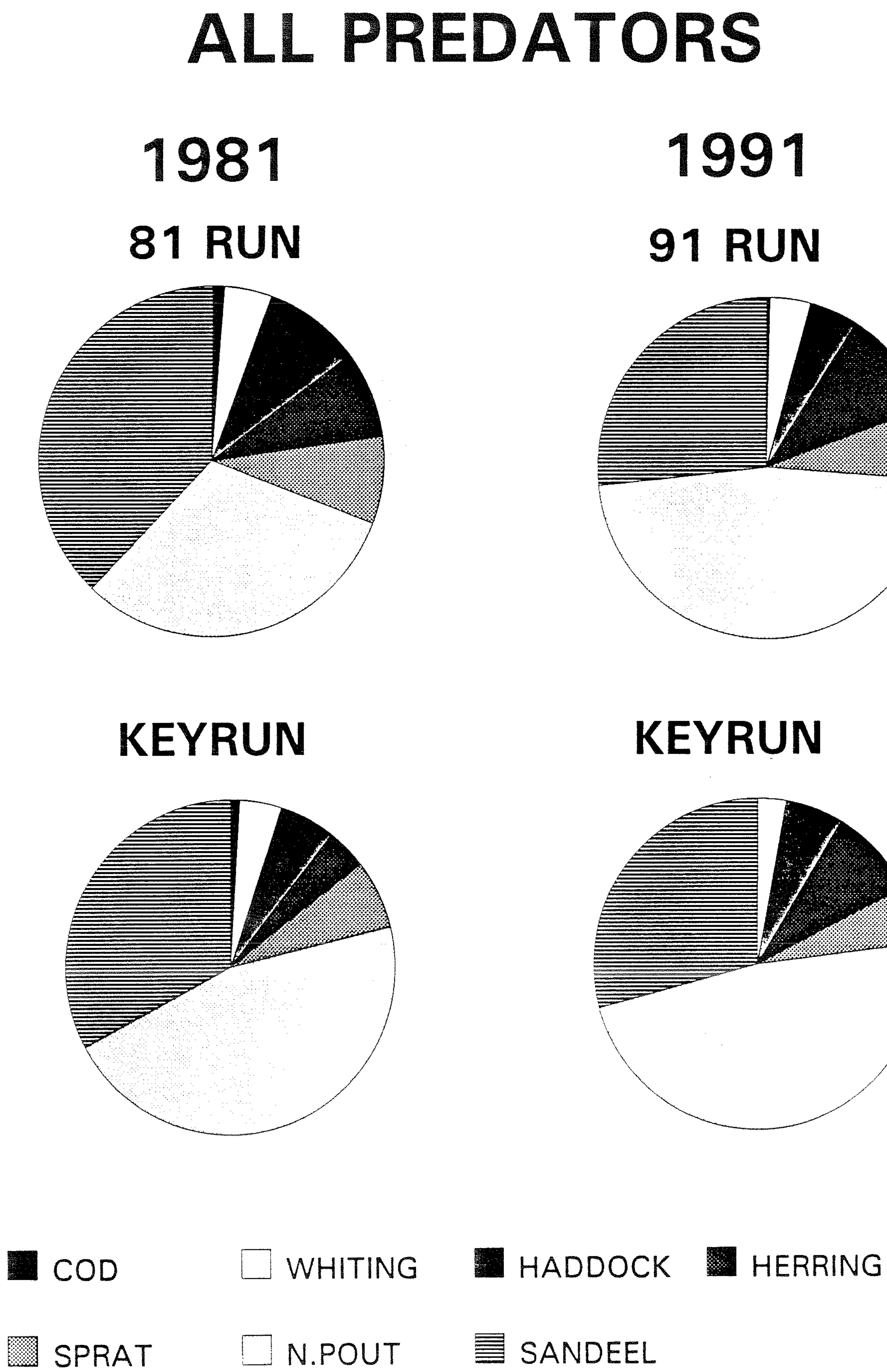

PREDATOR -- HADDOCK
1981
81 RUN
1991
91 RUN
KEYRUN
KEYRUN
COD
WHITING
HADDOCK
HERRING
SPRAT
N.POUT
SANDEEL

Figure 6.2.1.f


ALL PREDATORS
1981
81 RUN
1991
91 RUN
KEYRUN
KEYRUN
COD
WHITING
HADDOCK
HERRING
SPRAT
N.POUT
SANDEEL

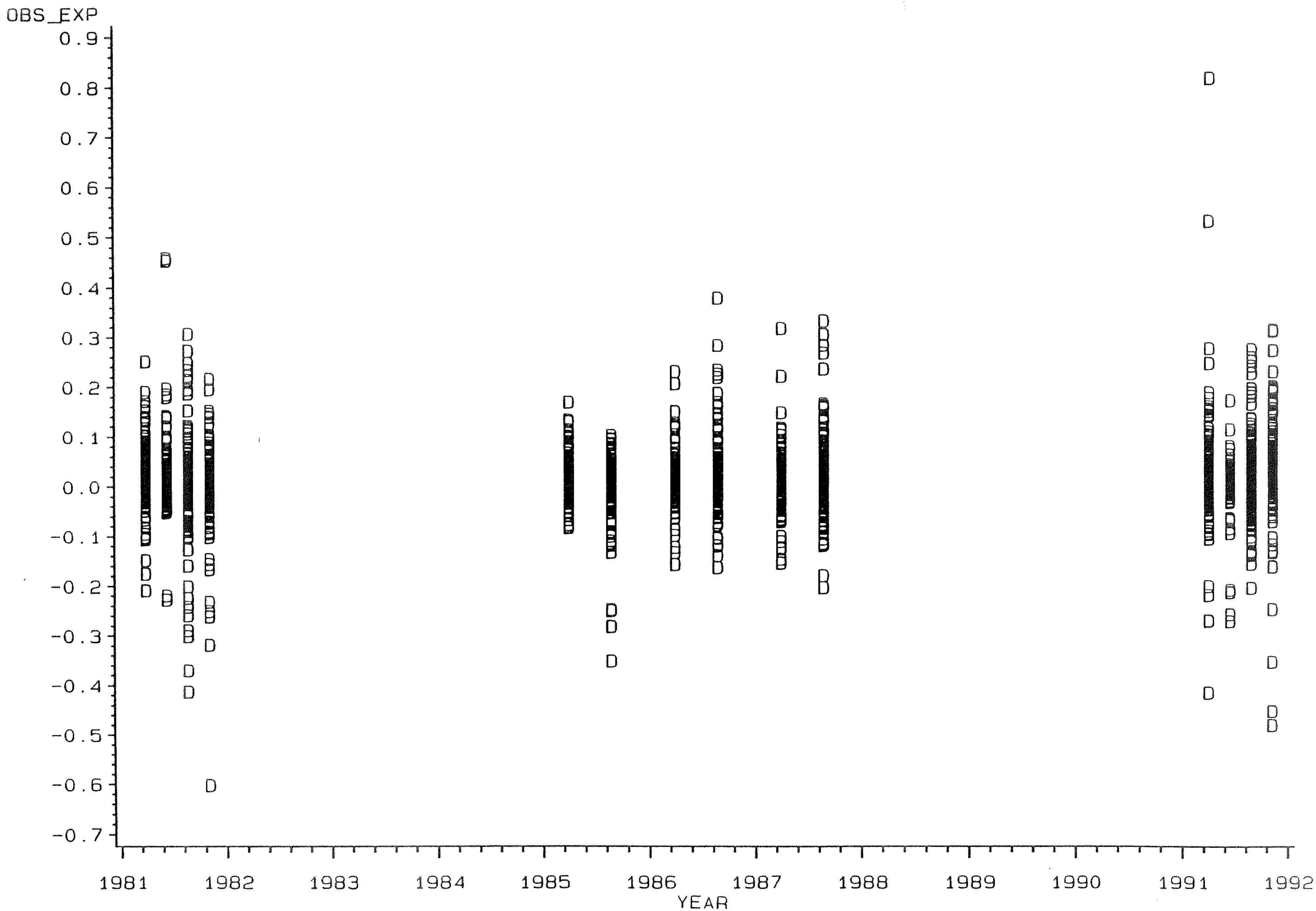
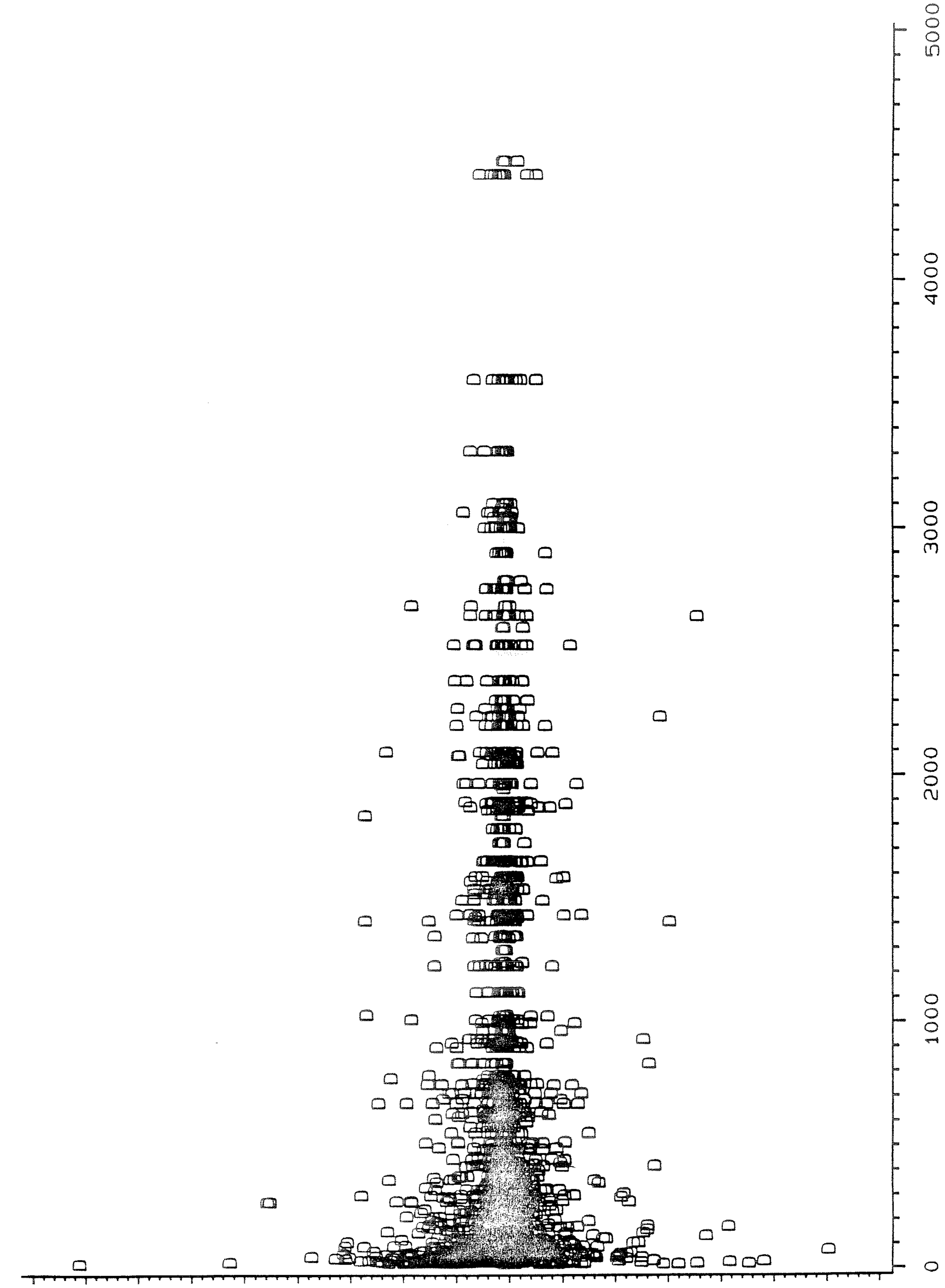


Figure 6.2.2.a Observed - expected proportion of prey in diet for all quarter - predator - age- prey - age combinations, vs year in which observations were made.


OBS_EXP
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
0
1000
2000
3000
4000
5000
NSTOM

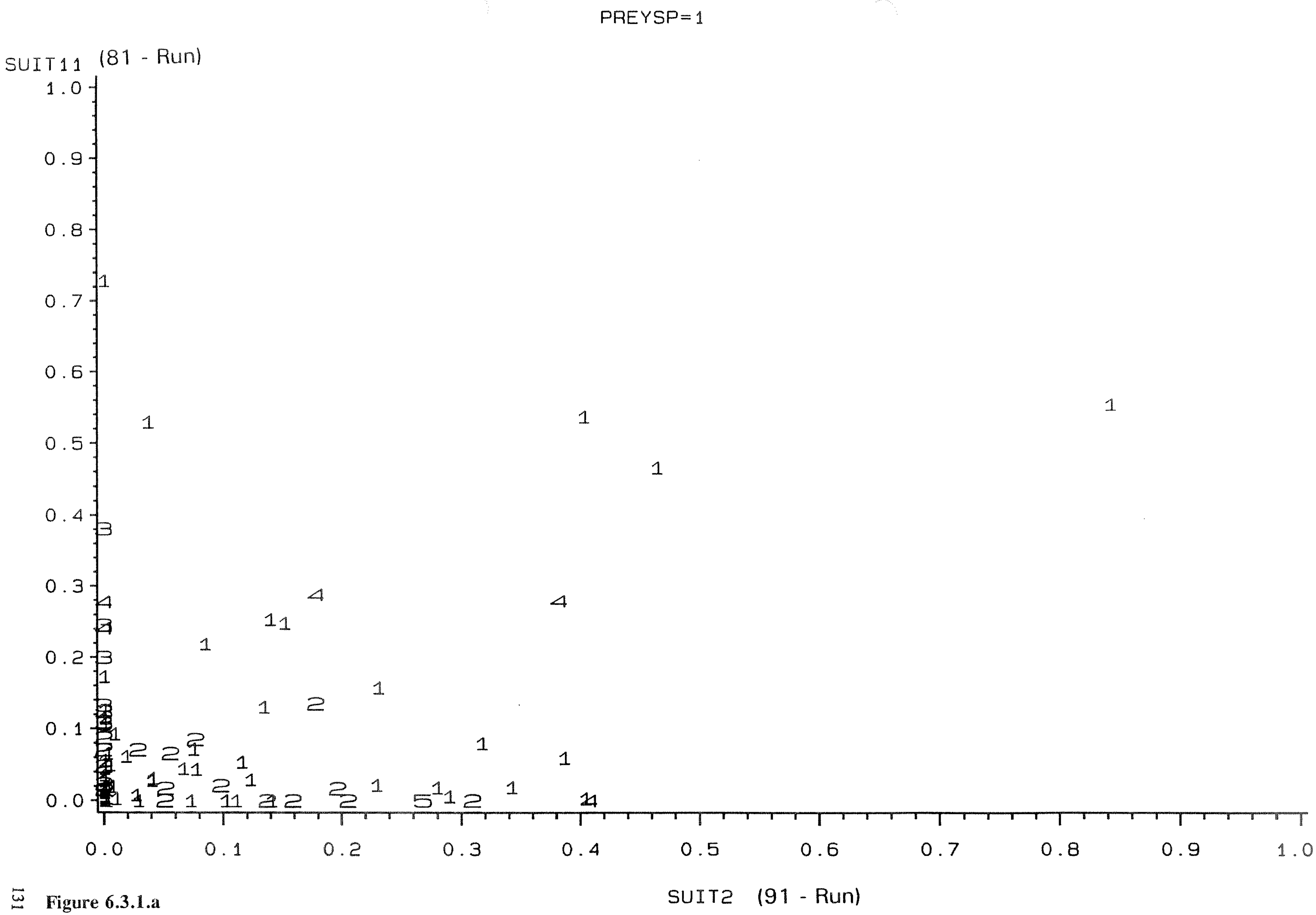


Figure 6.3.1.a

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

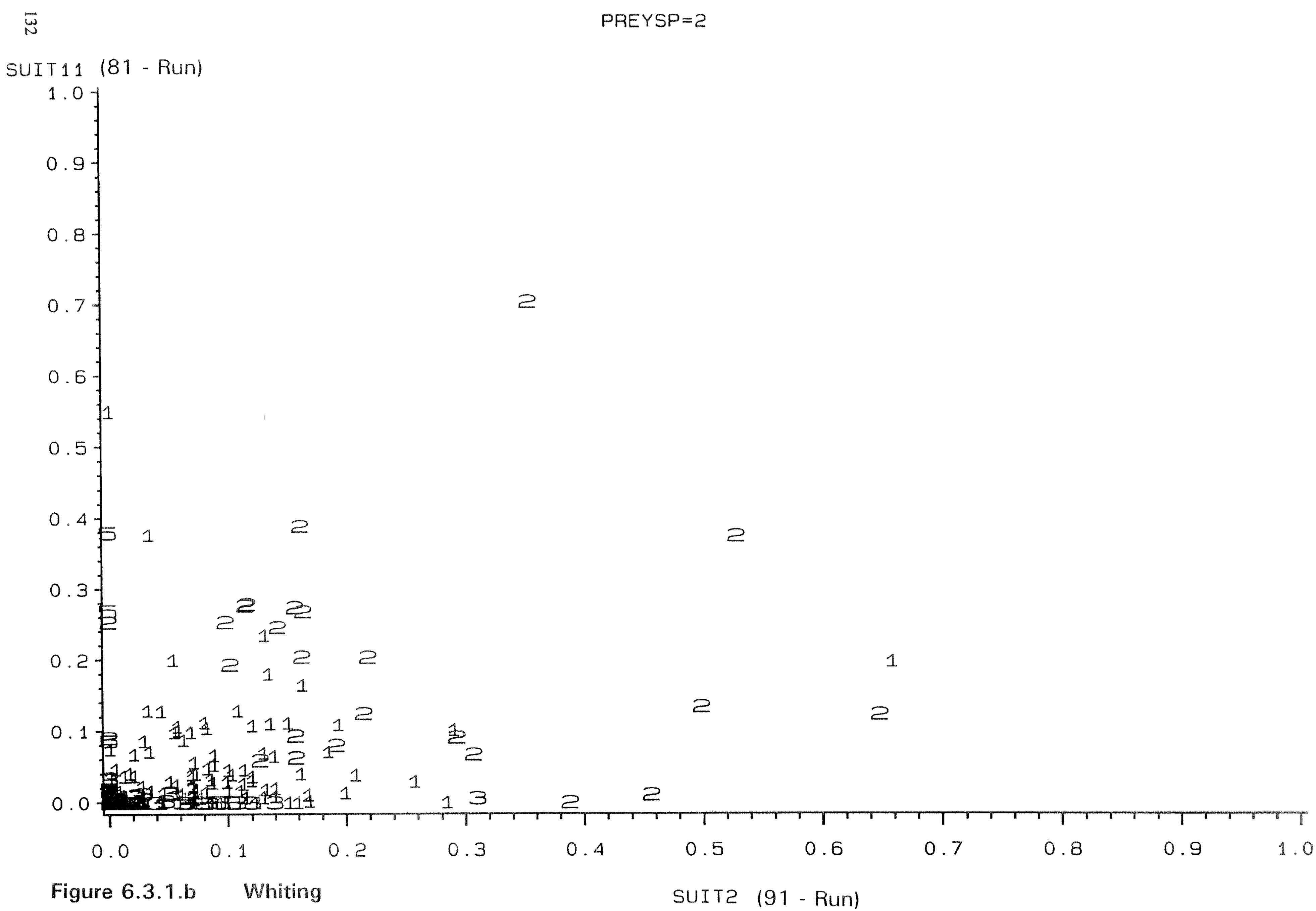


Figure 6.3.1.b Whiting

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

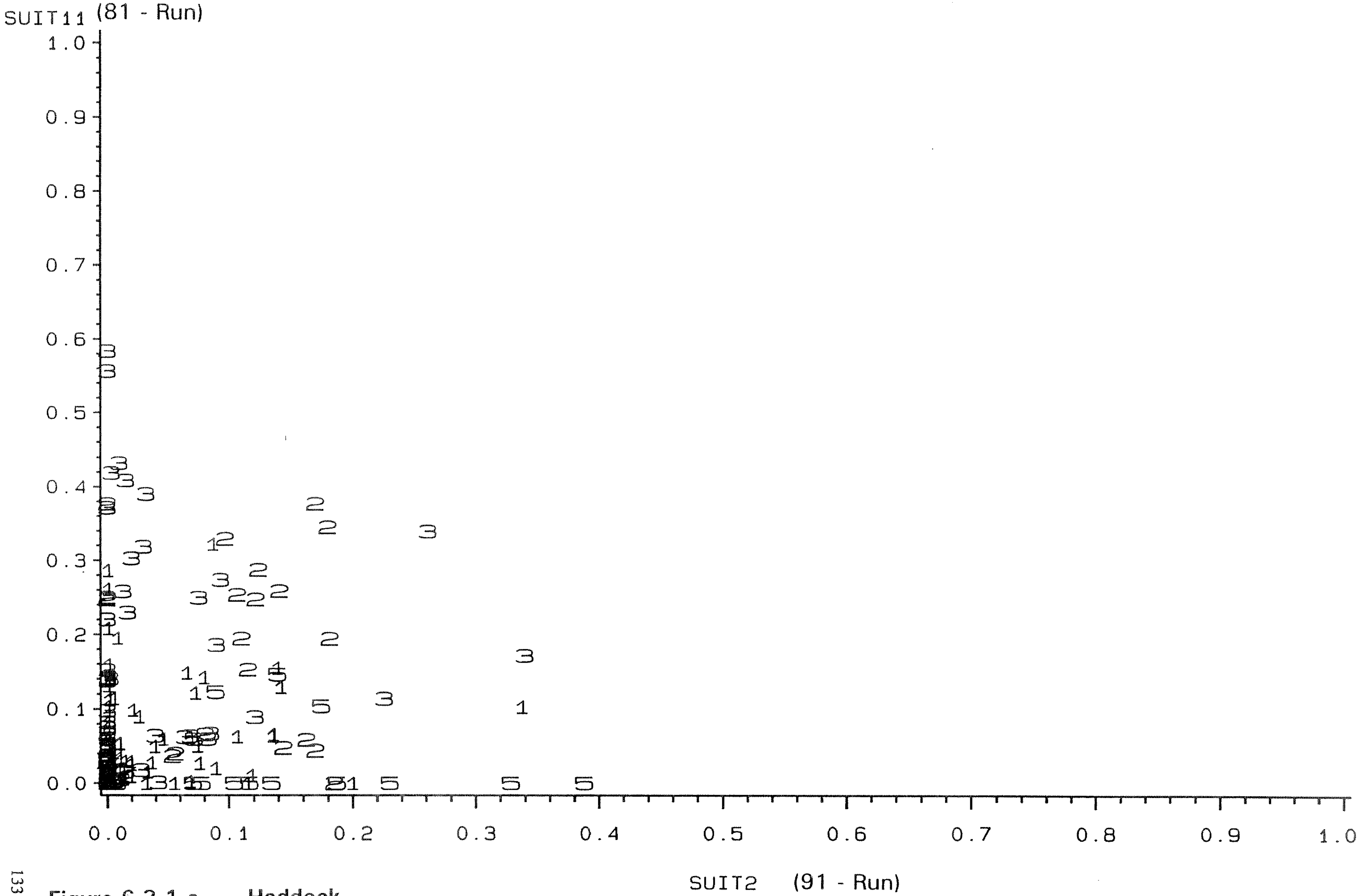


Figure 6.3.1.c **Haddock**

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

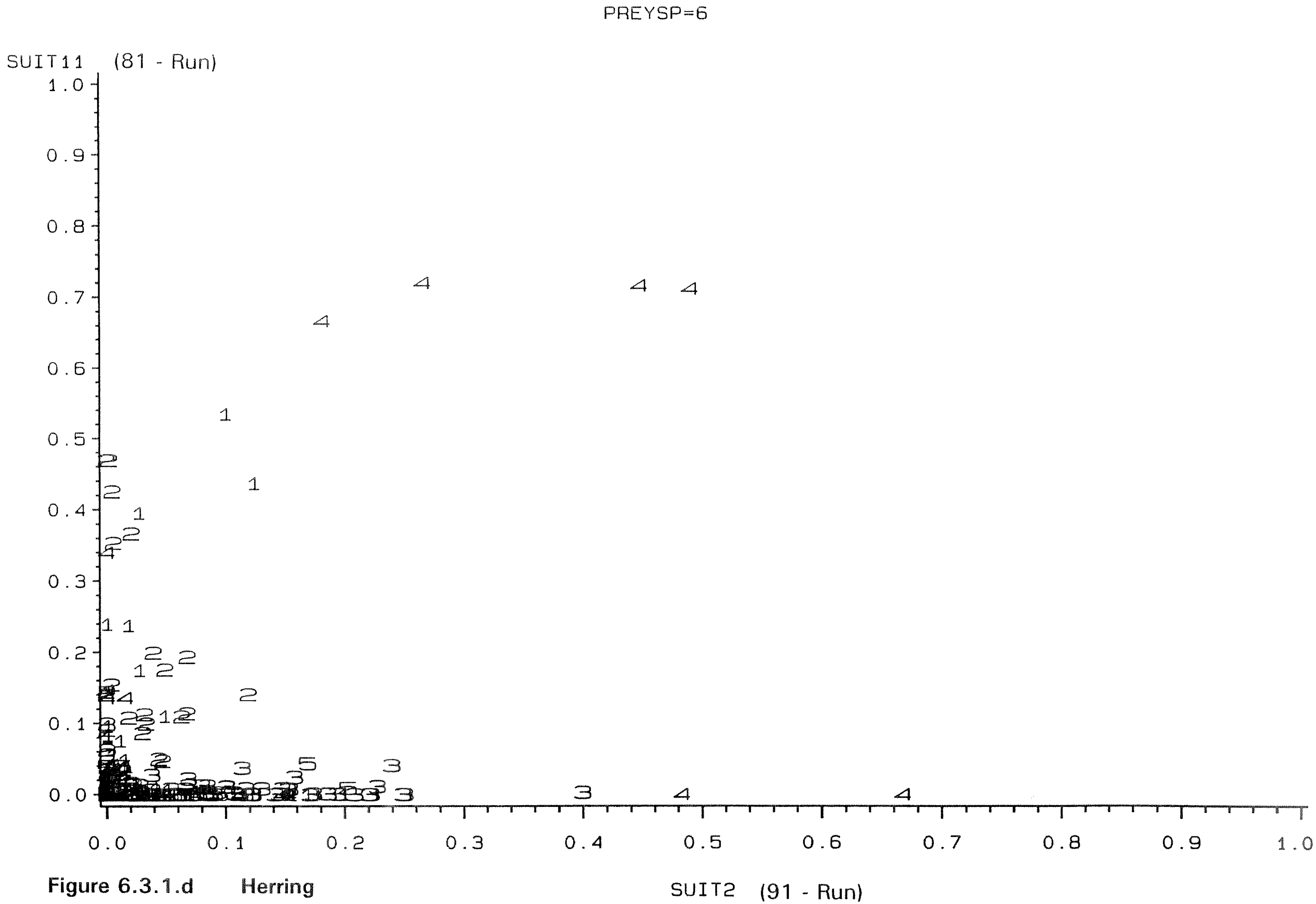


Figure 6.3.1.d **Herring**

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

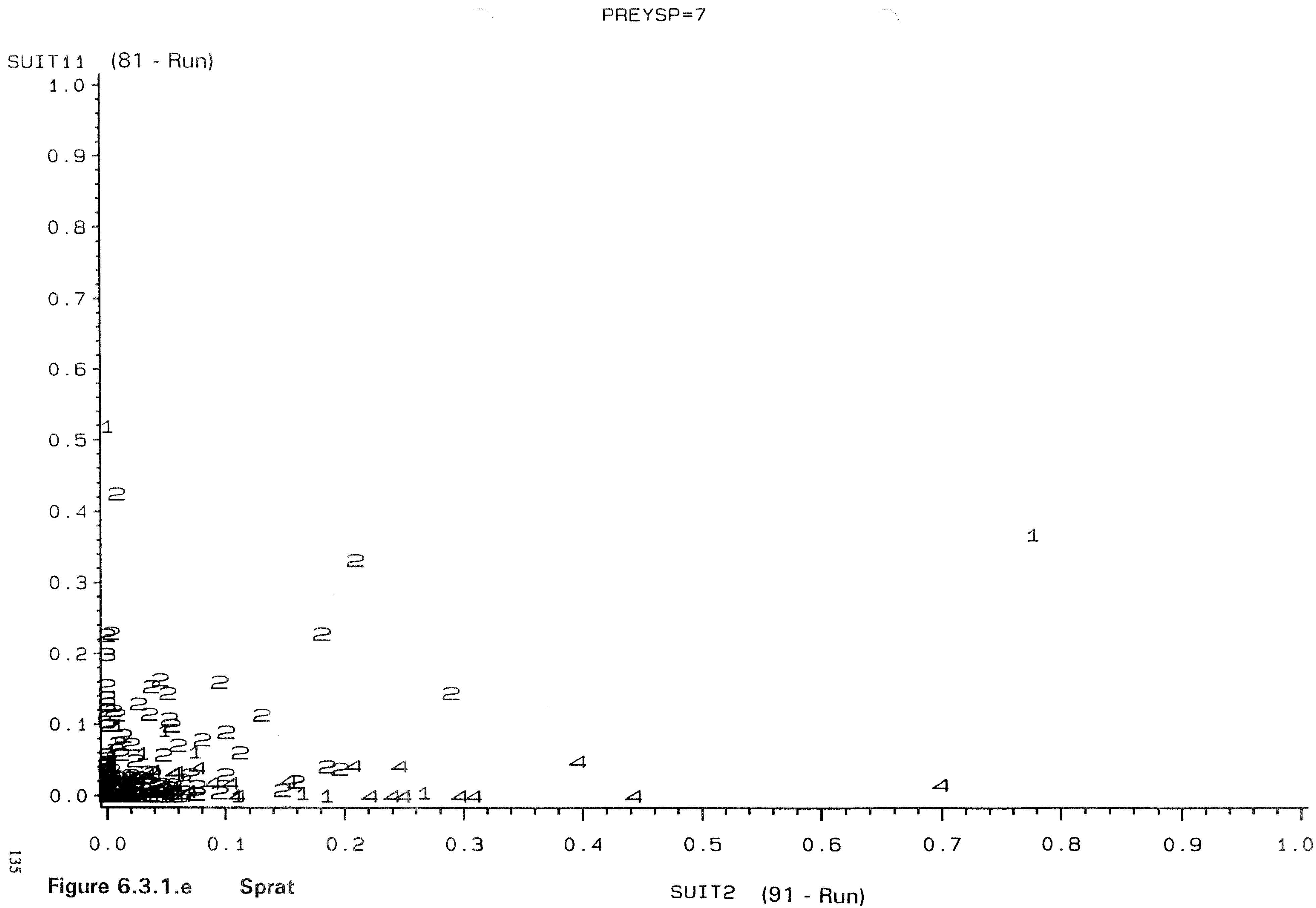


Figure 6.3.1.e **Sprat**

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

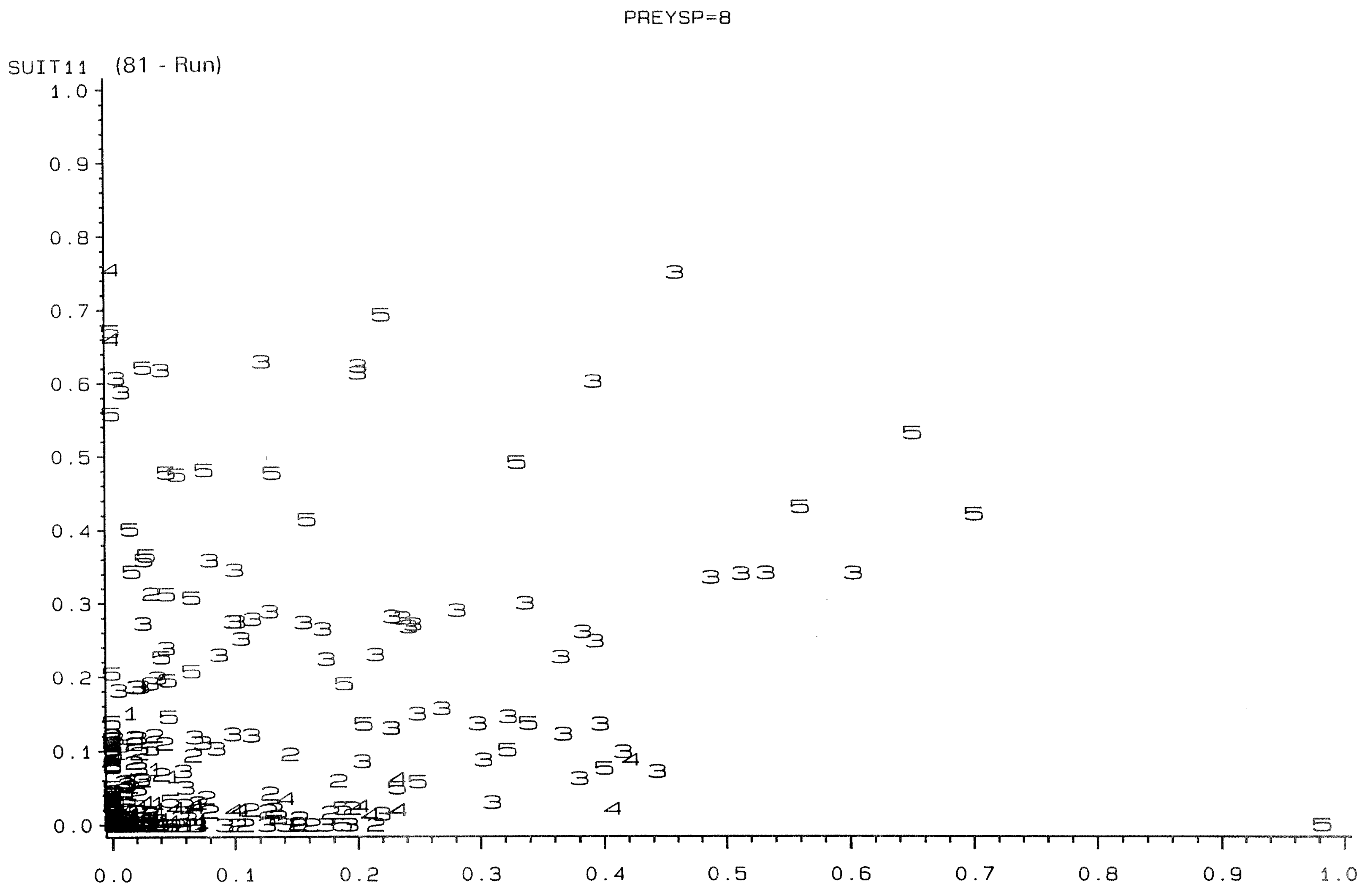


Figure 6.3.1.f **Norway Pout**

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

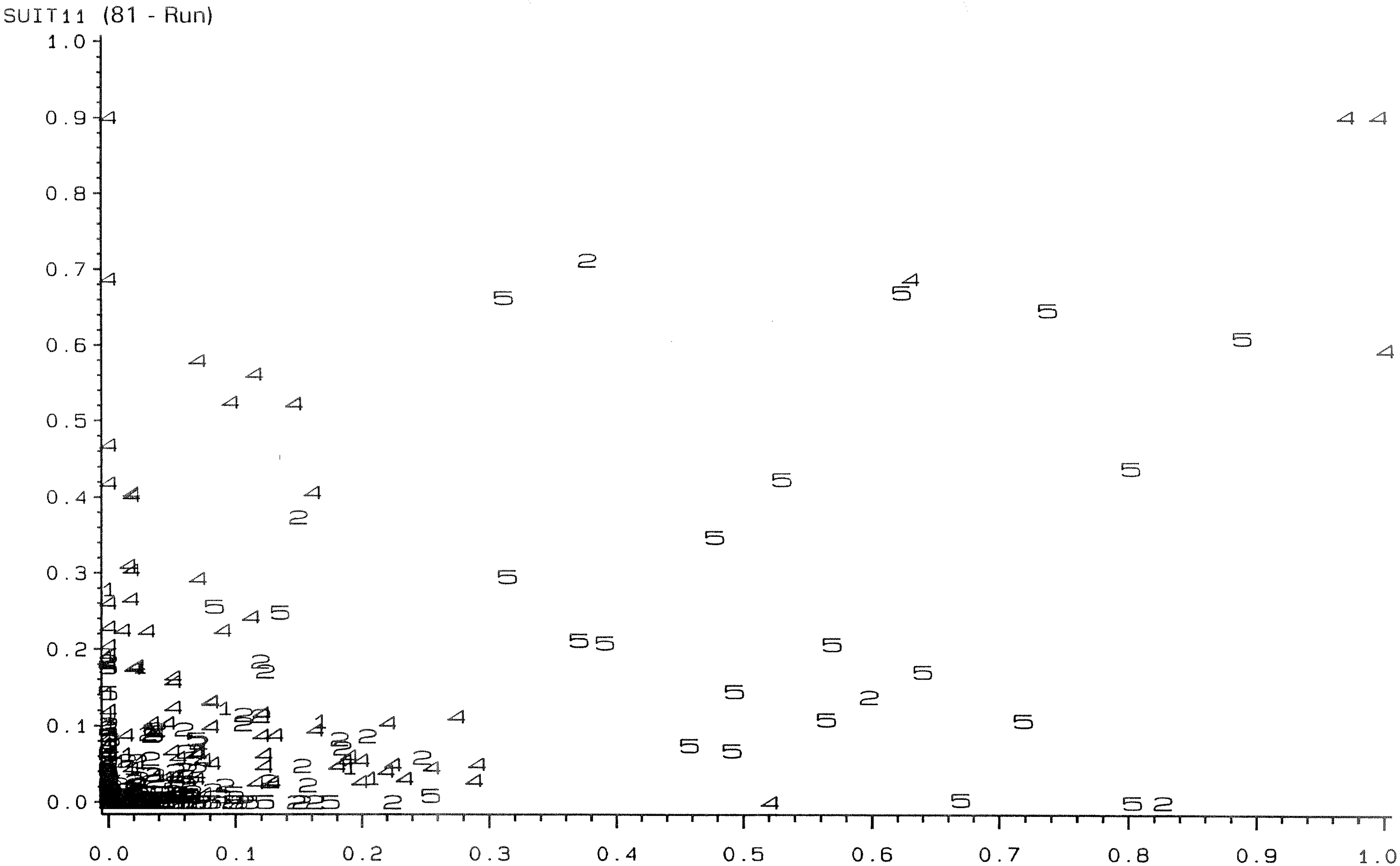


Figure 6.3.1.g **Sandeel**

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock, 6=herring, 7=sprat, 8=norway pout, 9=sandeel

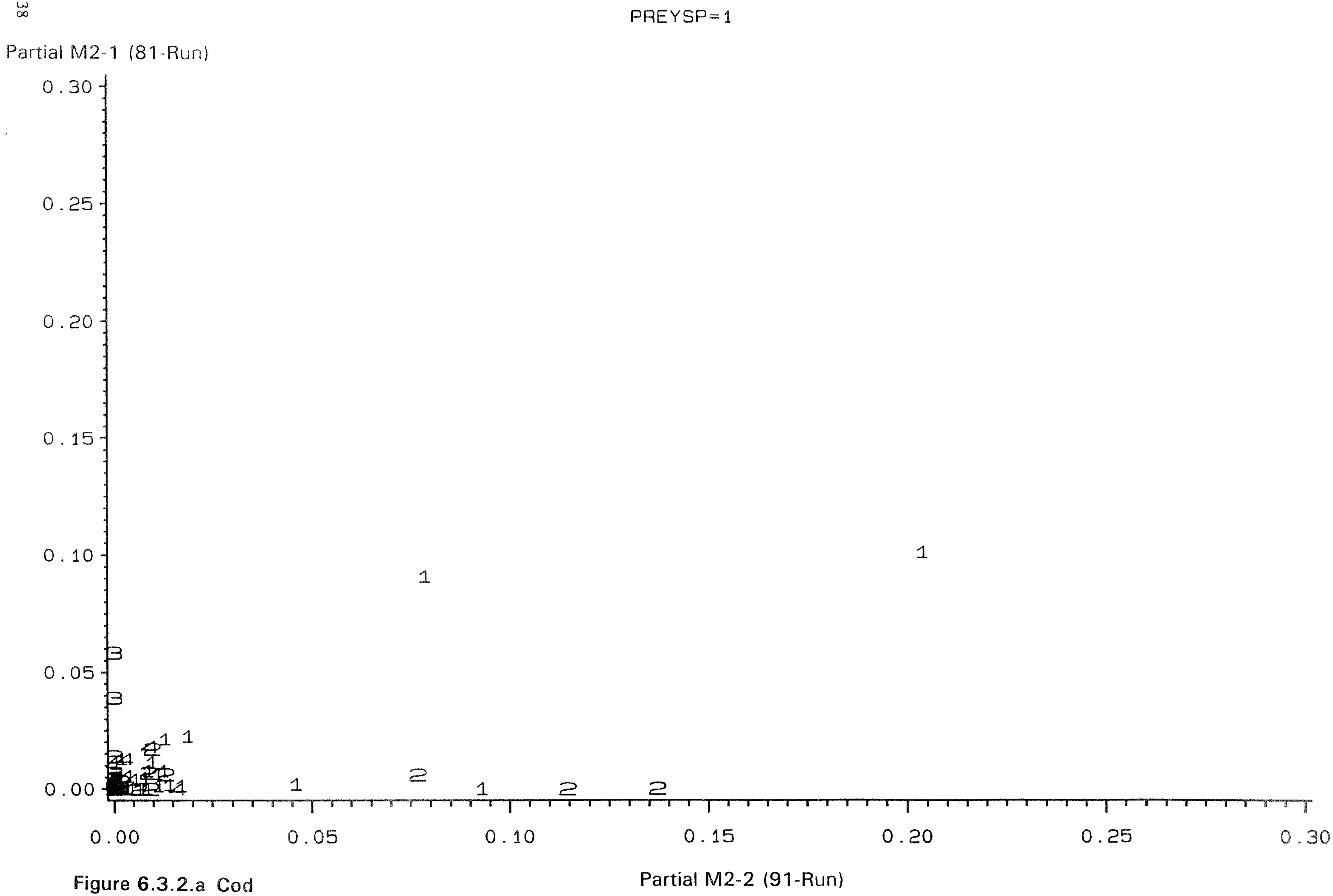


Figure 6.3.2.a Cod

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock, ...

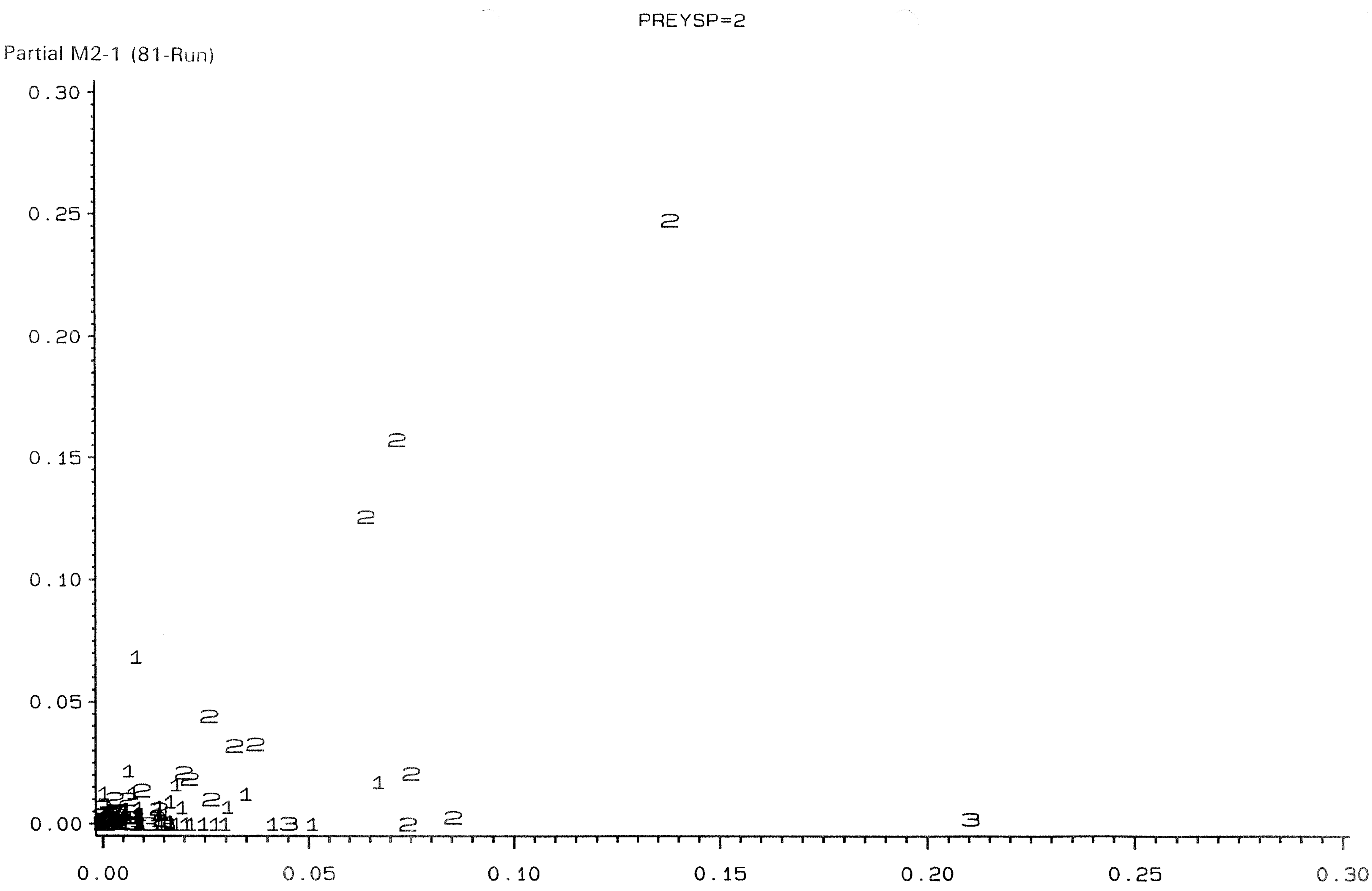


Figure 6.3.2.b Whiting

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

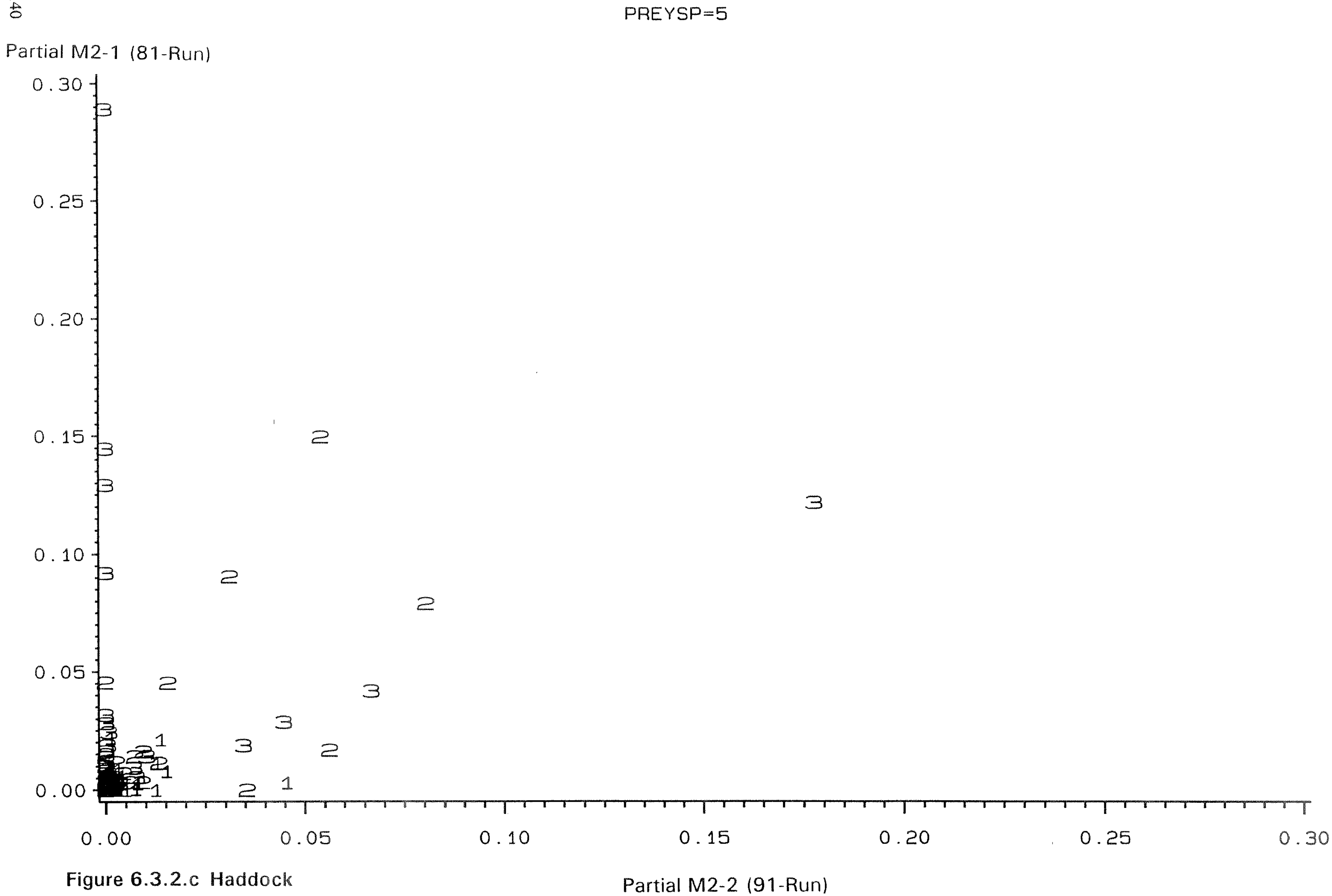


Figure 6.3.2.c Haddock

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

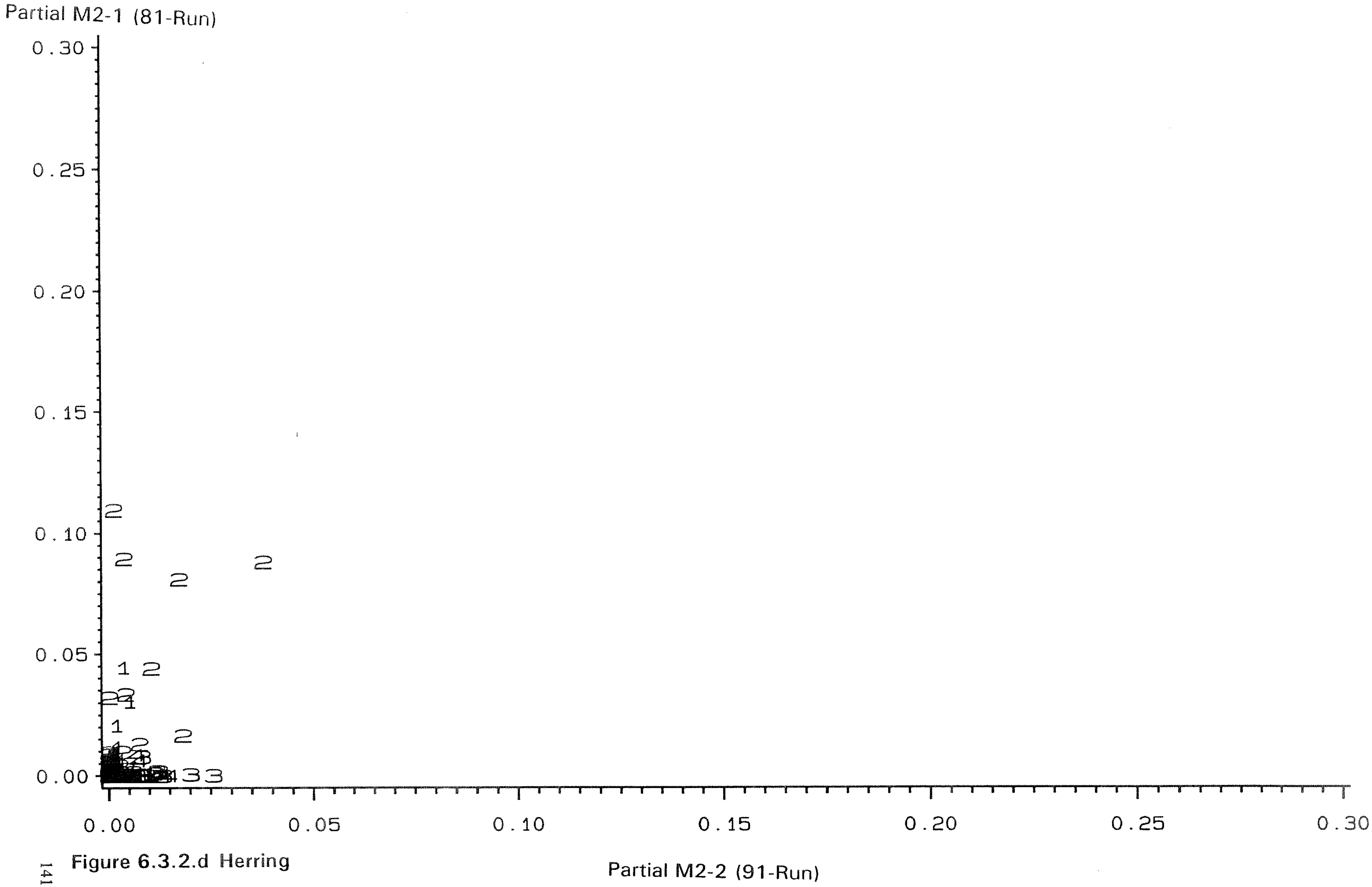


Figure 6.3.2.d Herring

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

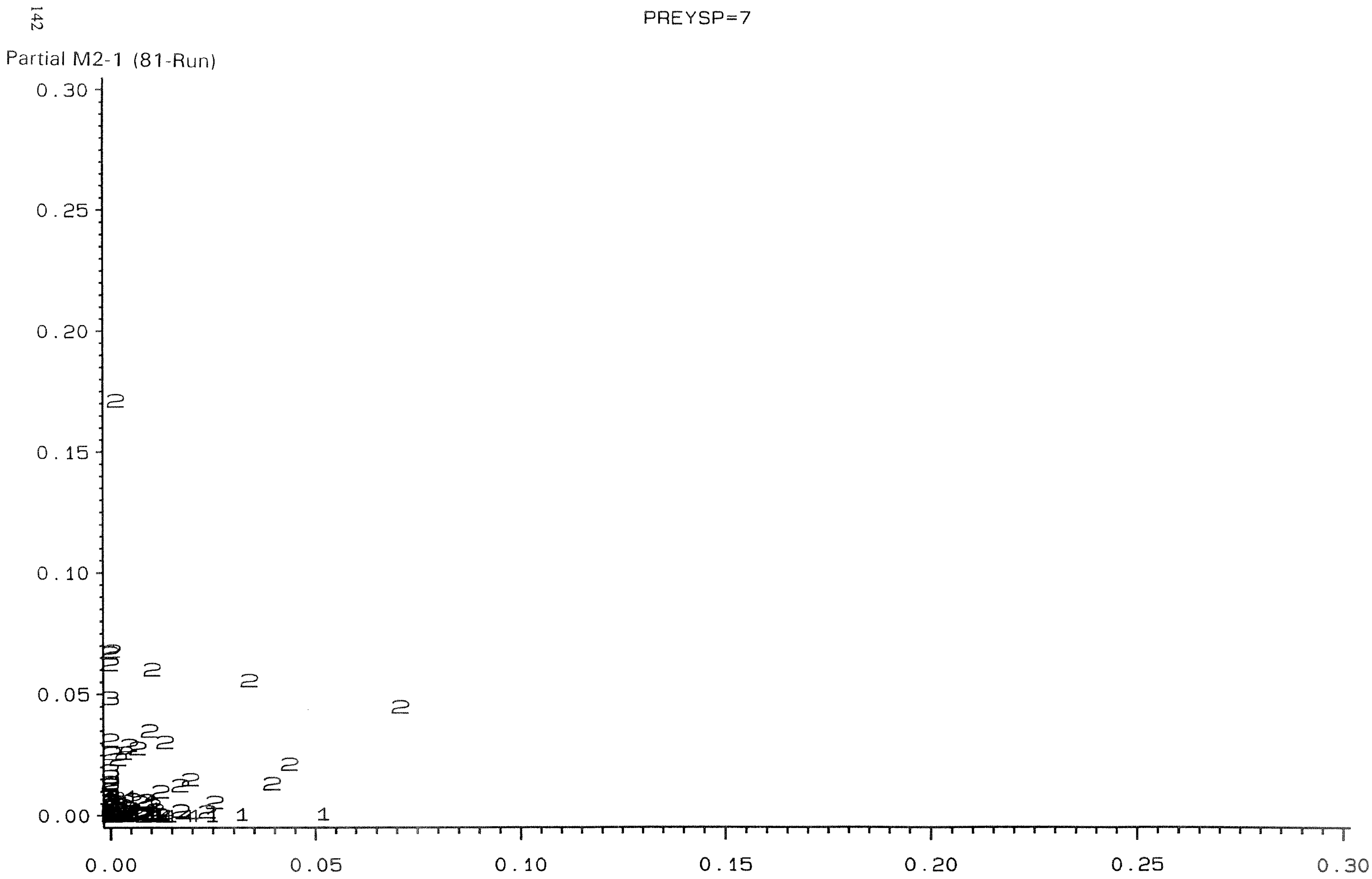


Figure 6.3.2.e Sprat

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

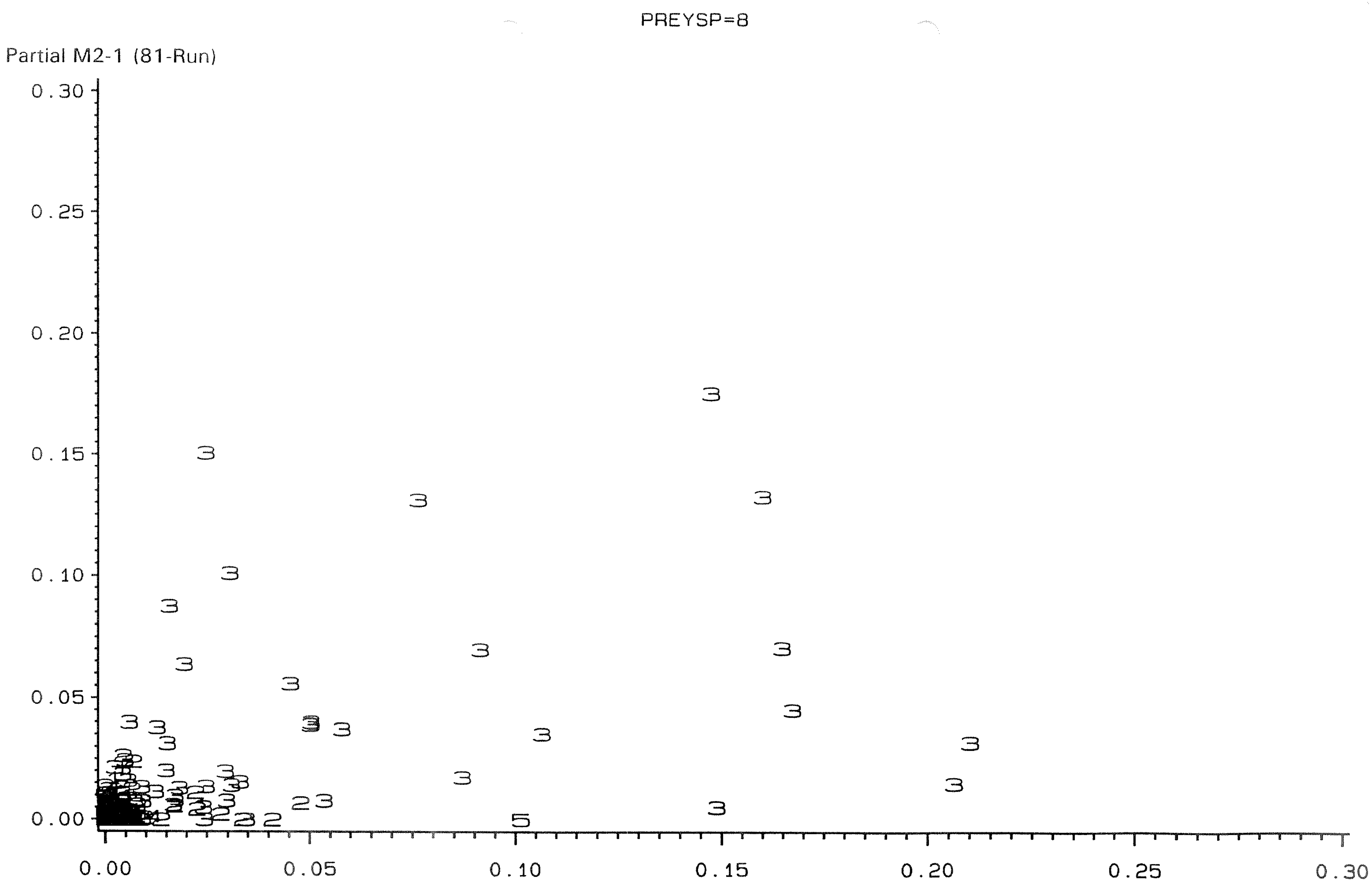


Figure 6.3.2.f Norway Pout

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

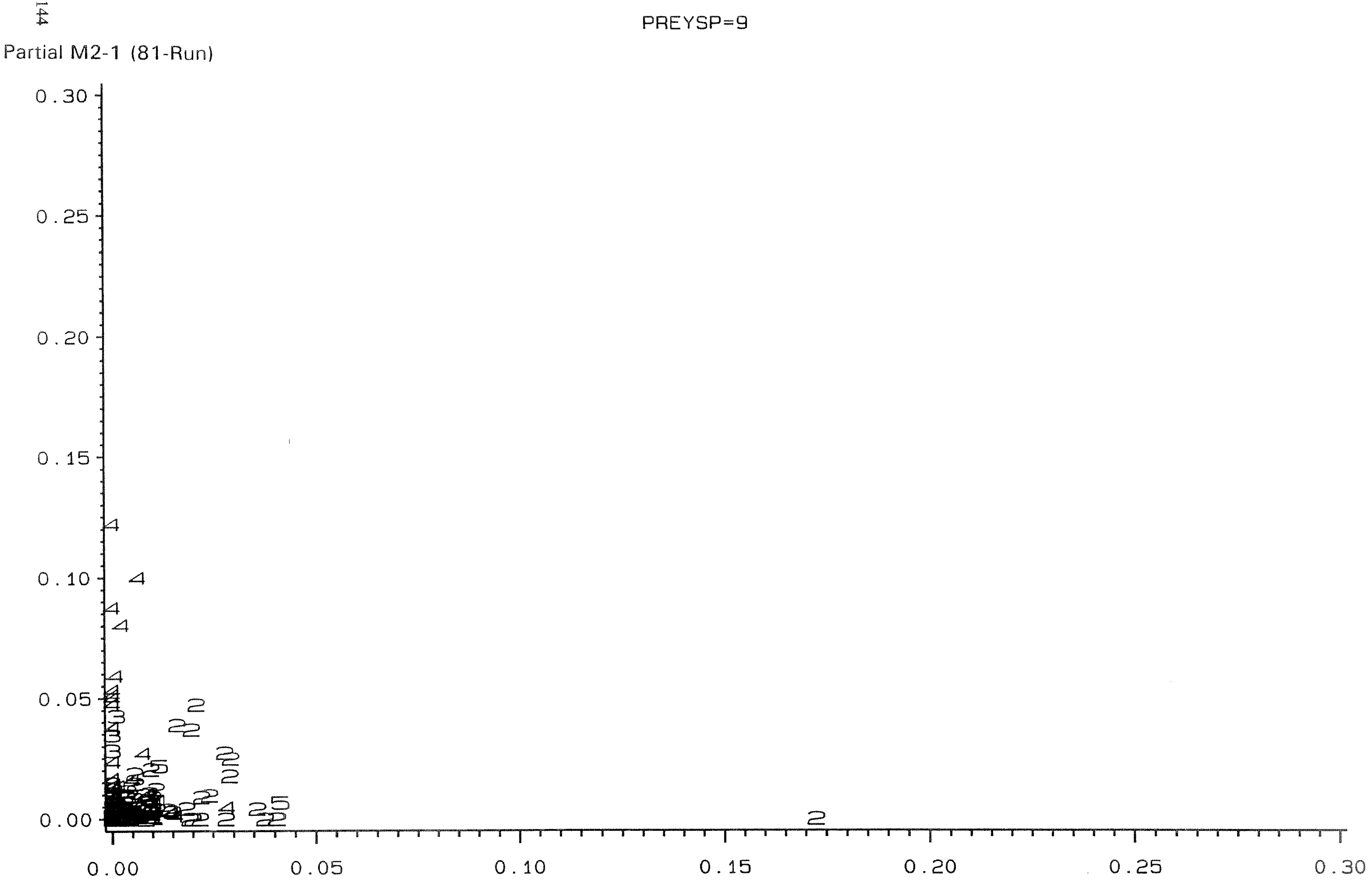


Figure 6.3.2.g Sandeel

1=cod, 2=whiting, 3=saithe, 4=mackerel, 5=haddock,

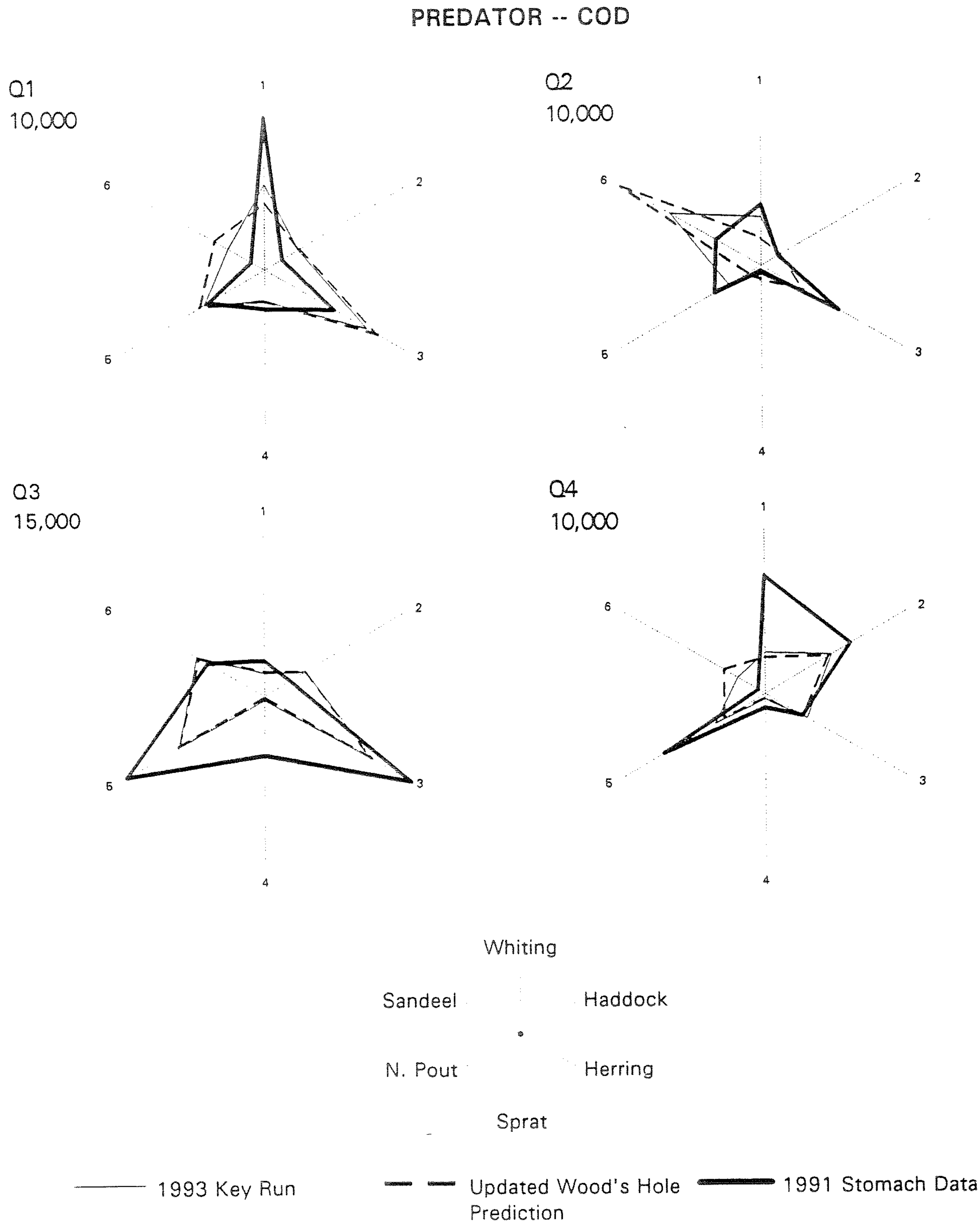


Figure 6.4.1.a Cod

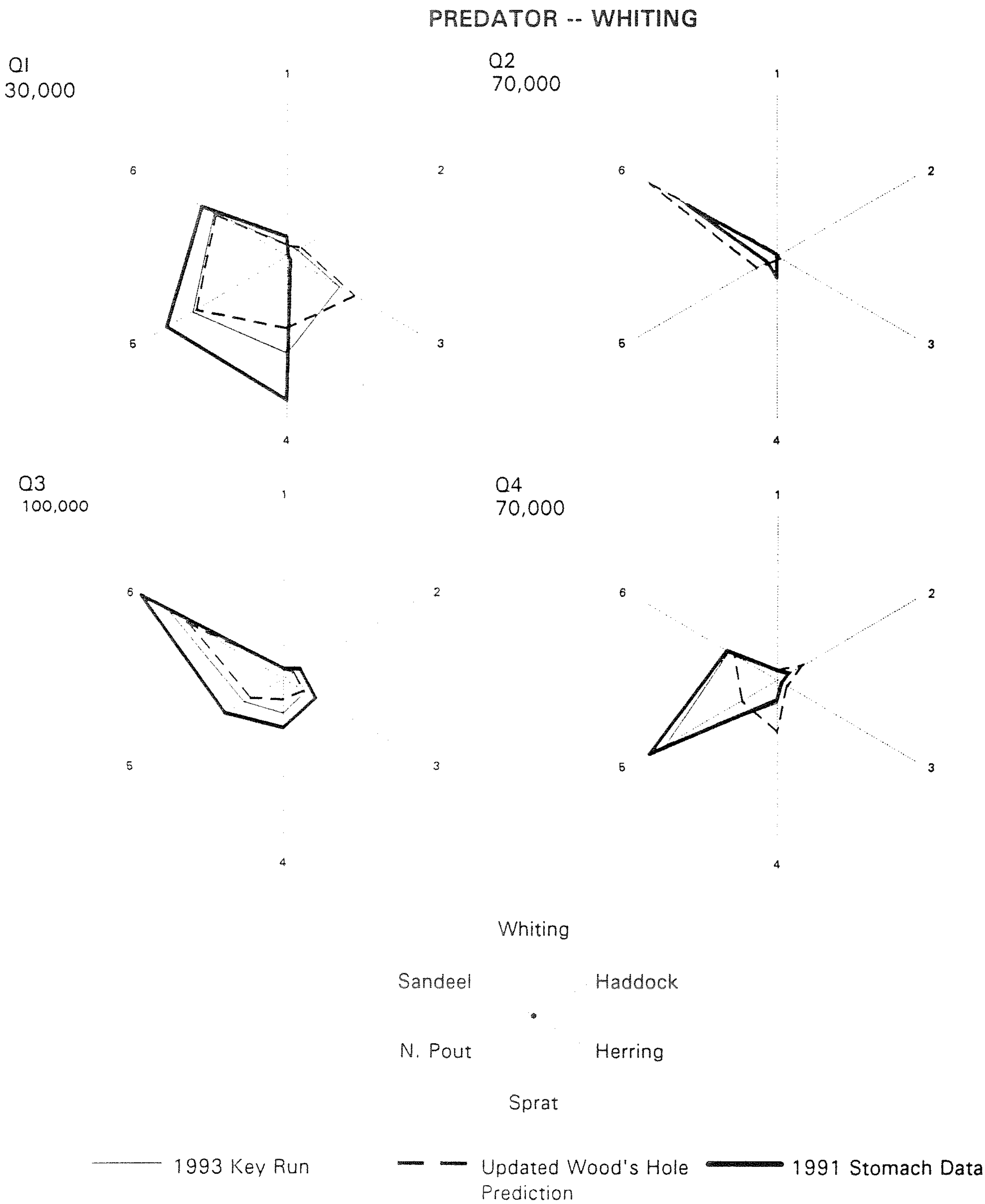


Figure 6.4.1.b Whiting

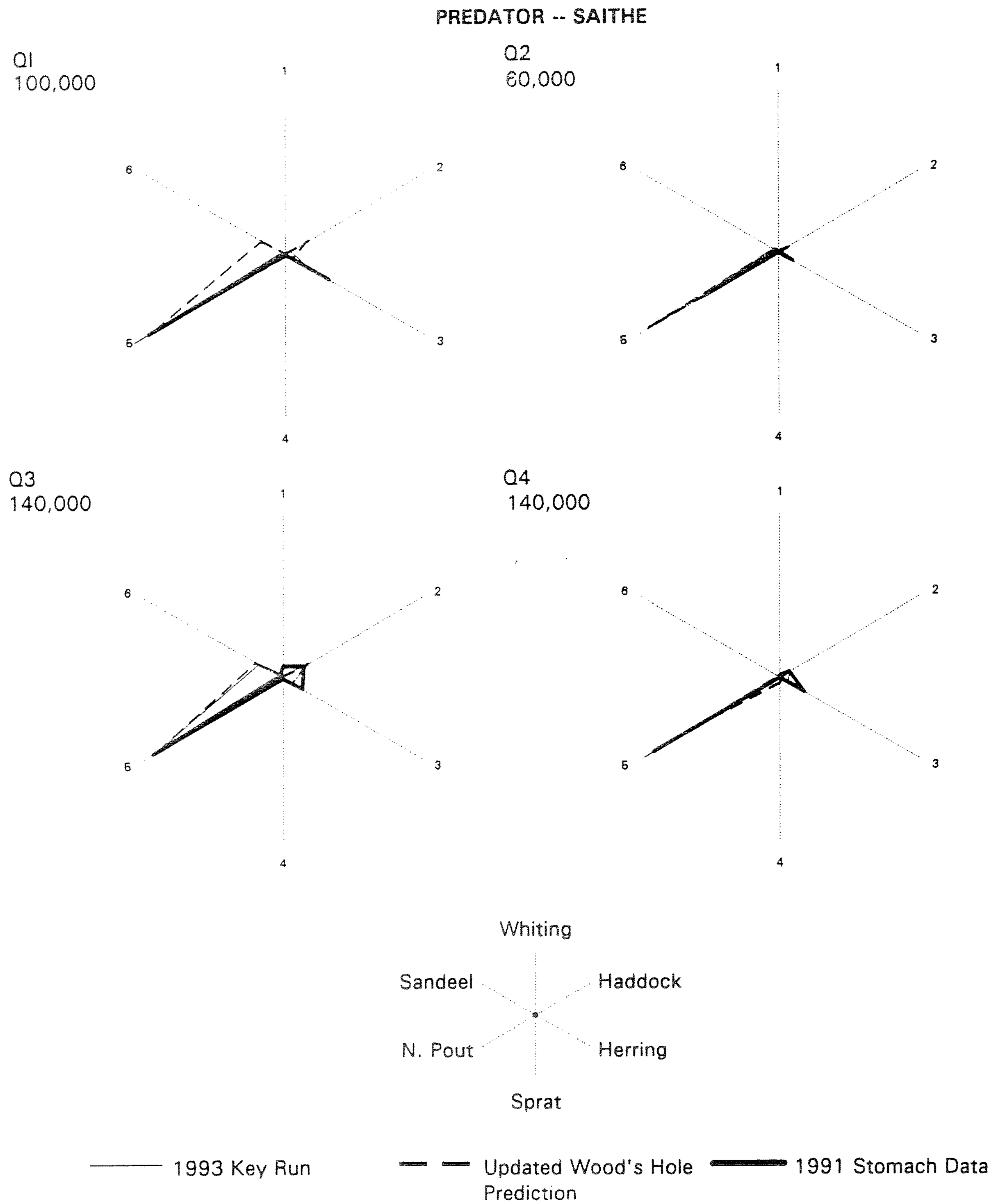


Figure 6.4.1.c Saithe

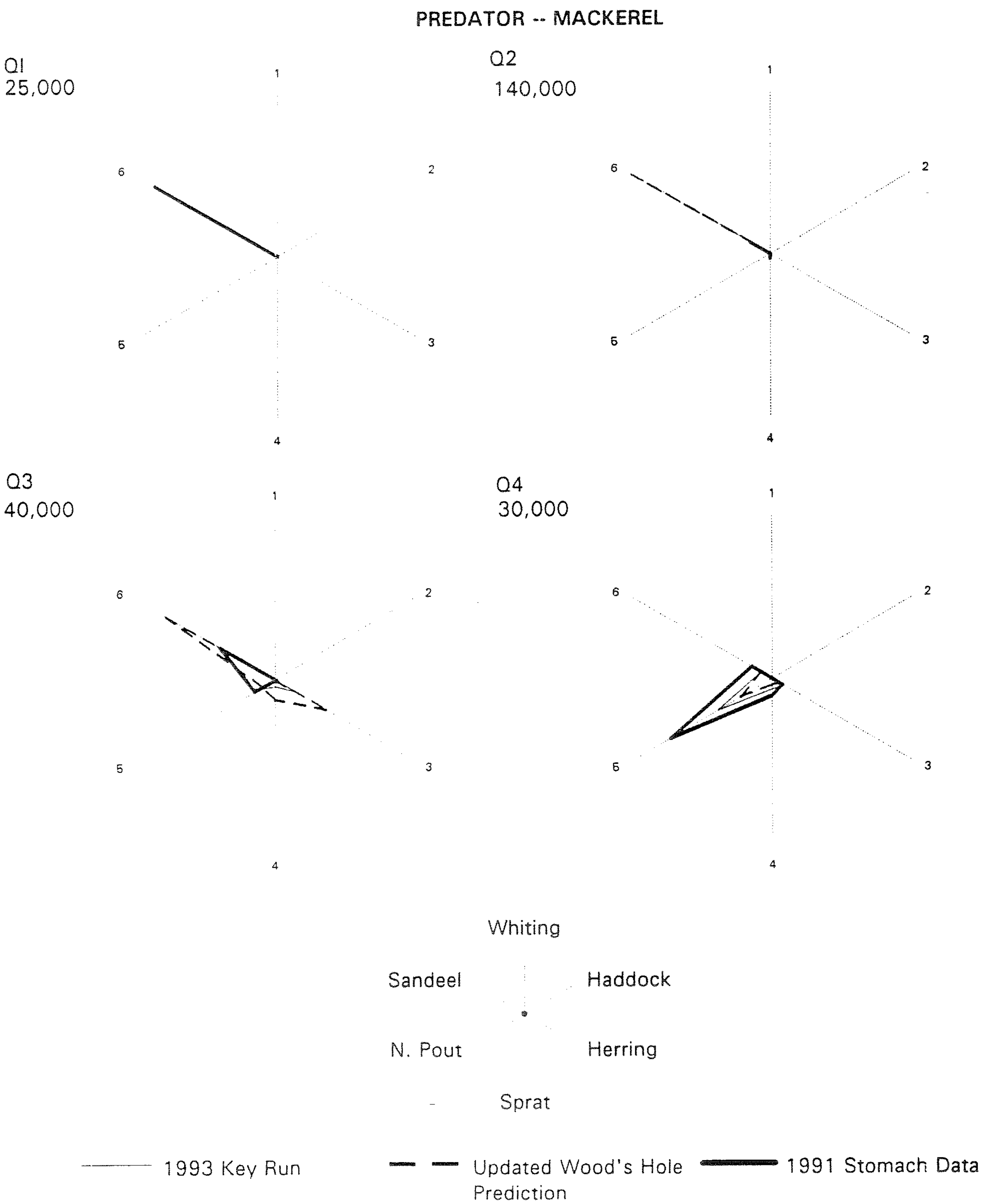


Figure 6.4.1.d Mackerel

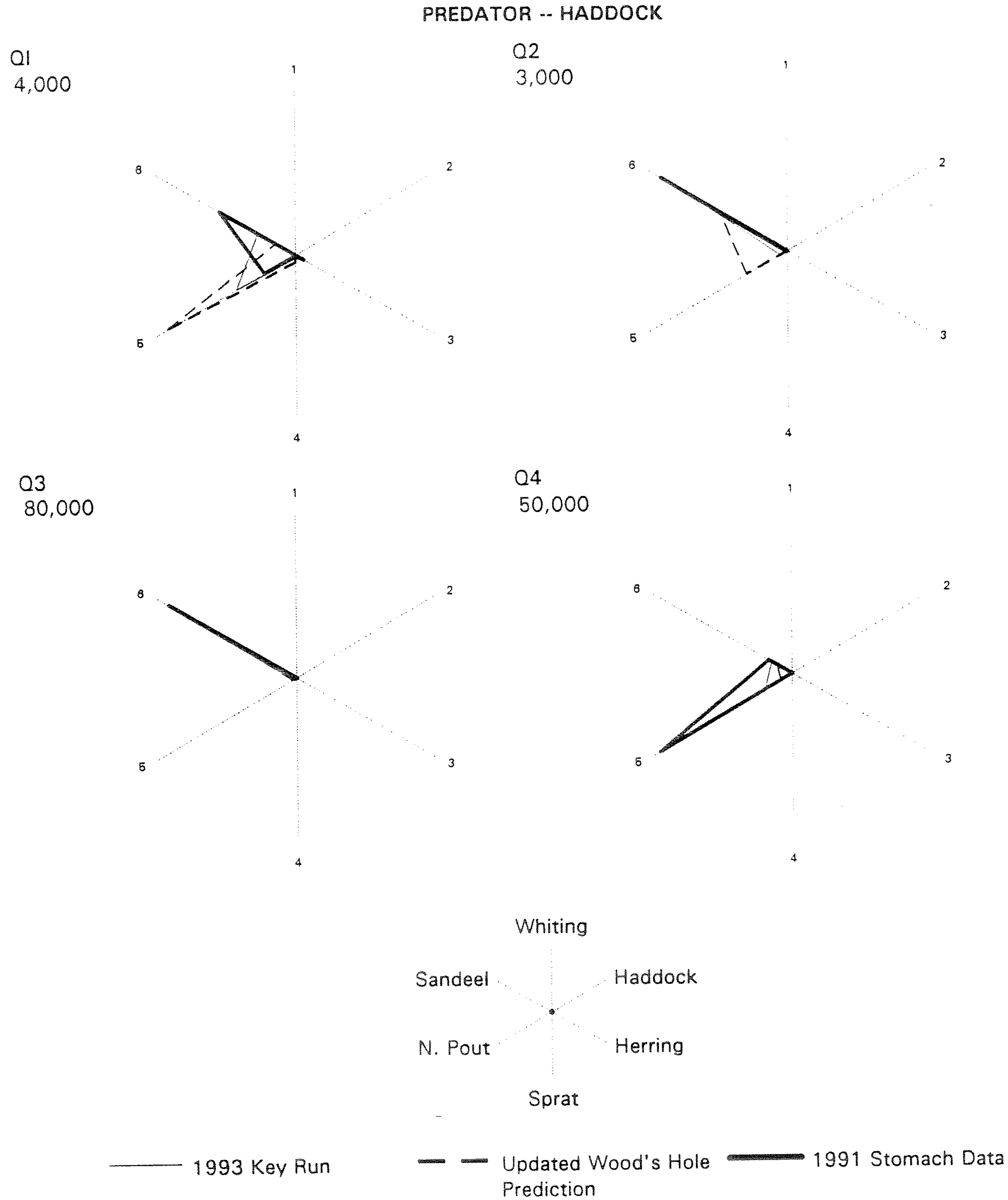


Figure 6.4.1.e **Haddock**

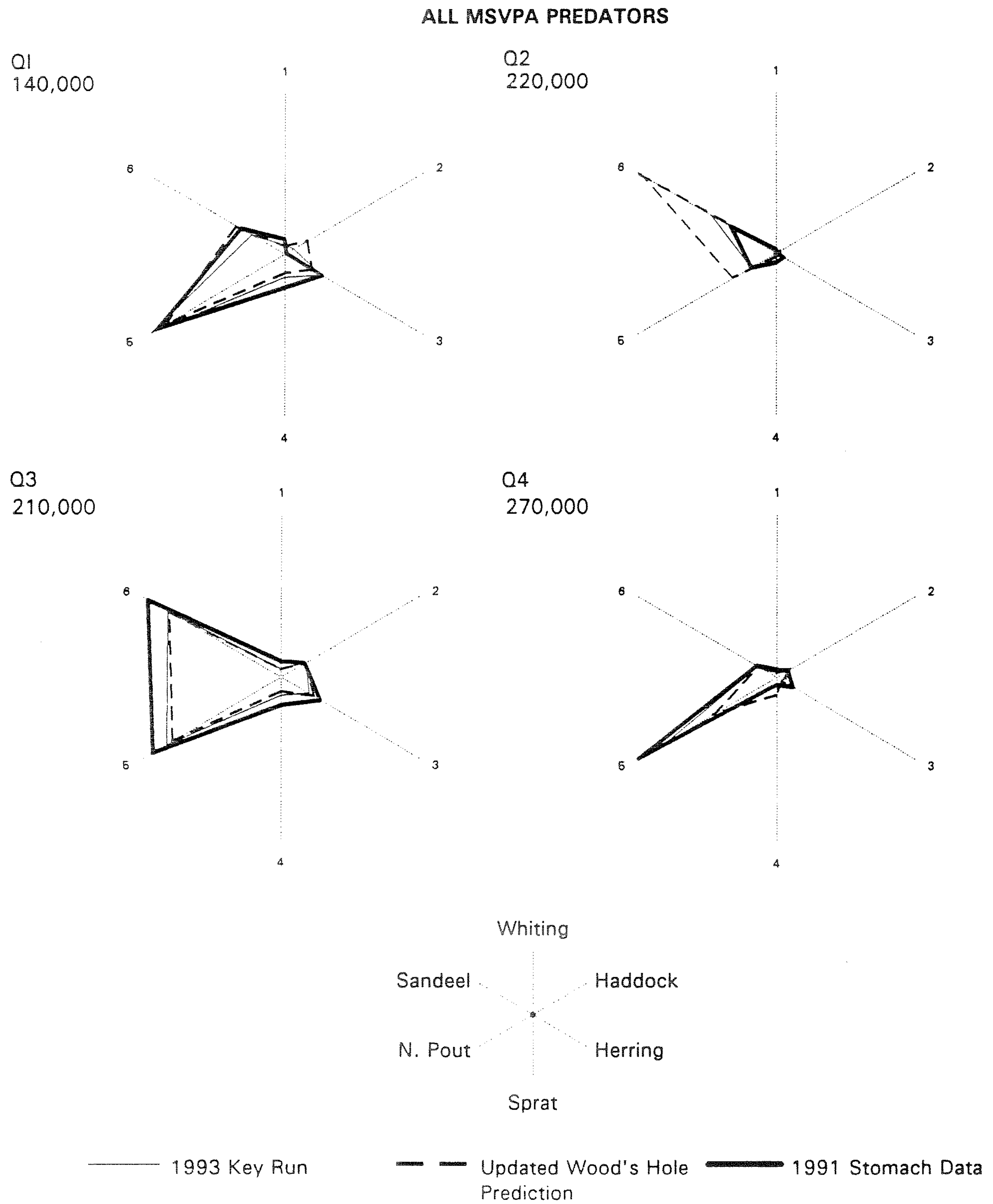


Figure 6.4.1.f (All MSVPA Predators)

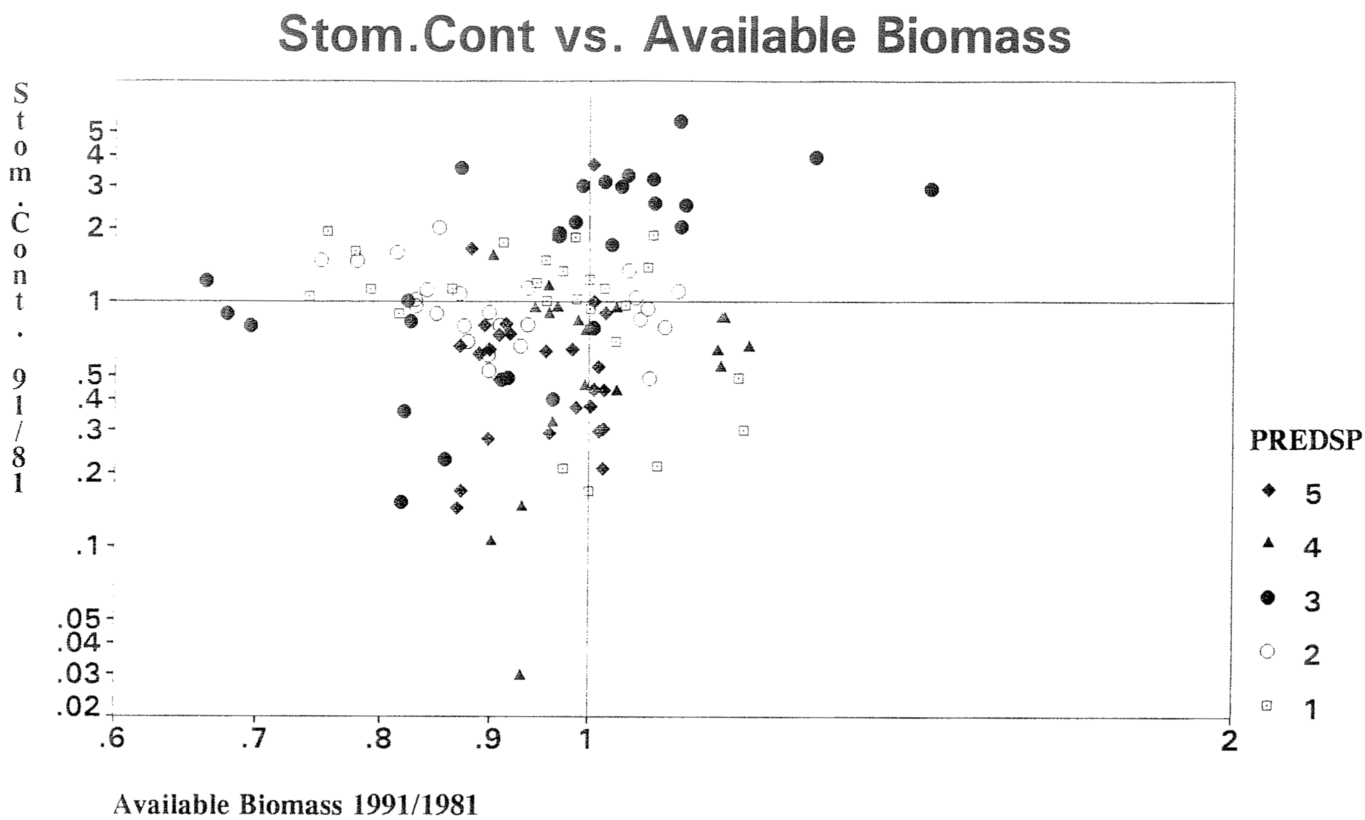


Figure 6.5.1.a Ratio of observed stomach contents in 1991 to 1981 plotted aginst ratio of available biomass for that predator/age combination in 1991 to 1991: seperable entry for each age of each predator 1 = Cod, 2 = Whiting, 3 = Saithe, 4 = Mackerel, 5 = Haddock.

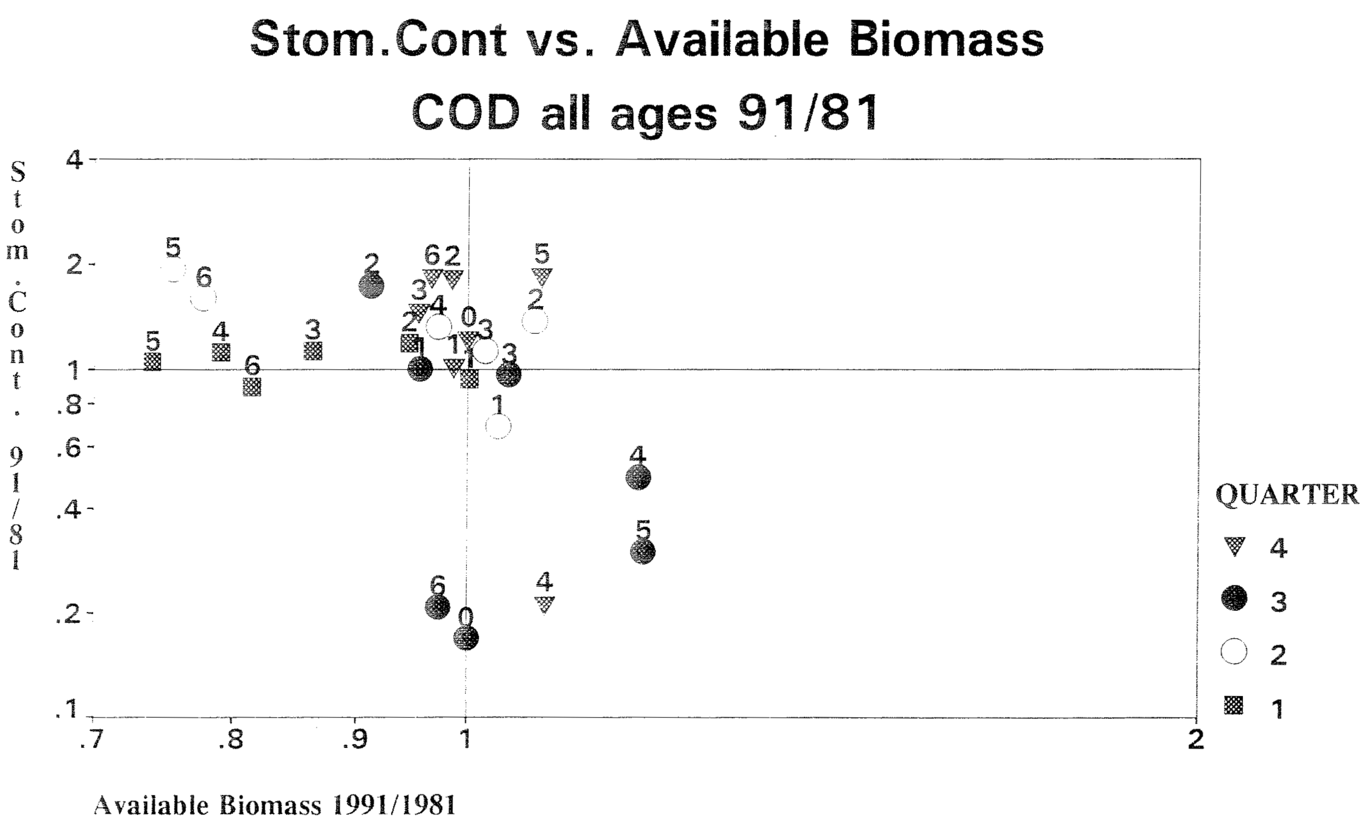


Figure 6.5.1.b Ratios as in Figure 6.5.1.a, for Cod as predator only. Broken out by quarter. Numbers refer to predator age.

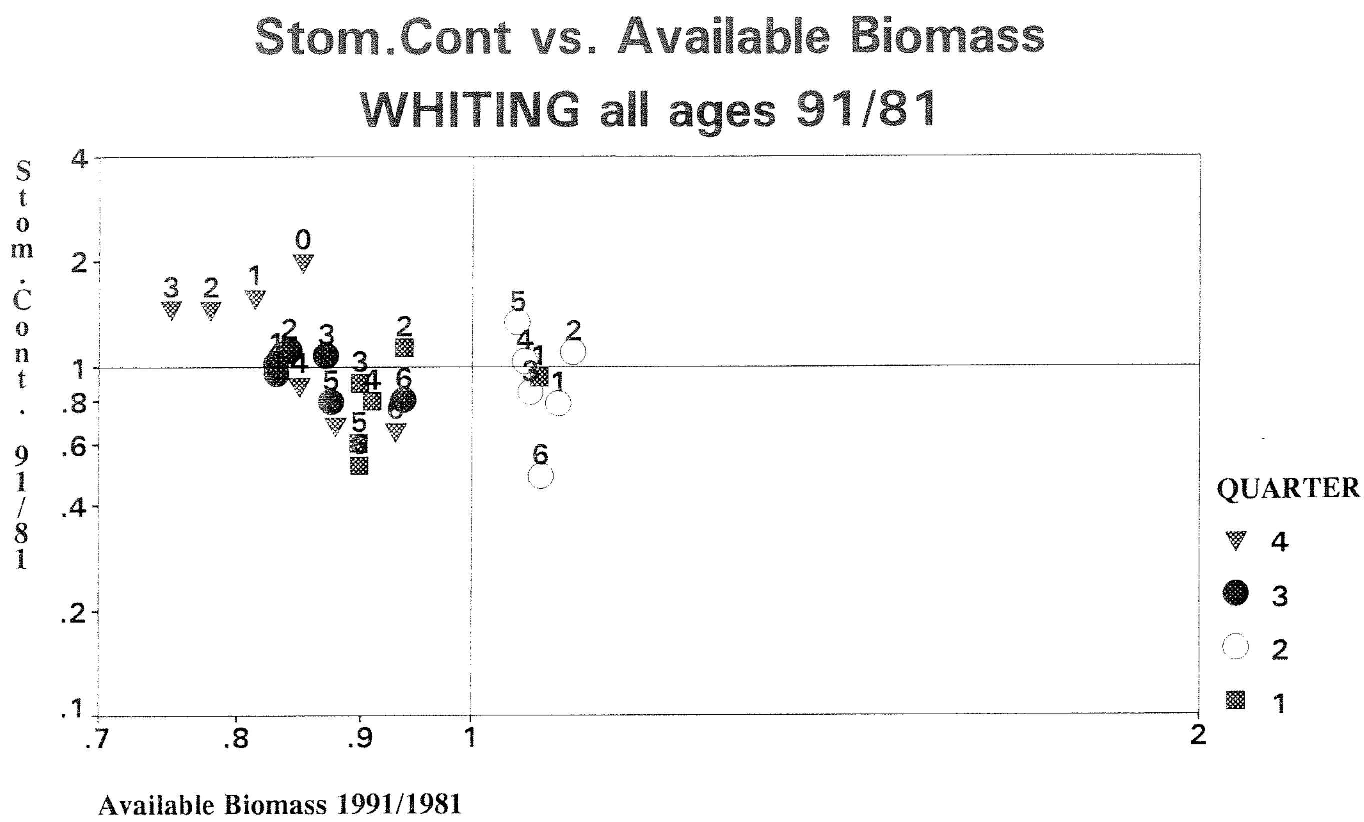


Figure 6.5.1.c

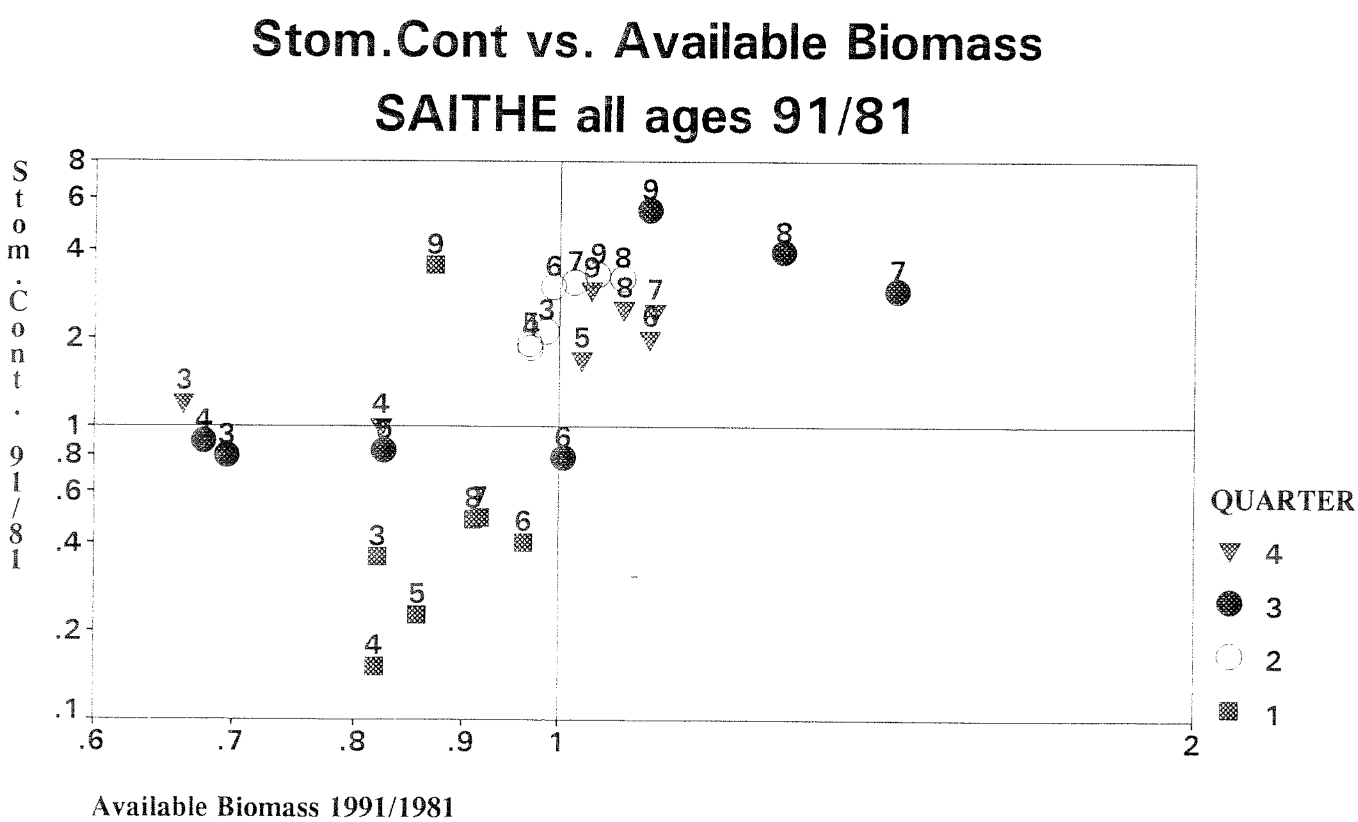


Figure 6.5.1.d

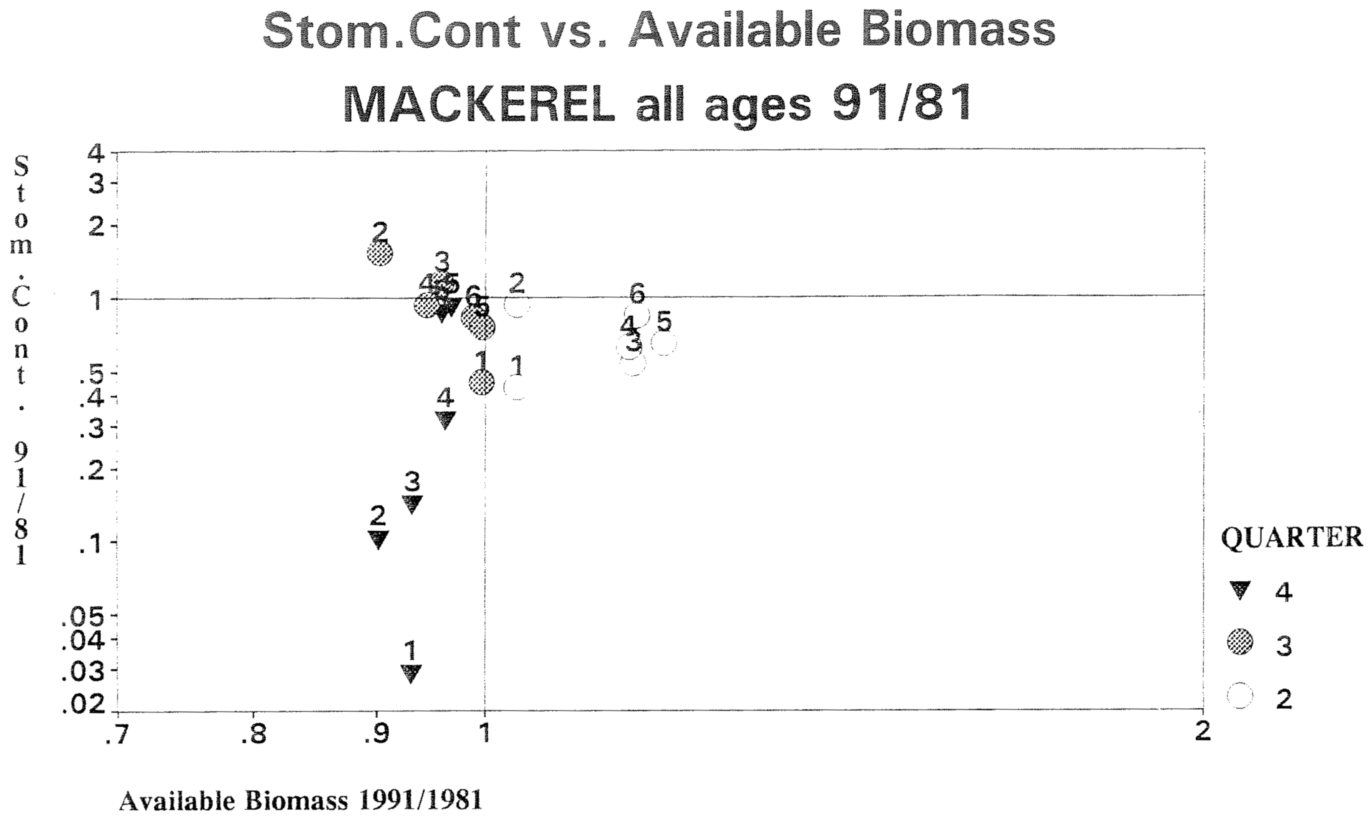


Figure 6.5.1.e

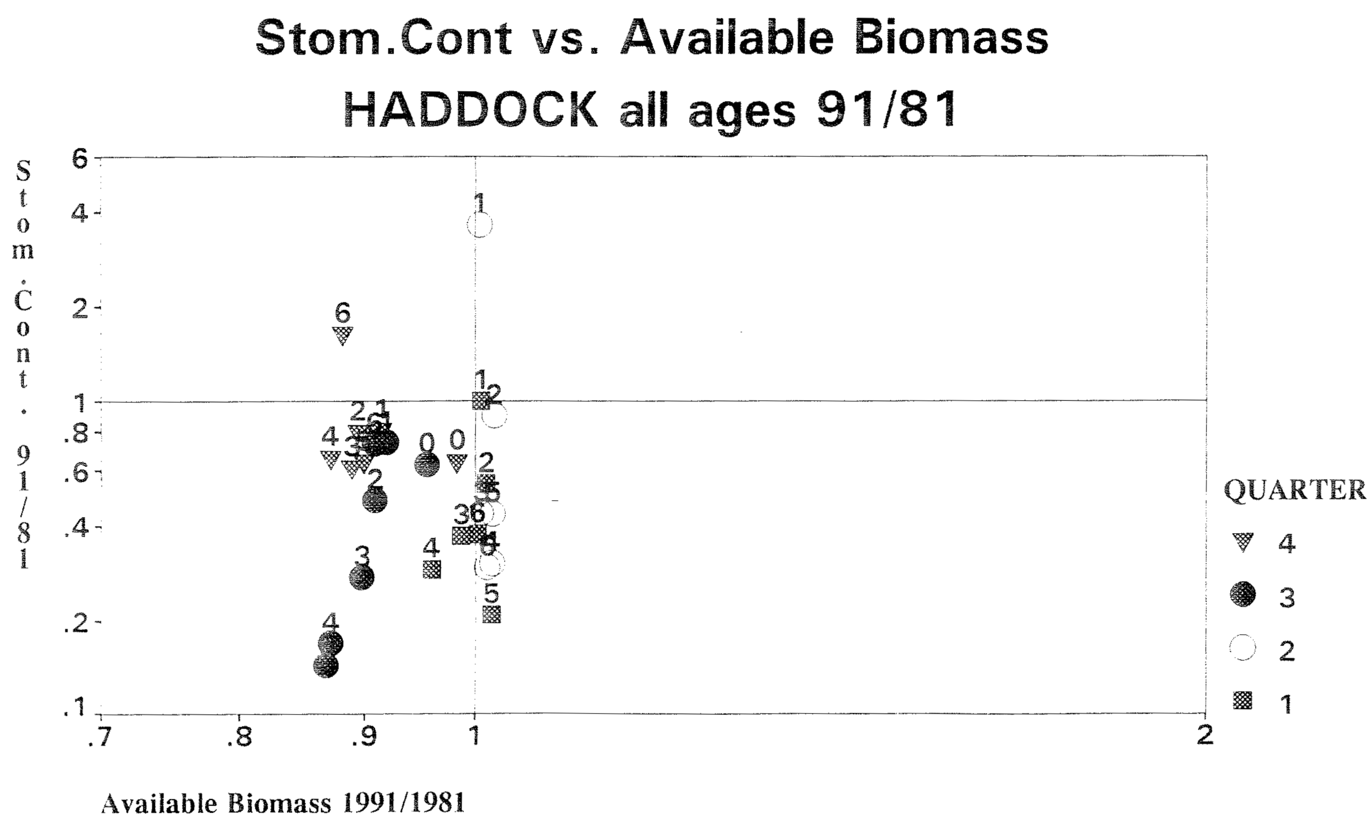


Figure 6.5.1.f

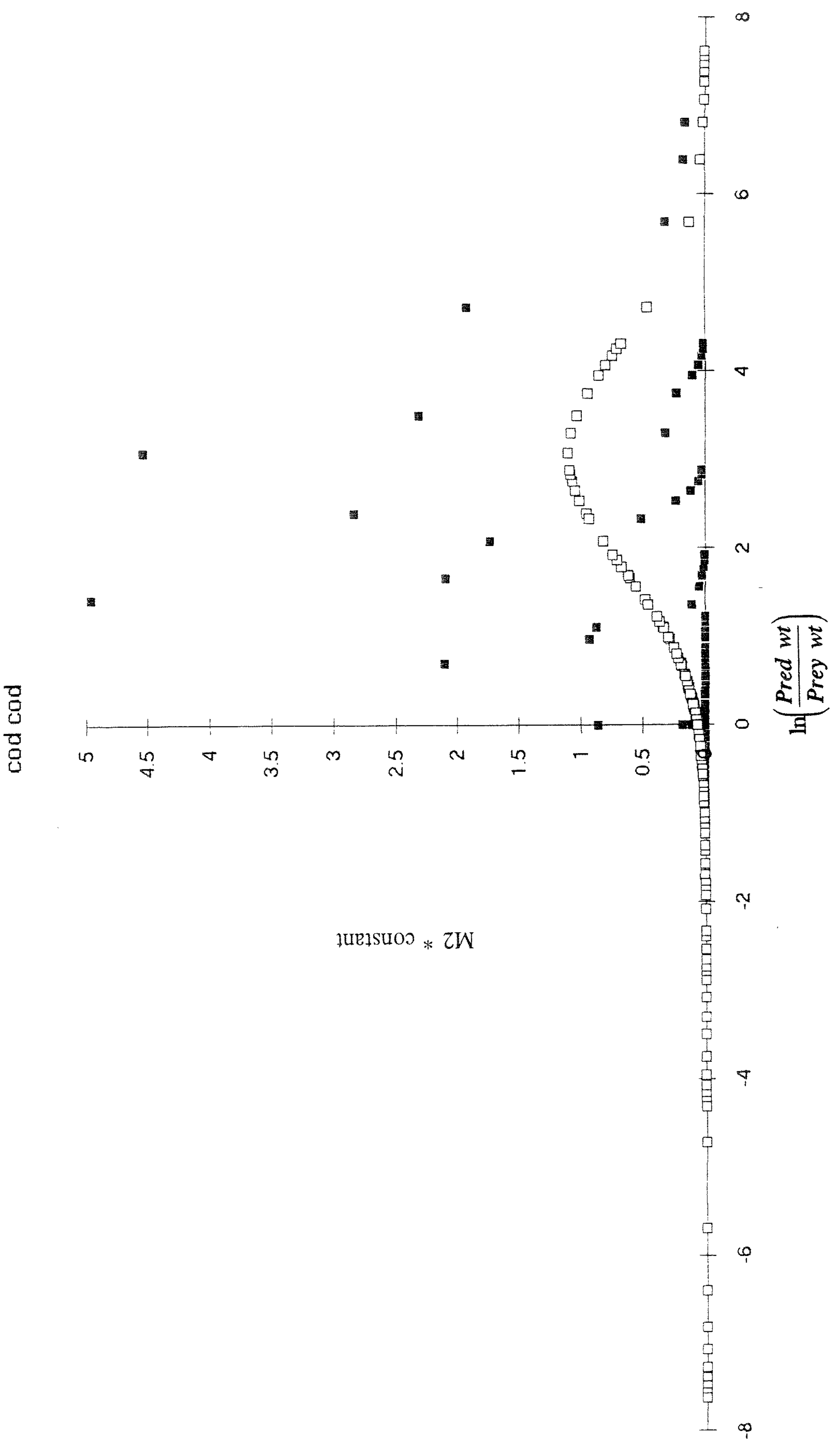

cod cod
M2 * constant
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-8
-6
-4
-2
0
2
4
6
8
$\ln\left(\frac{Pred\ wt}{Prey\ wt}\right)$

Figure 6.6.1.a

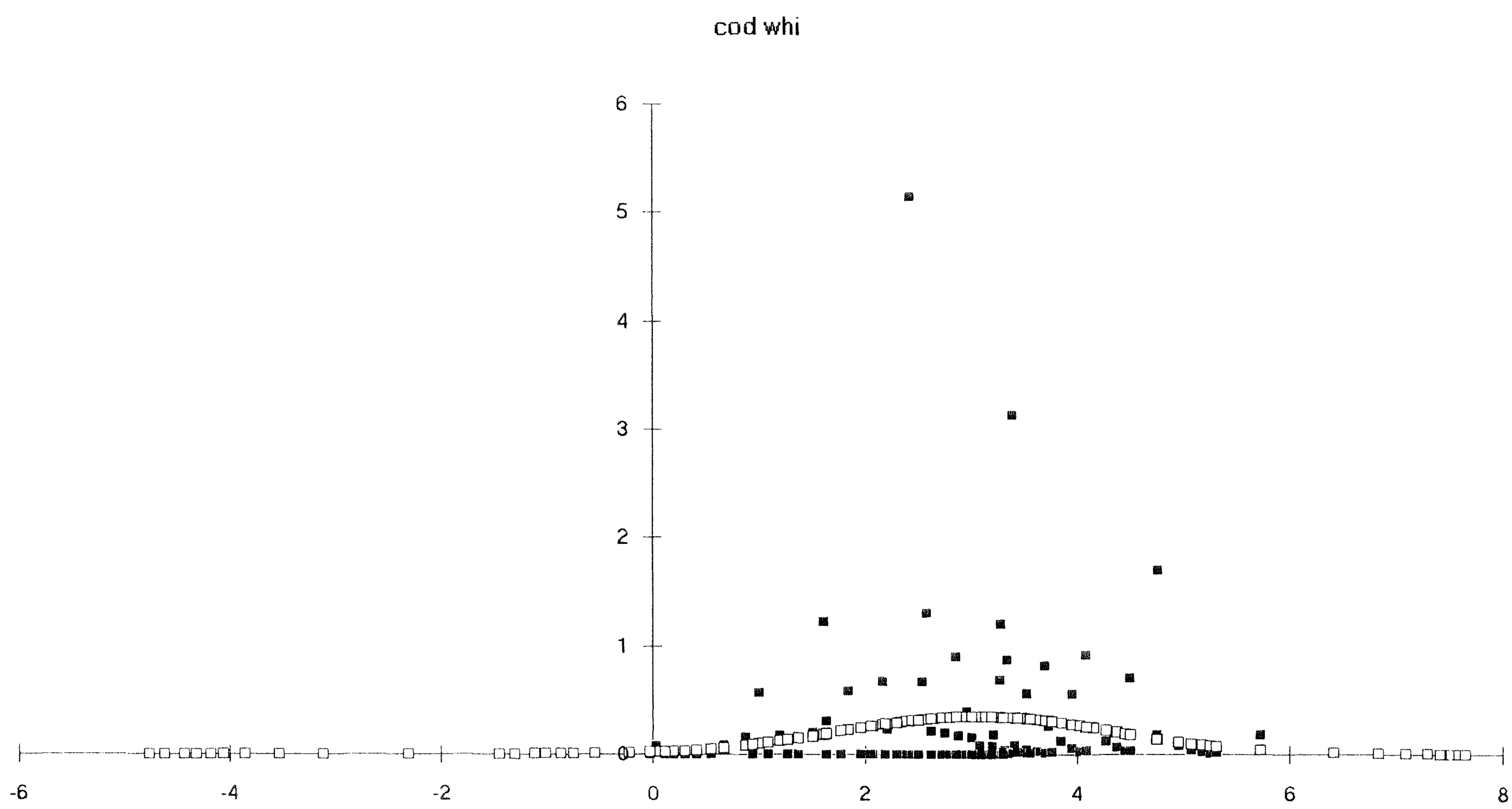


Figure 6.6.1.b

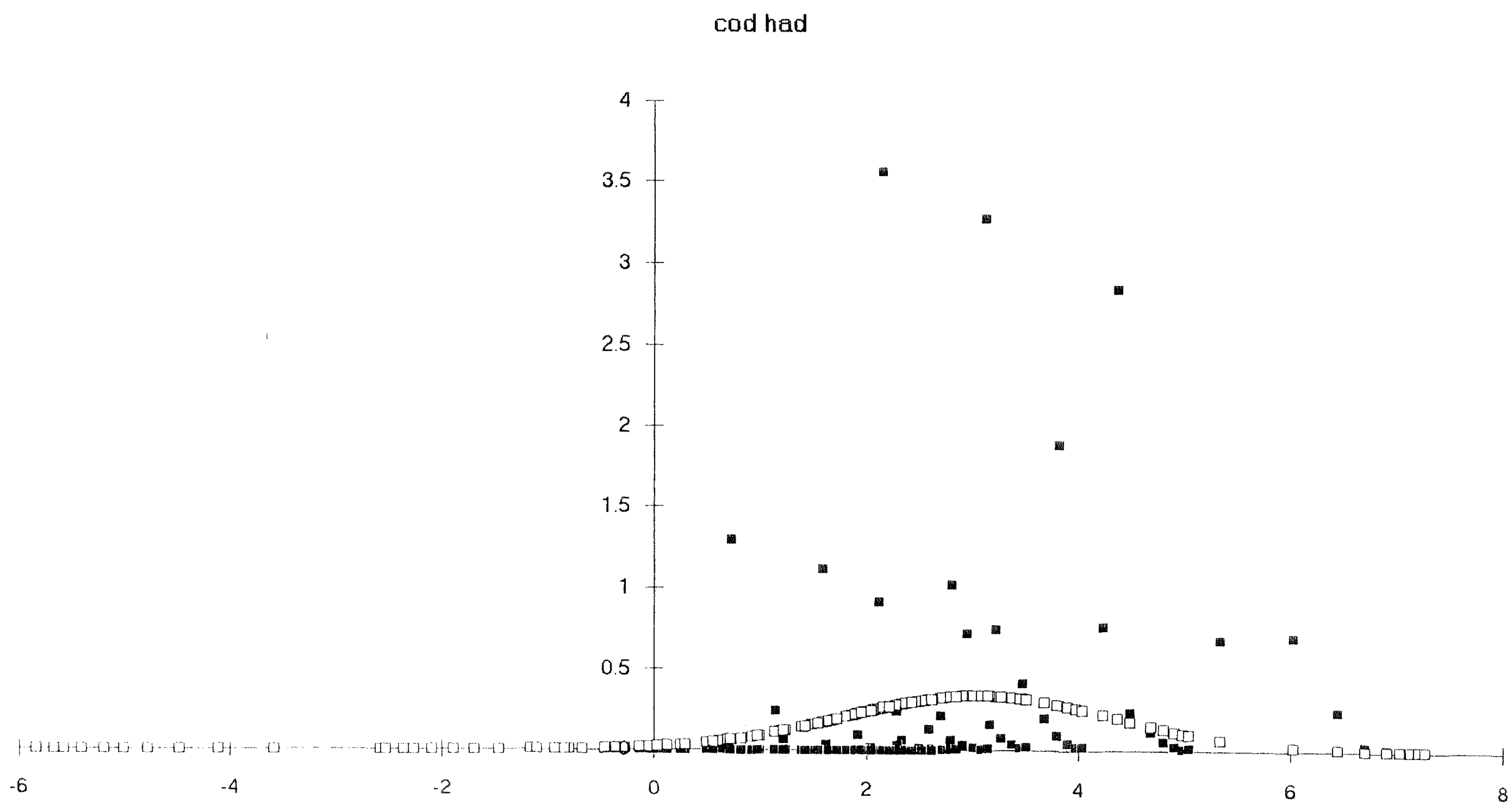


Figure 6.6.1.c

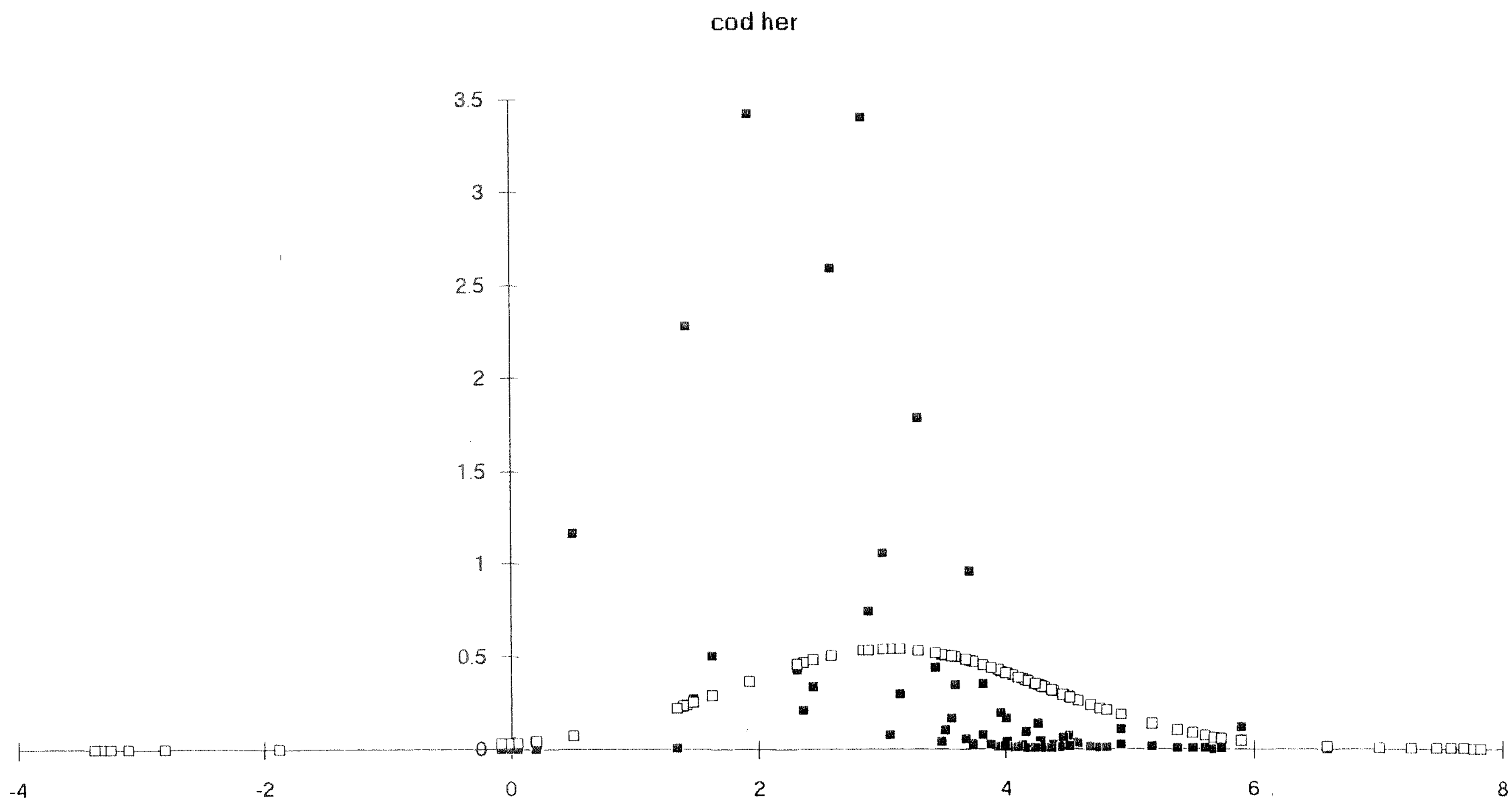


Figure 6.6.1.d

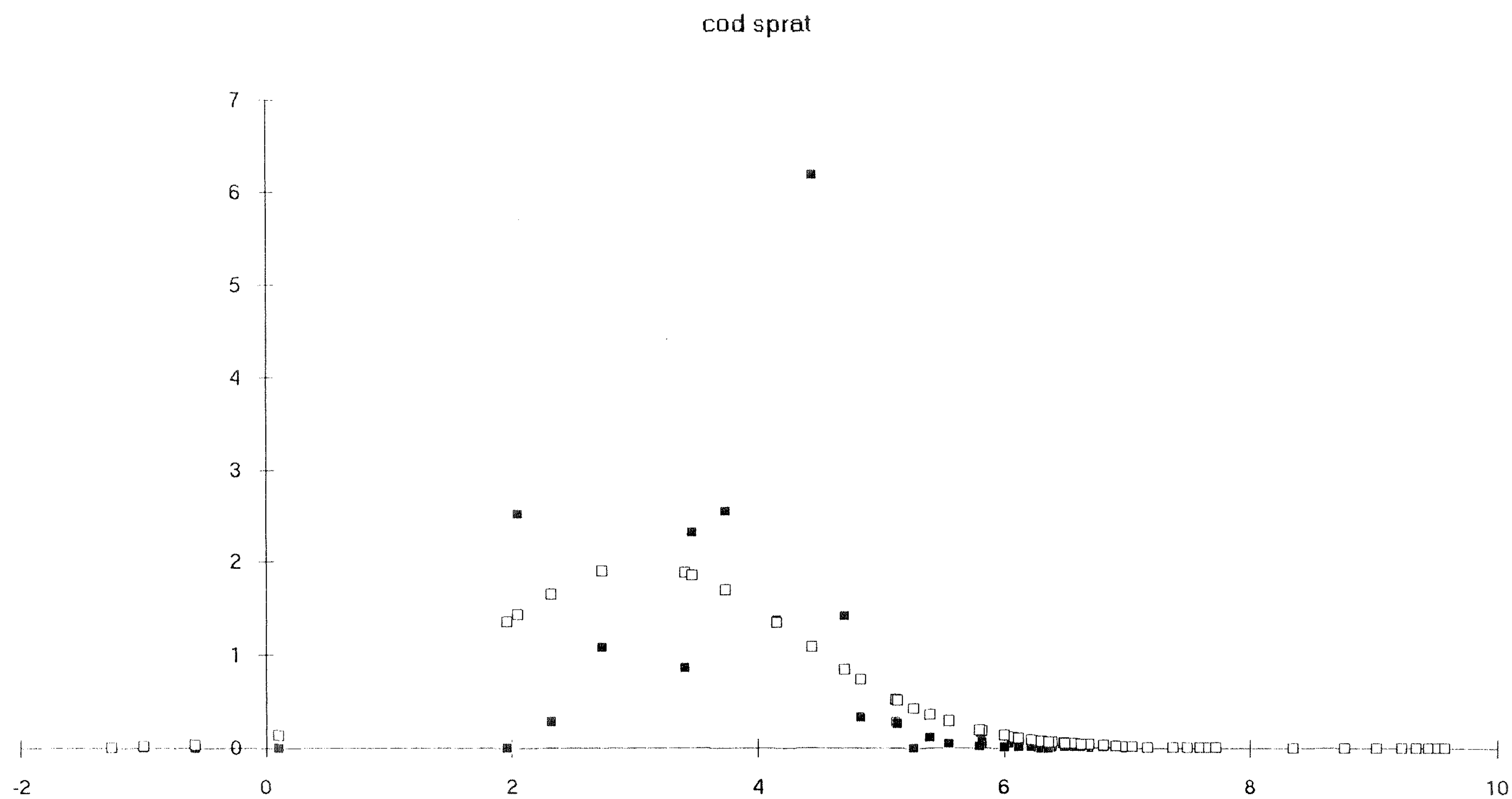


Figure 6.6.1.e

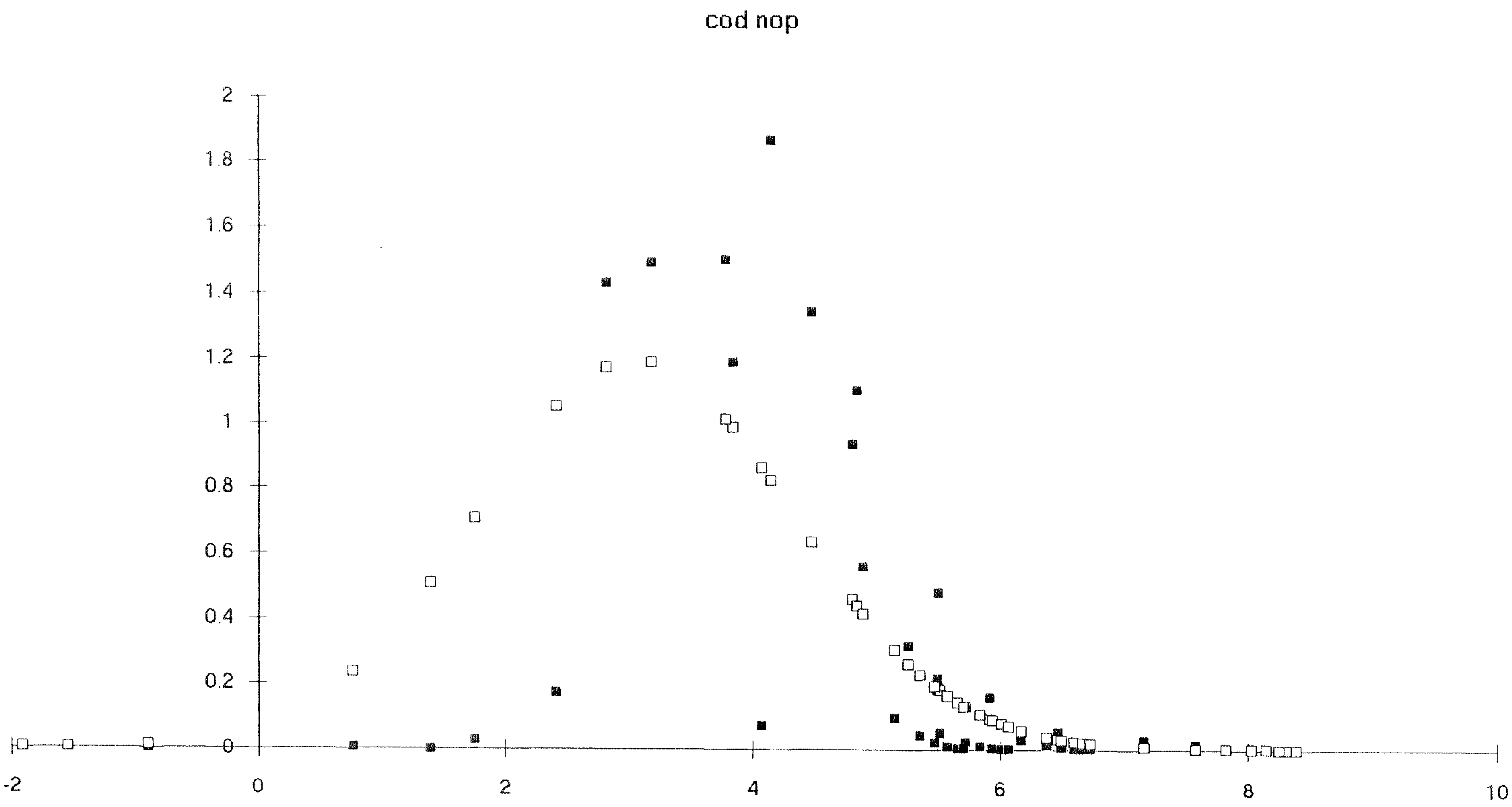


Figure 6.6.1.f

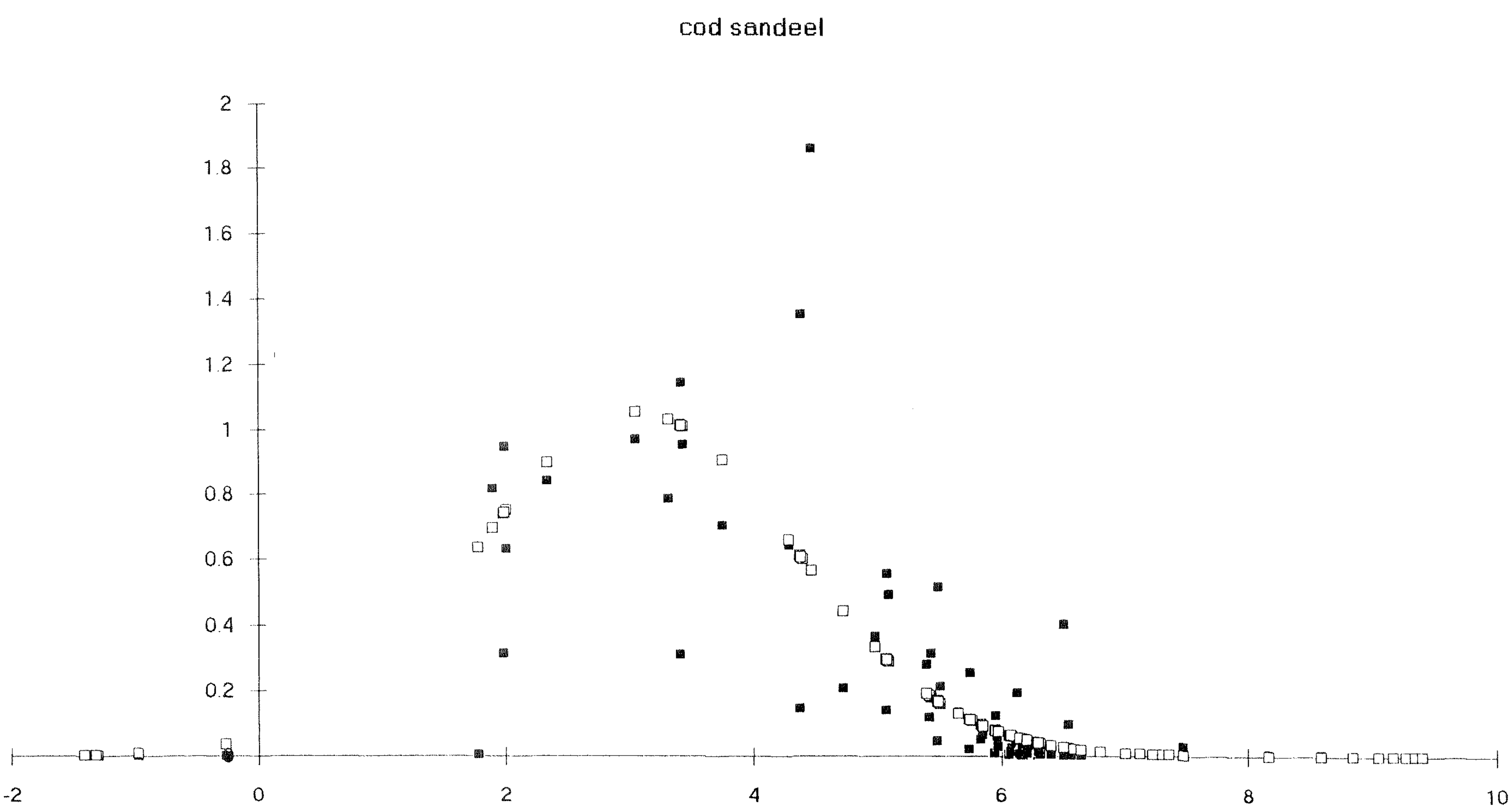
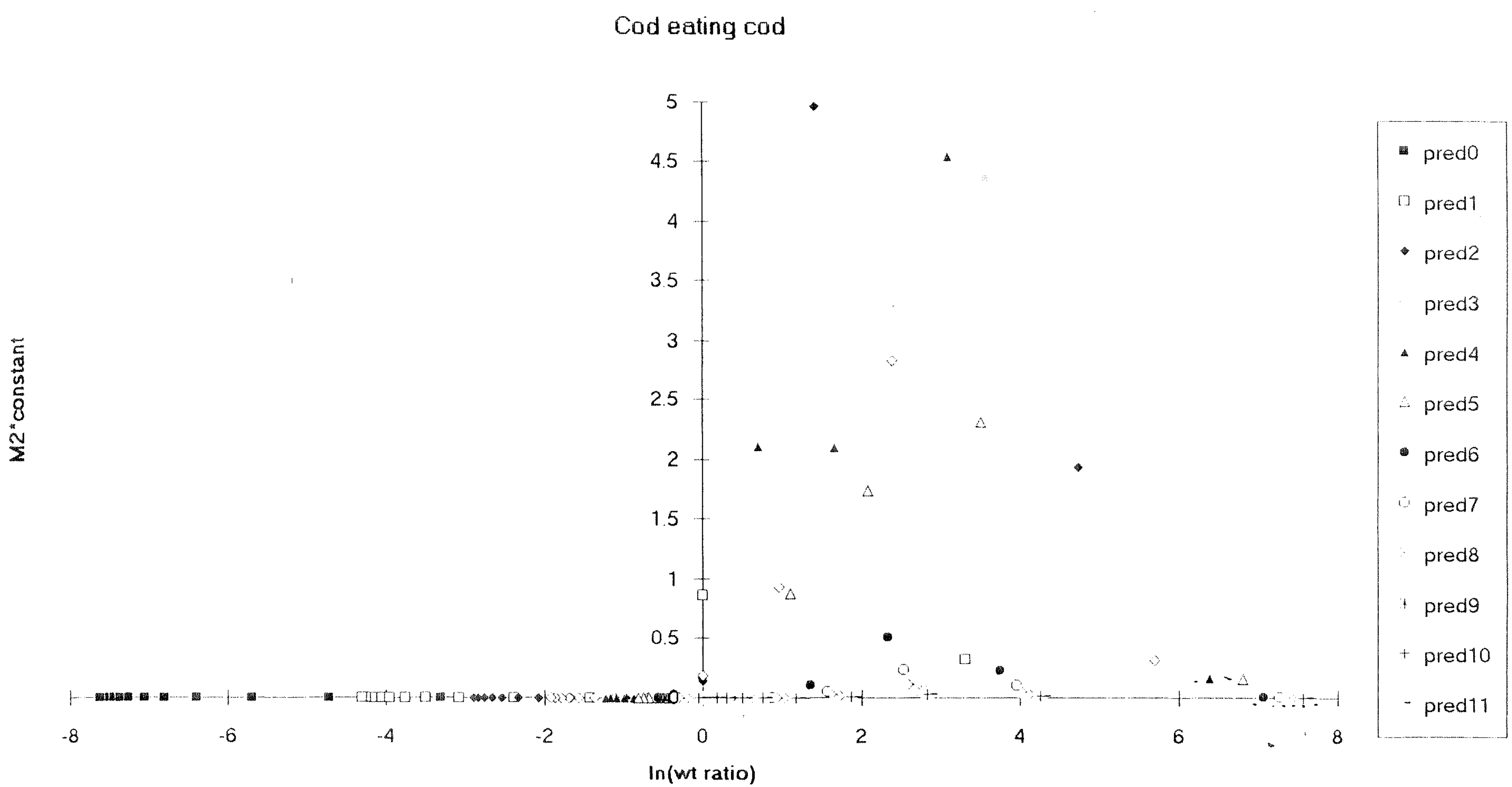


Figure 6.6.1.g

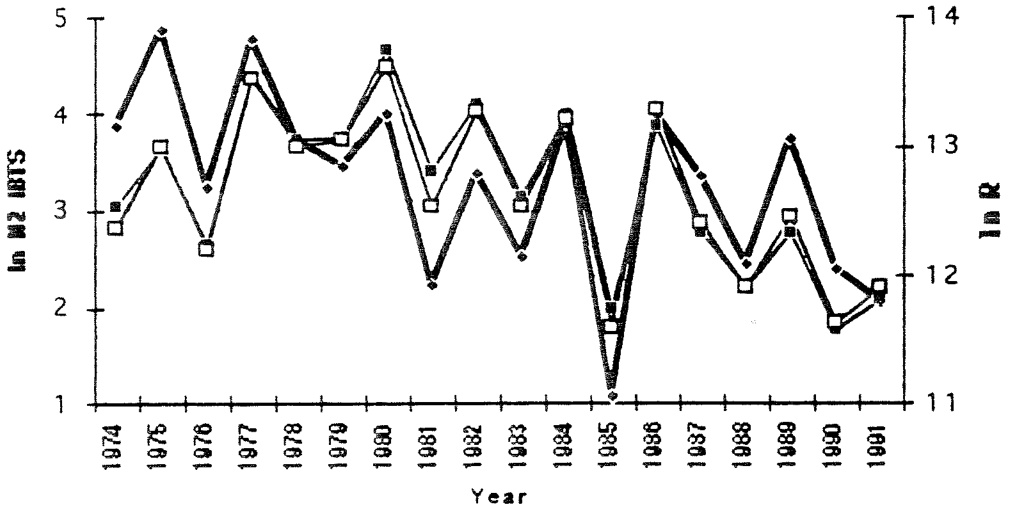


Cod eating cod
M2*constant
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
-8
-6
-4
-2
0
2
4
6
8
ln(wt ratio)
pred0
pred1
pred2
pred3
pred4
pred5
pred6
pred7
pred8
pred9
pred10
pred11

Figure 6.6.1.h

Survey-msvpa

COD: Trends in recruitment at age 1



COD: Trends in recruitment at age 2

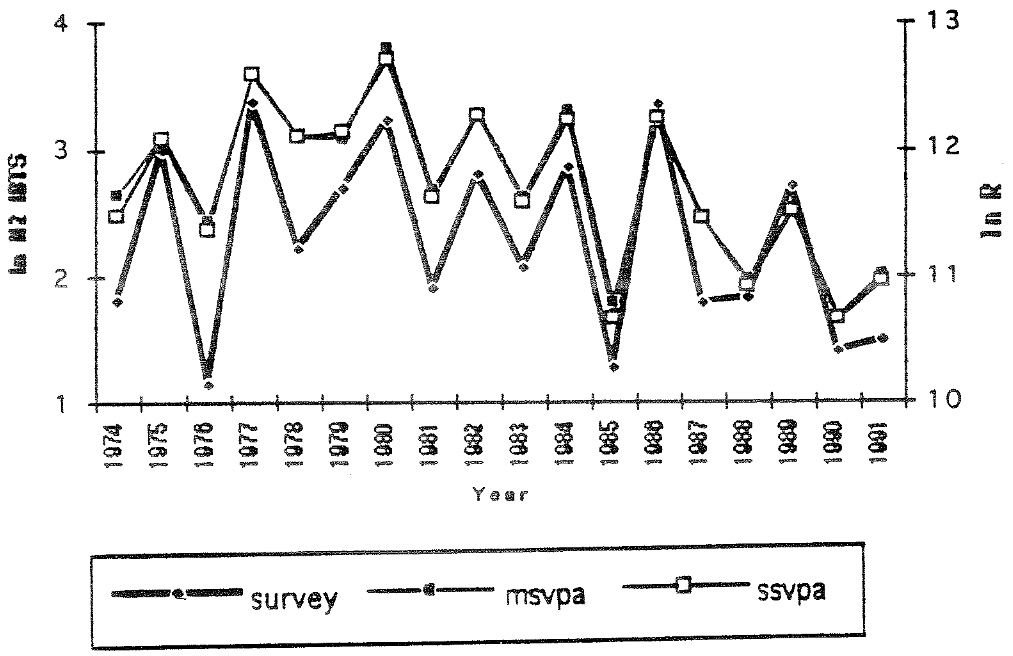
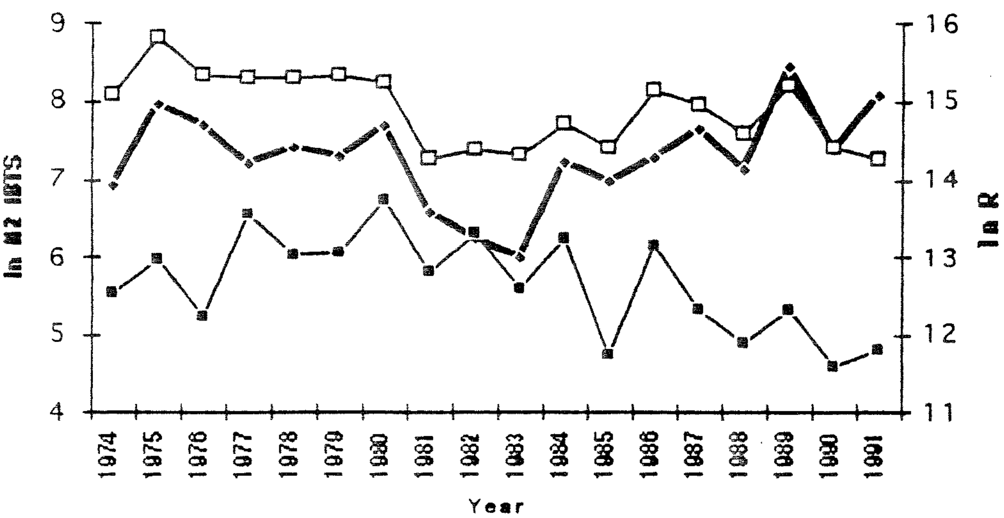


Figure 6.9.1.a

Survey-msvpa

WHITING: Trends in recruitment at age 1



WHITING: Trends in recruitment at age 2

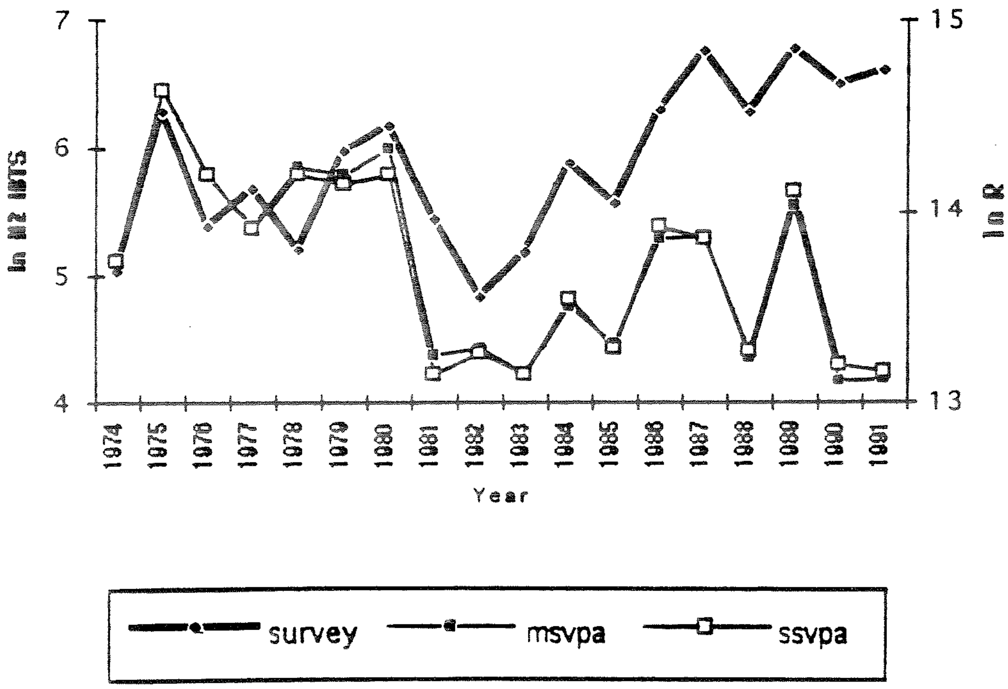


Figure 6.9.1.b

Figure 6.9.3.a

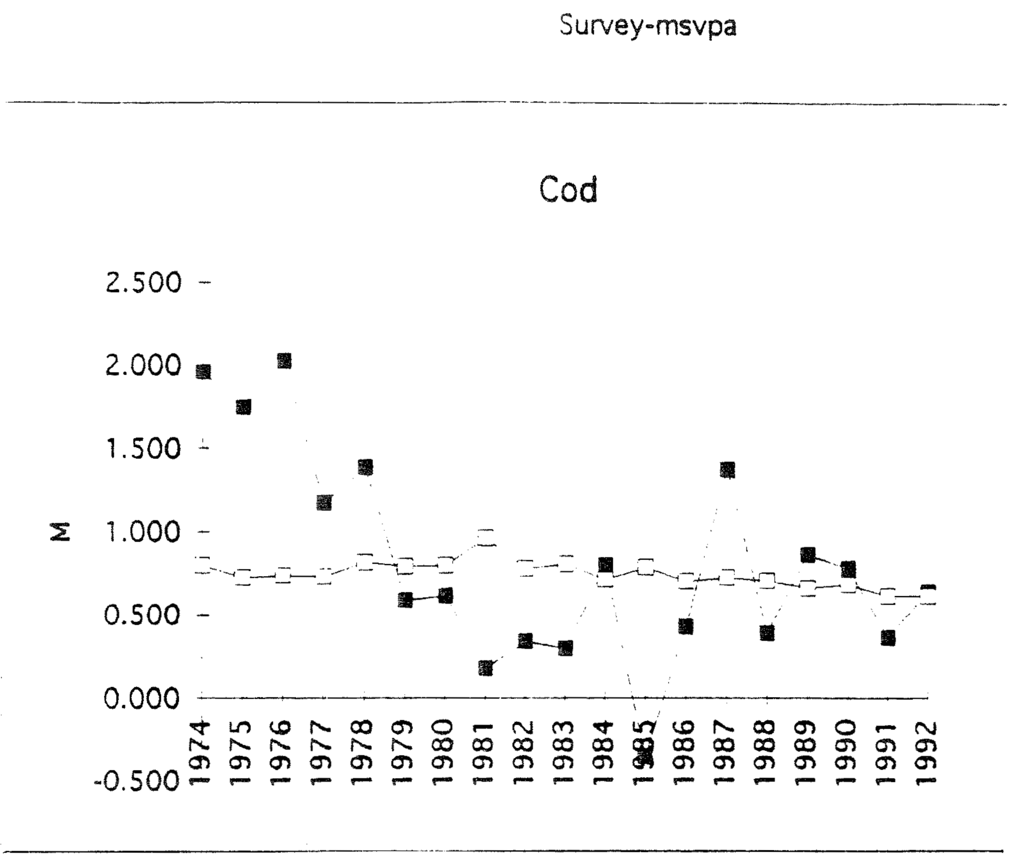


Figure 6.9.3.b

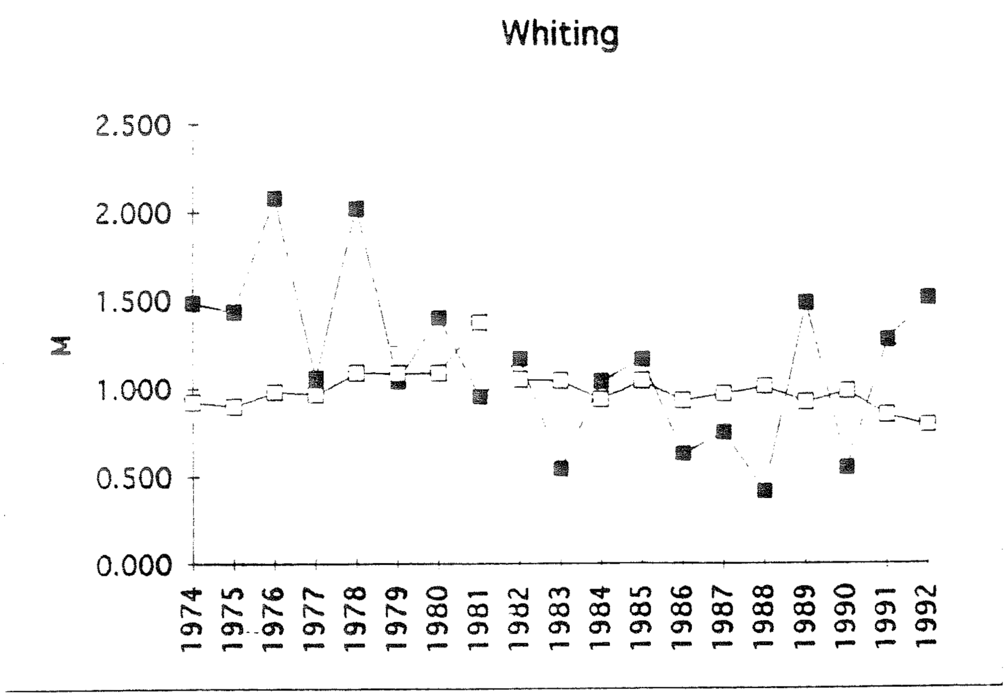
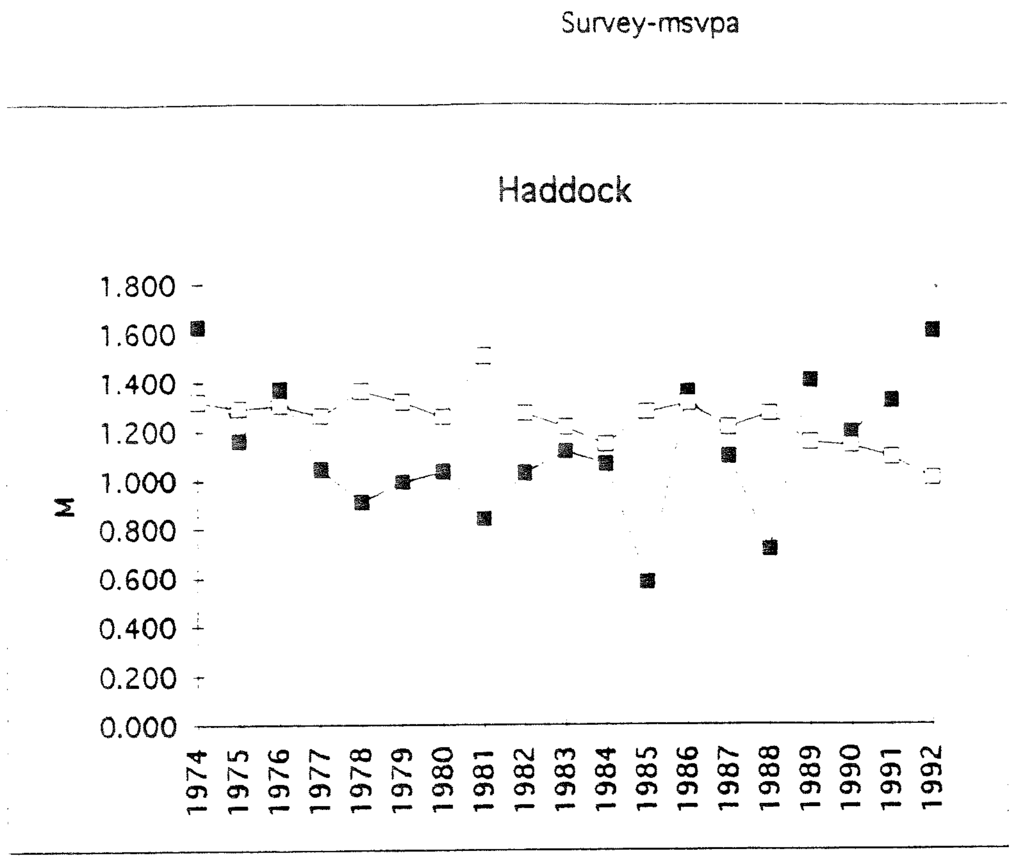


Figure 6.9.3.c



Survey-msvpa
Haddock
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
M
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992

Survey-msvpa

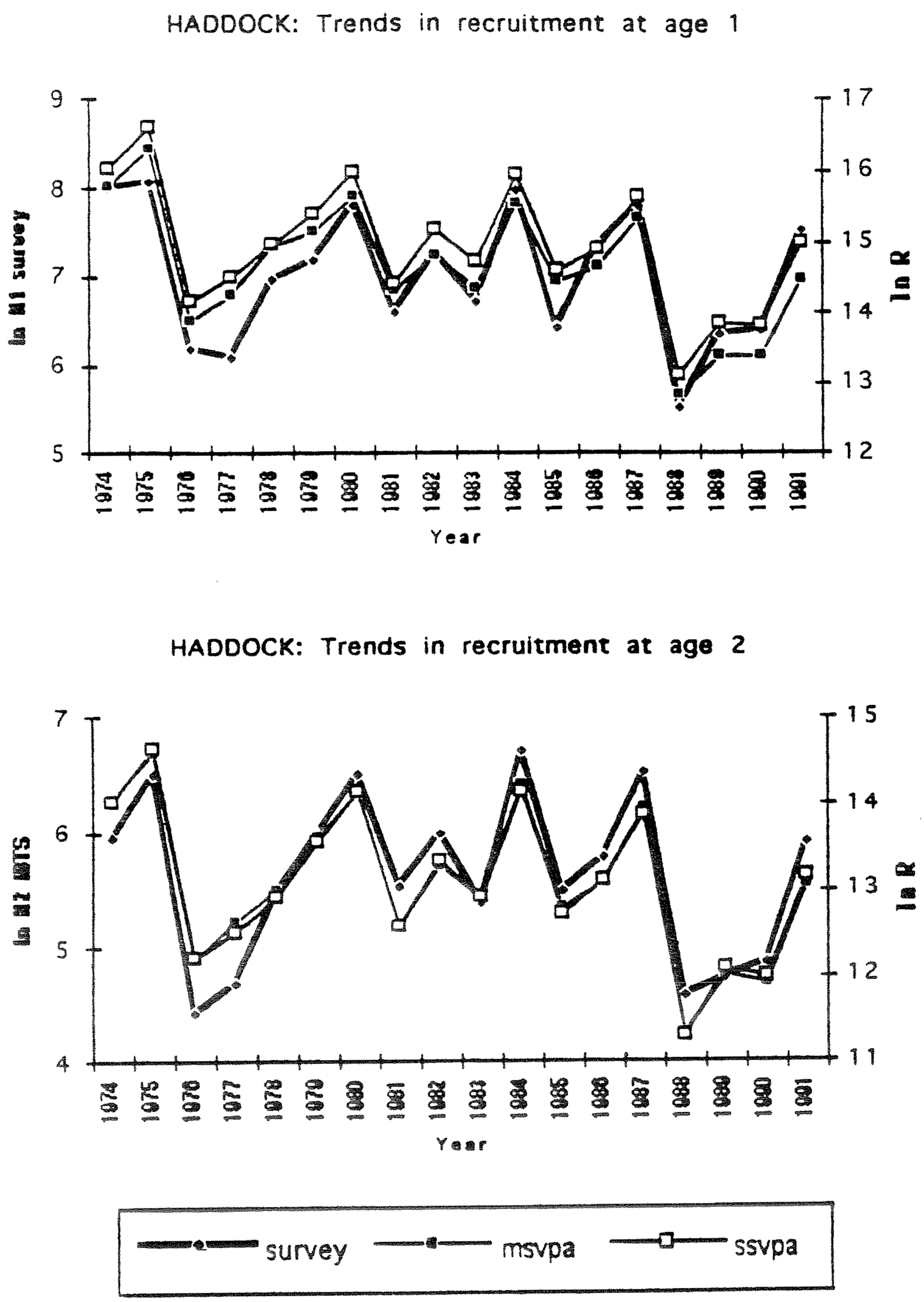


Figure 6.9.1.c

Survey-msvpa

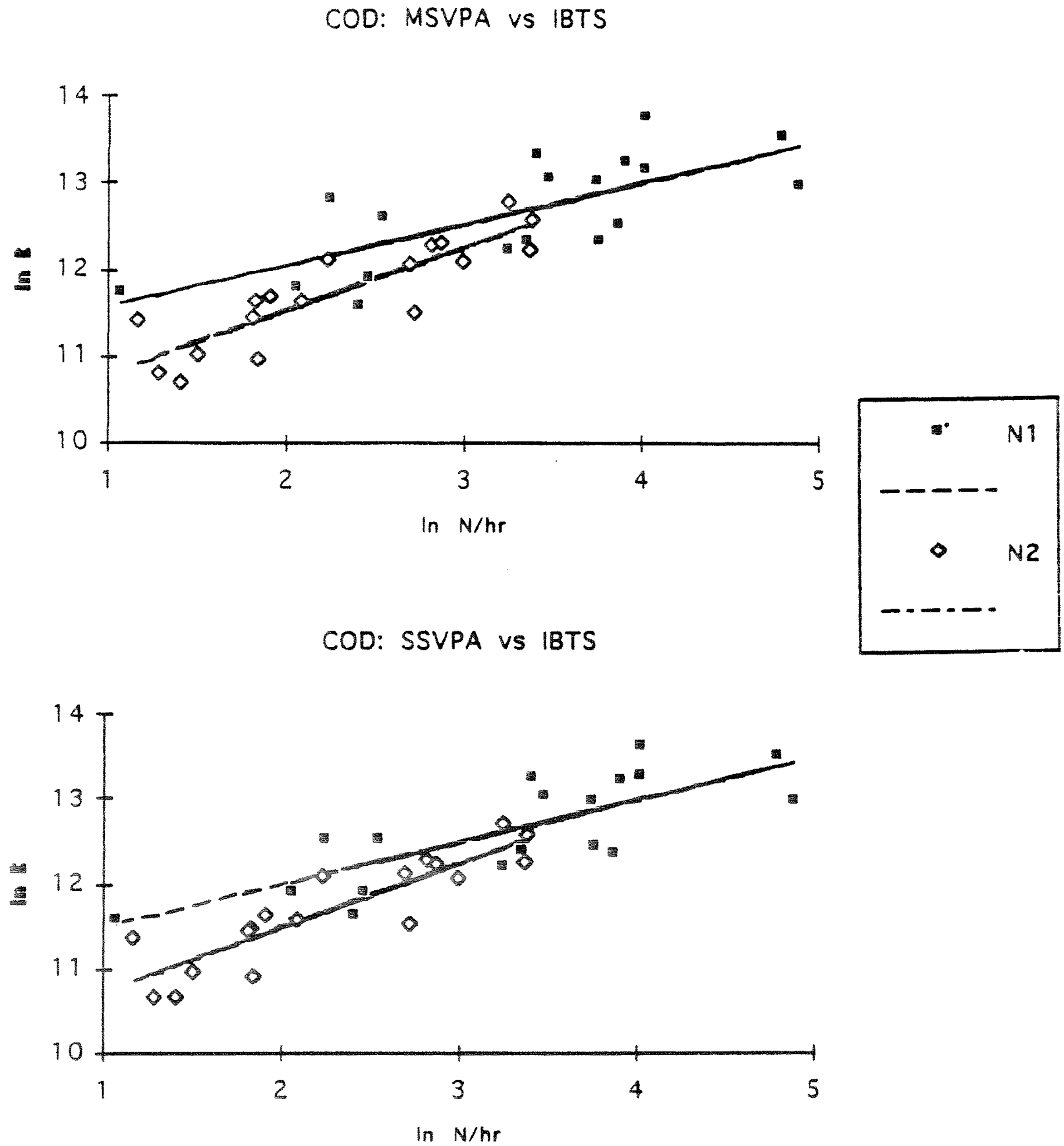


Figure 6.9.2.a

Survey-msvpa

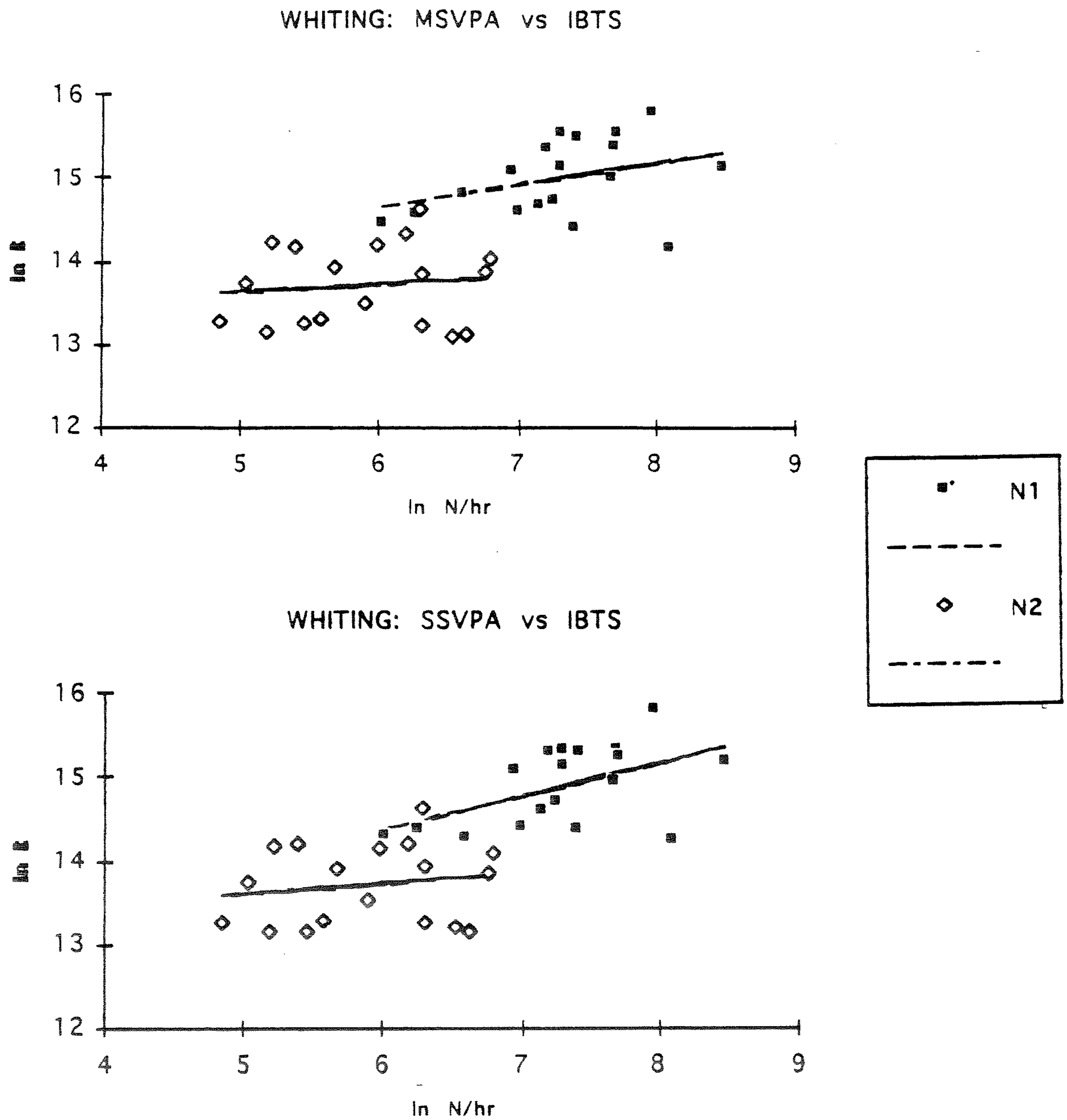


Figure 6.9.2.b

Survey-msvpa

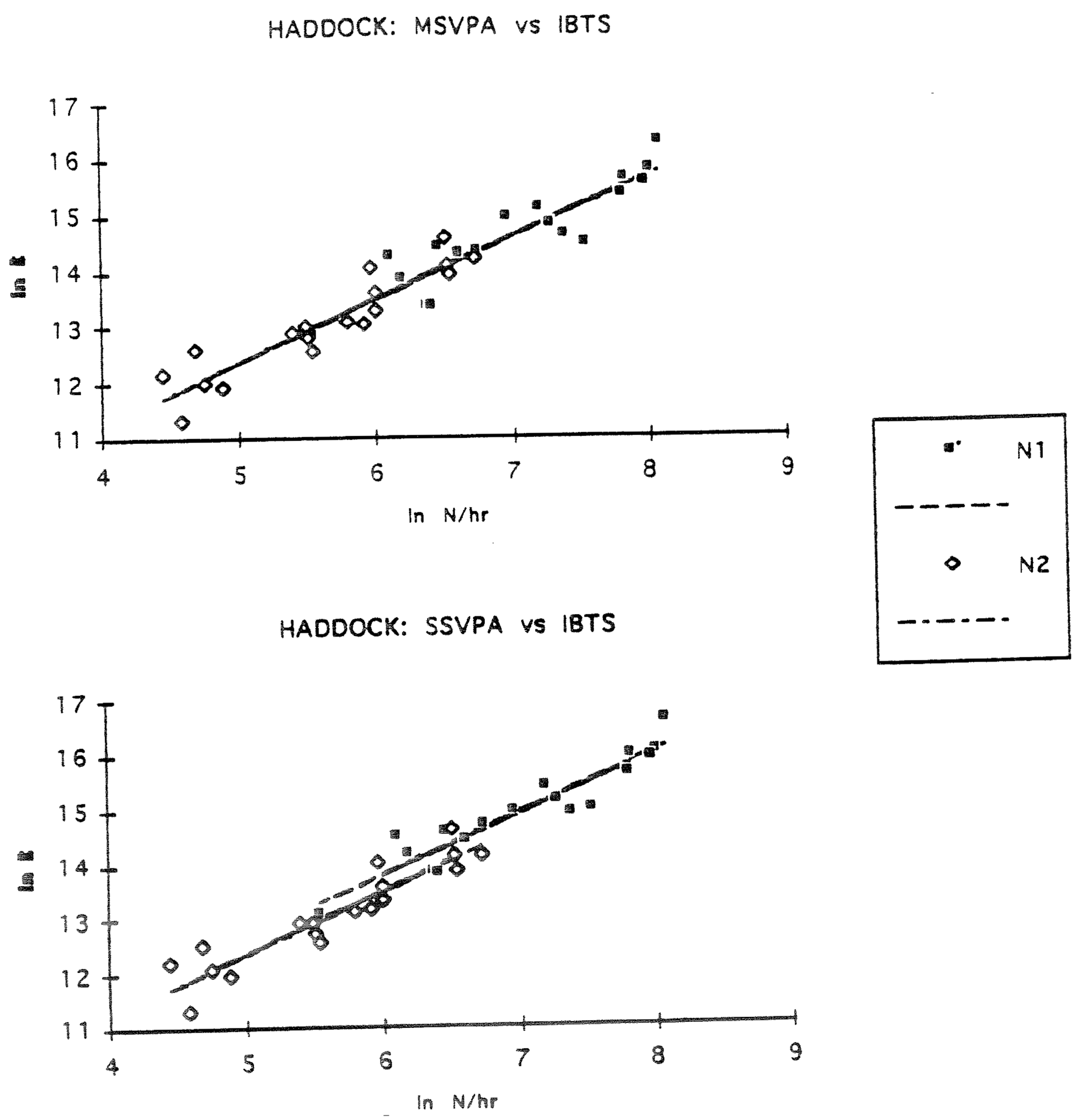


Figure 6.9.2.c

Figure 6.10.1

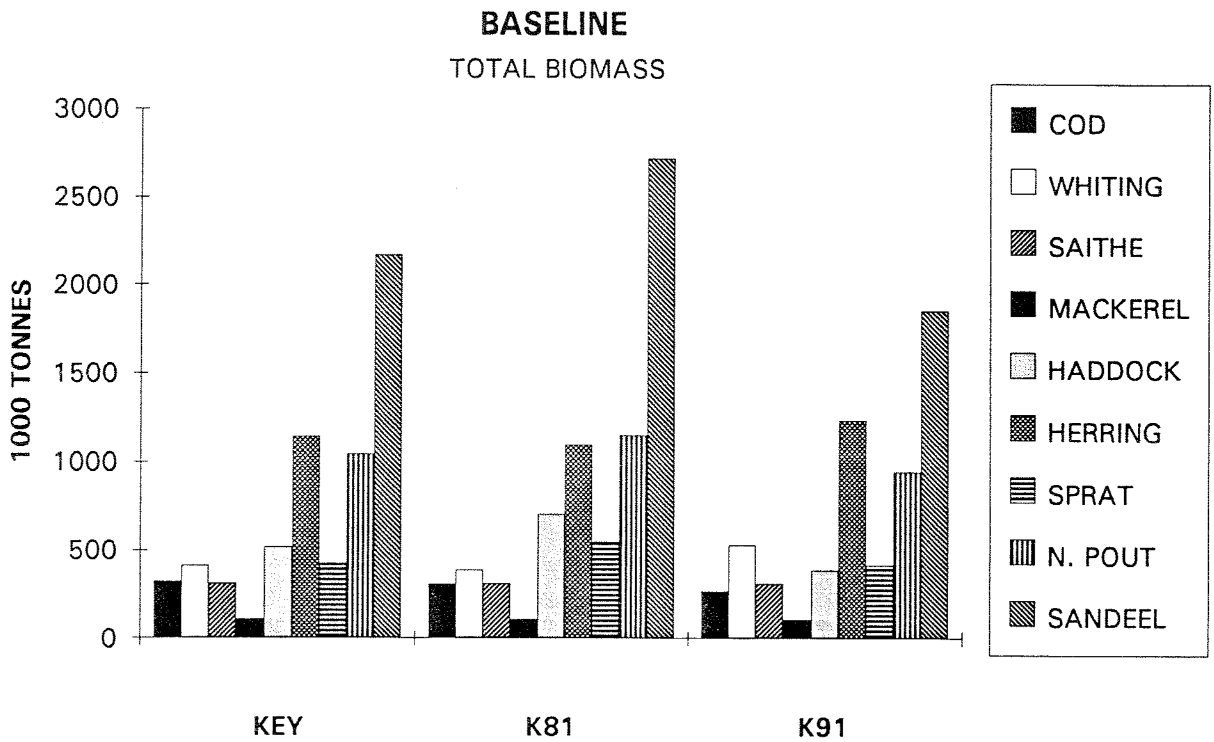


Figure 6.10.2

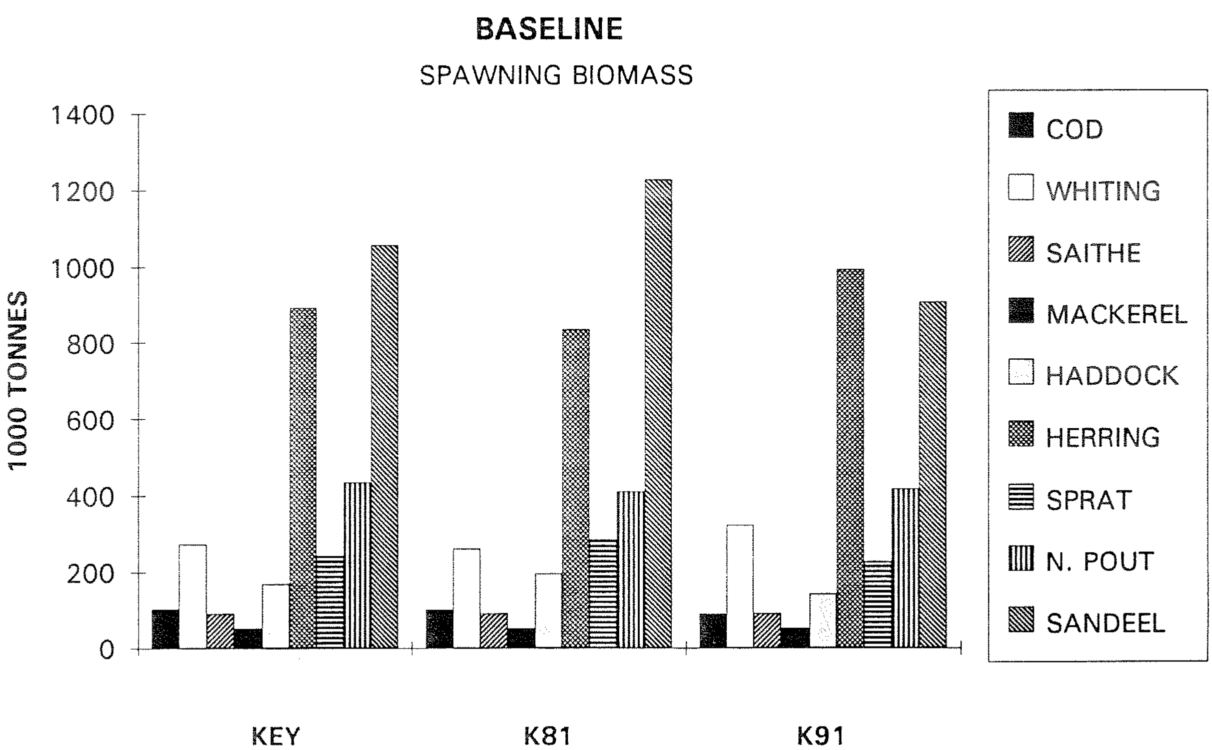


Figure 6.10.3

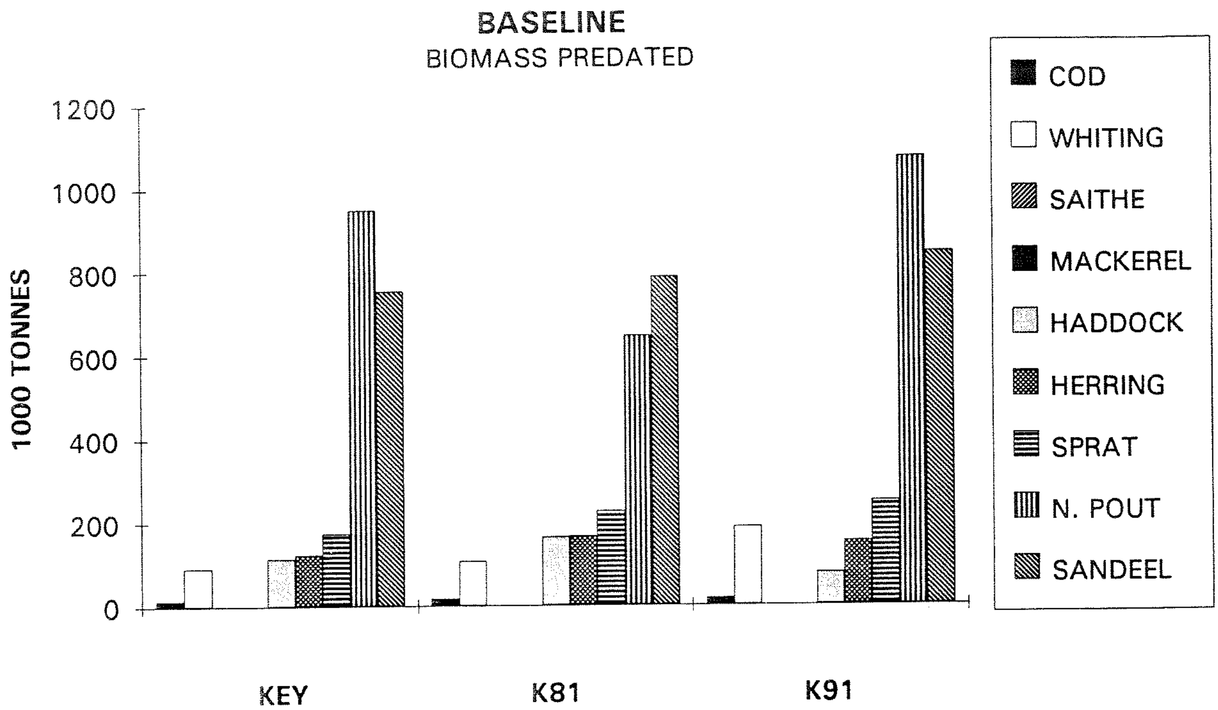


Figure 6.10.4

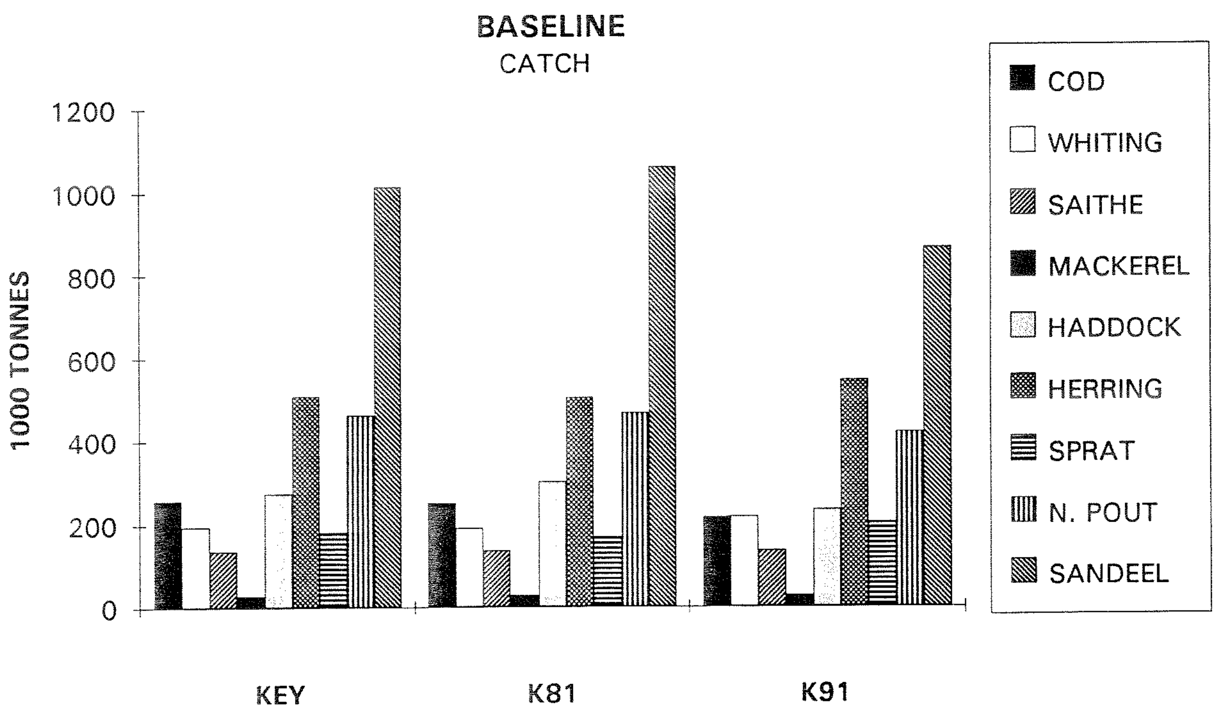


Figure 6.10.5

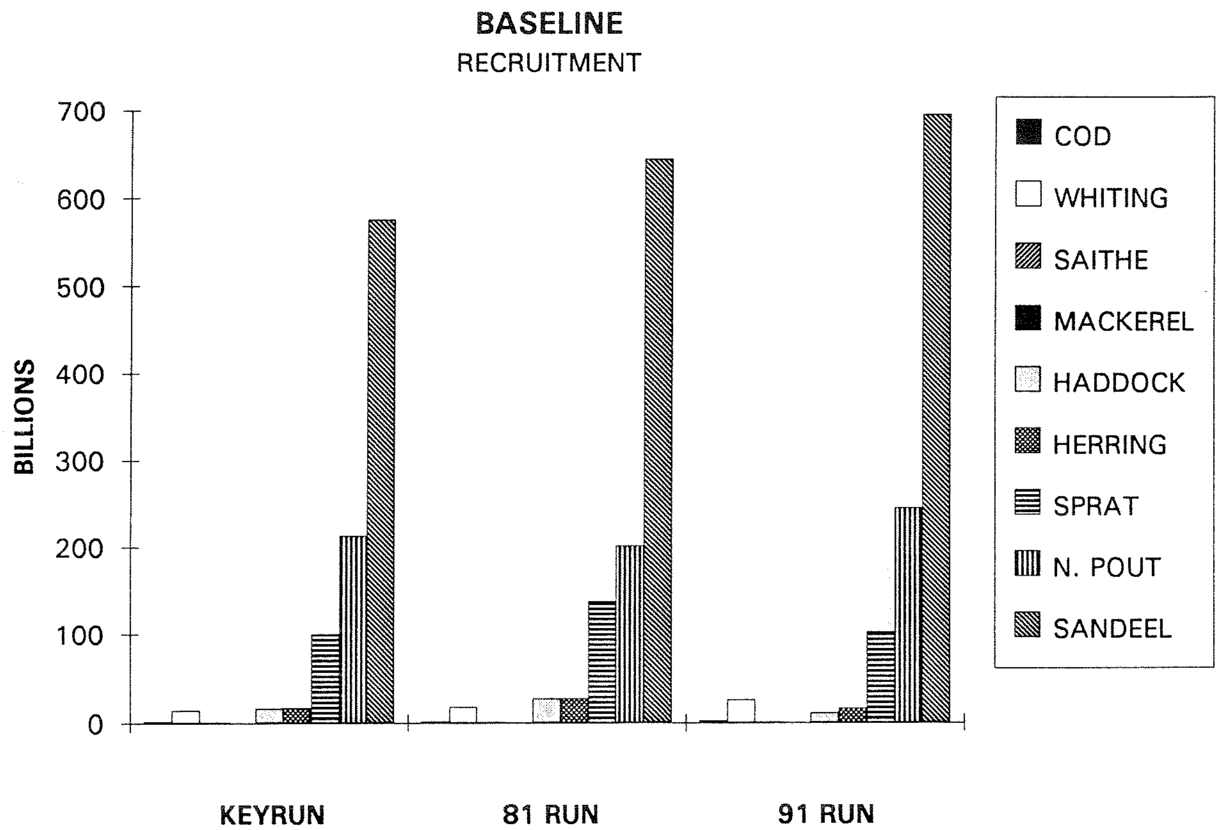


Figure 6.10.6

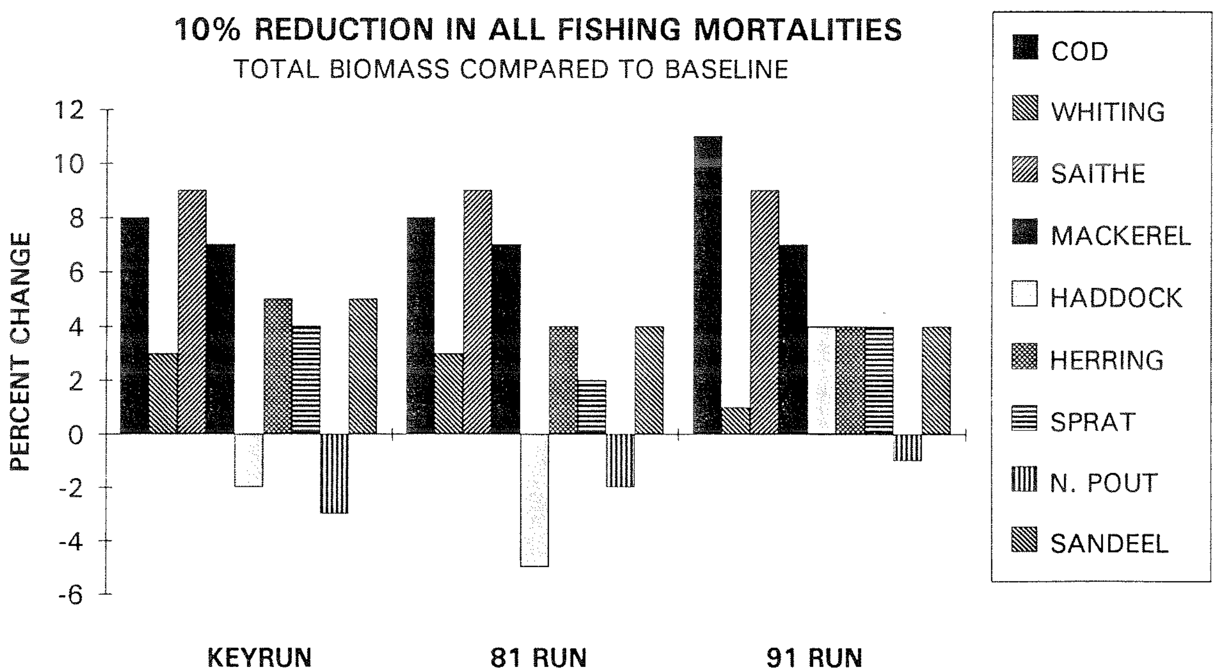


Figure 6.10.7

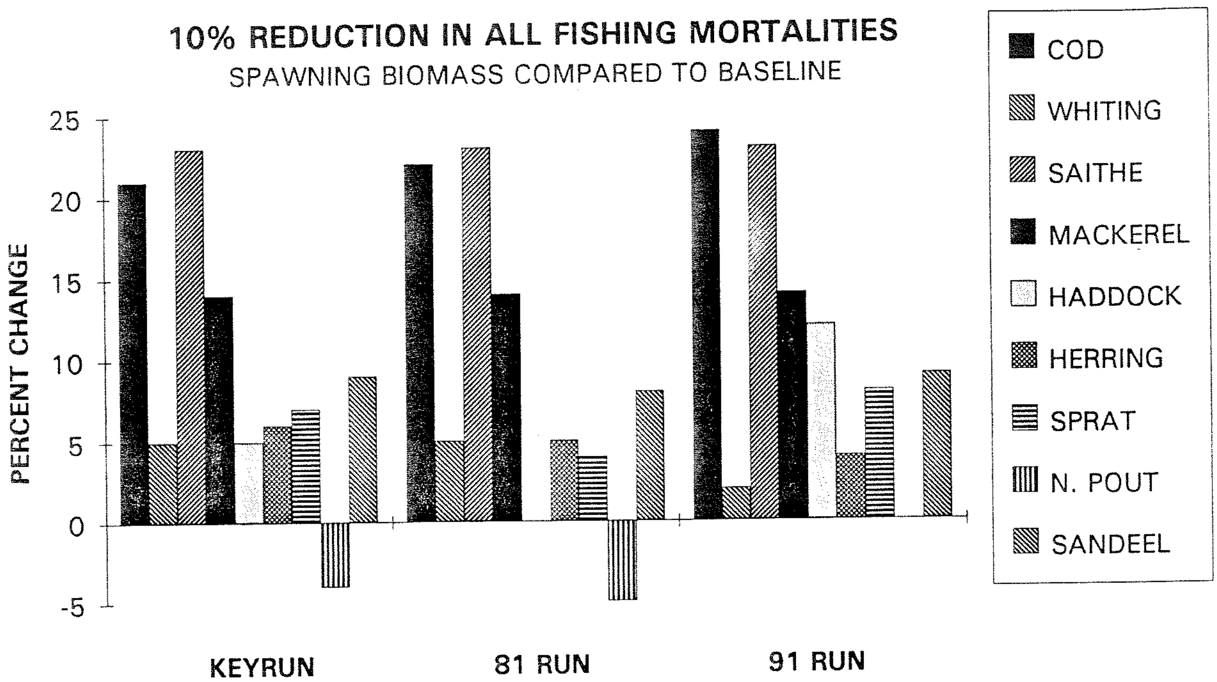


Figure 6.10.8

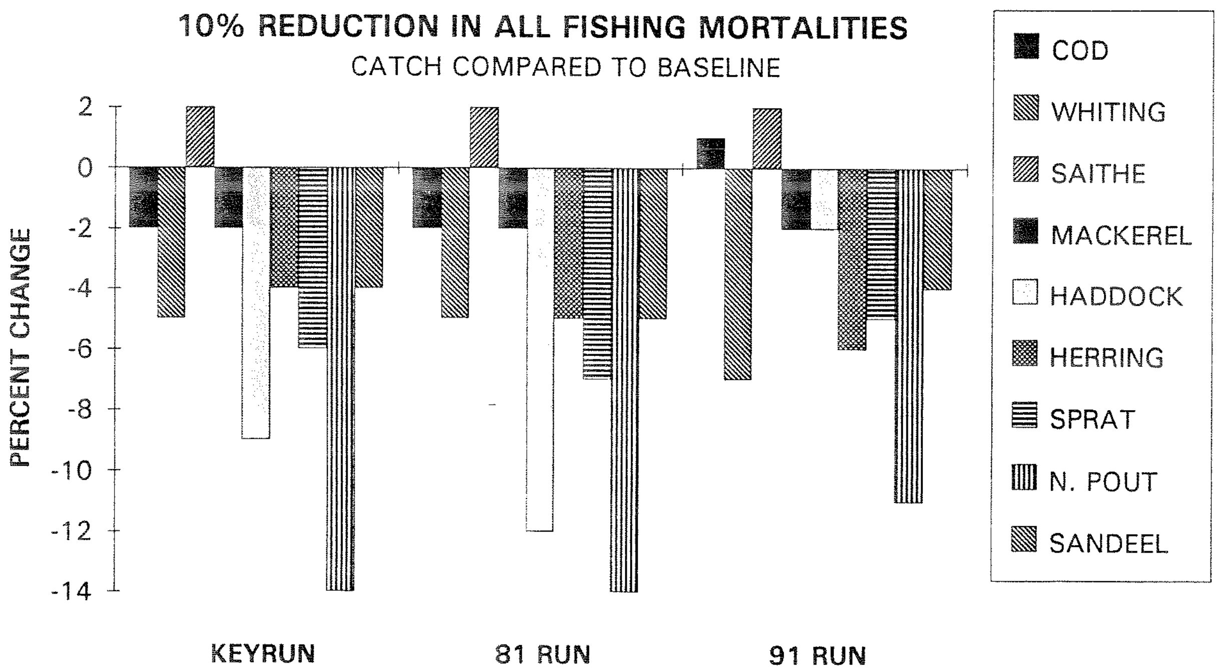


Figure 6.10.9

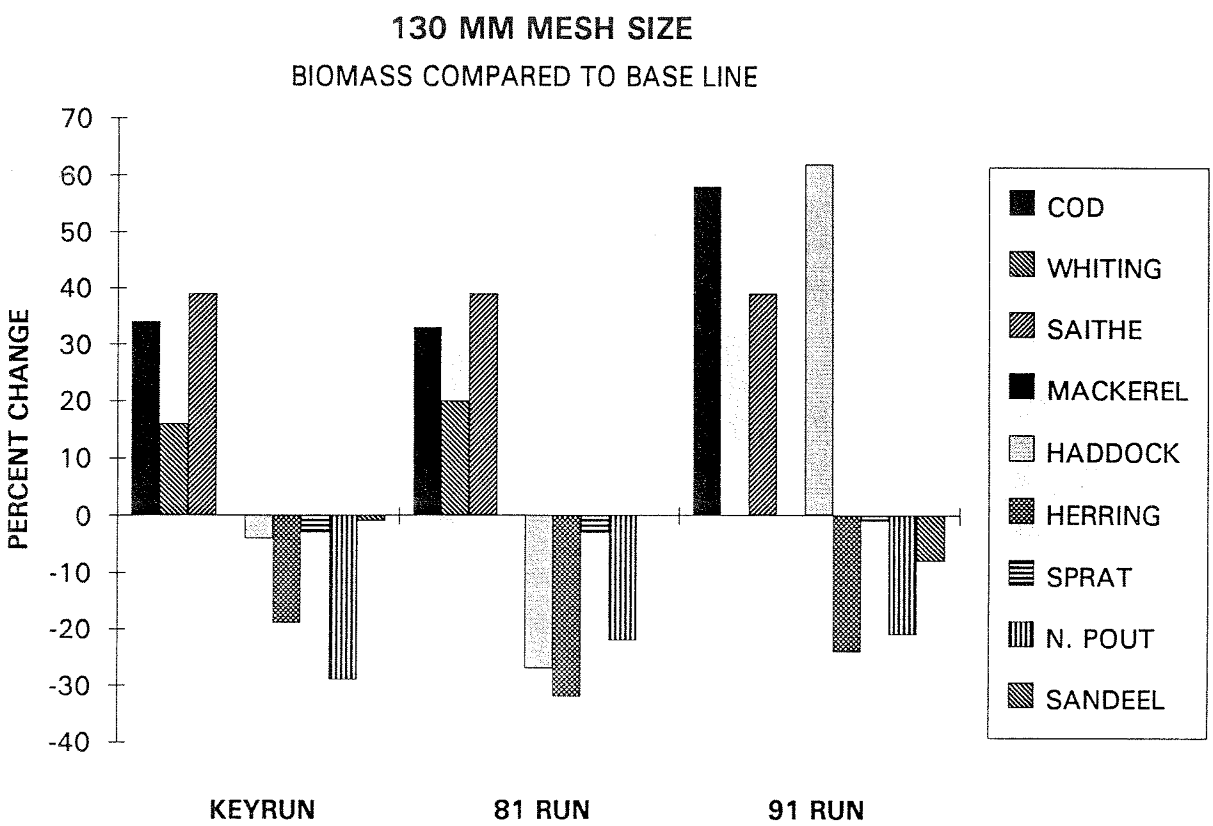


Figure 6.10.10

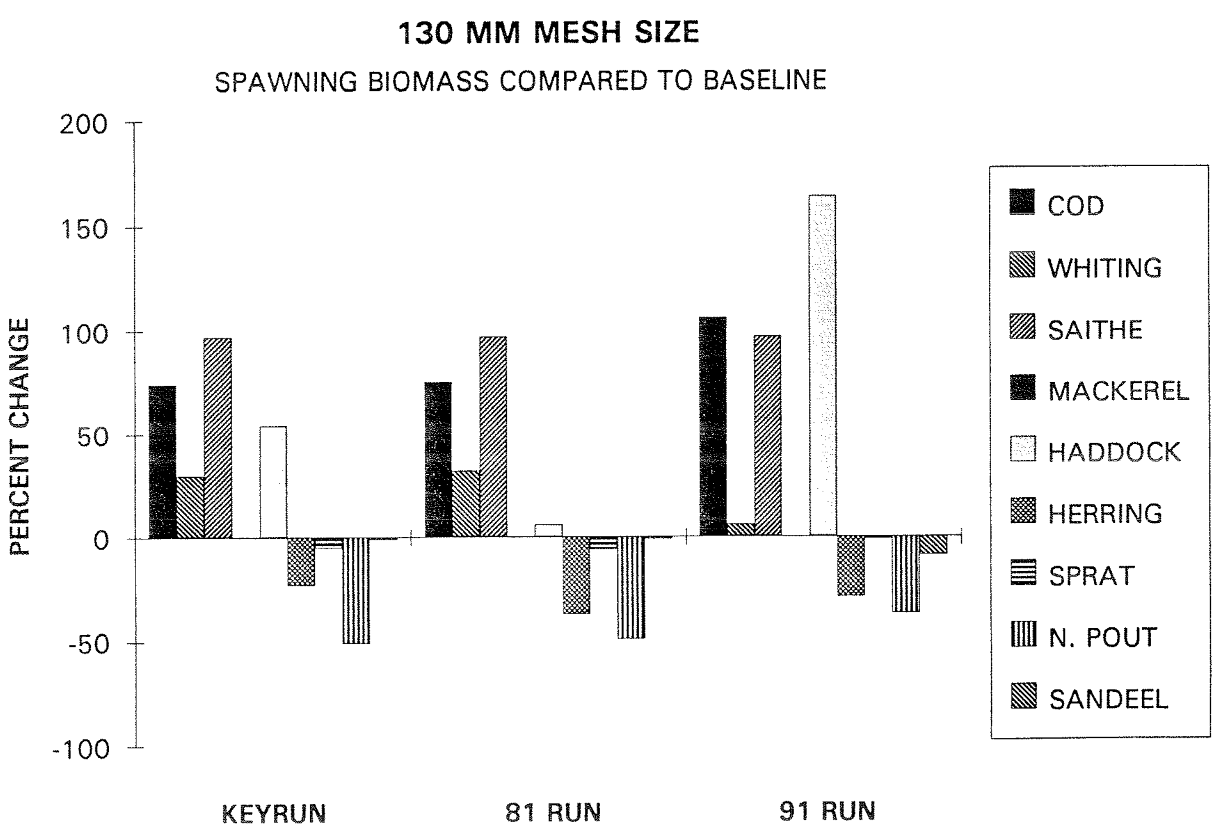


Figure 6.10.11

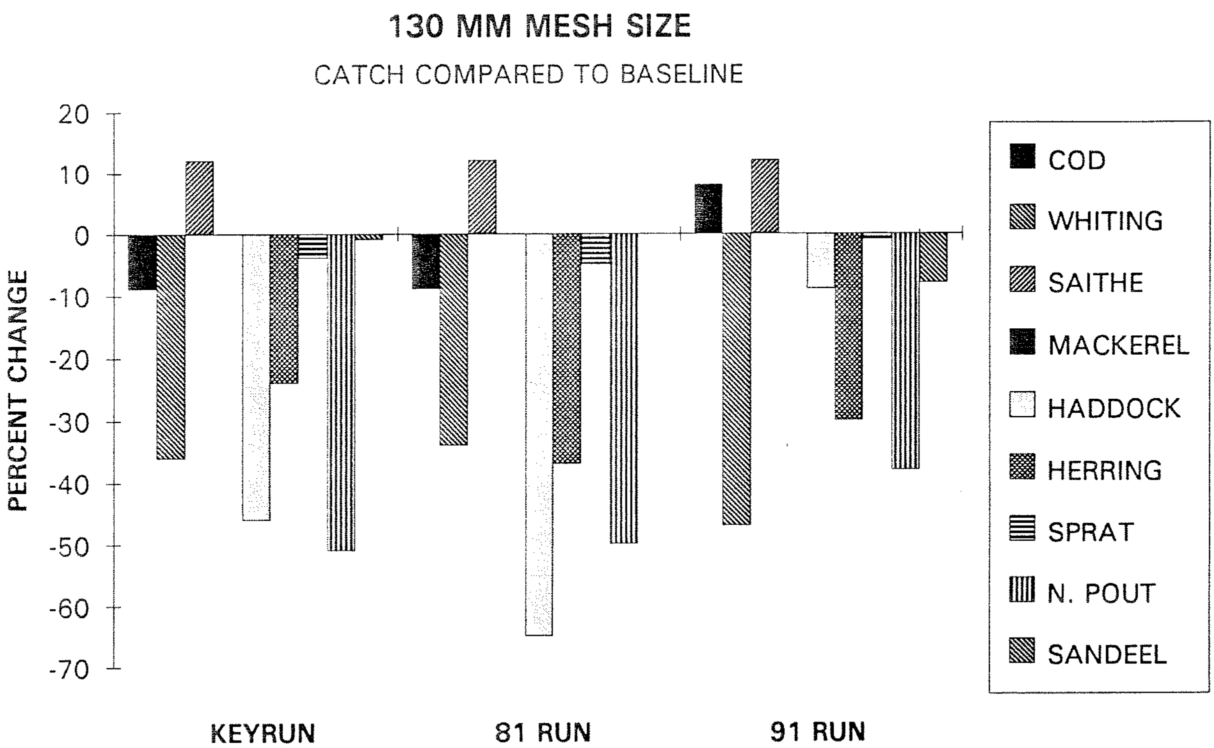


Figure 6.10.12

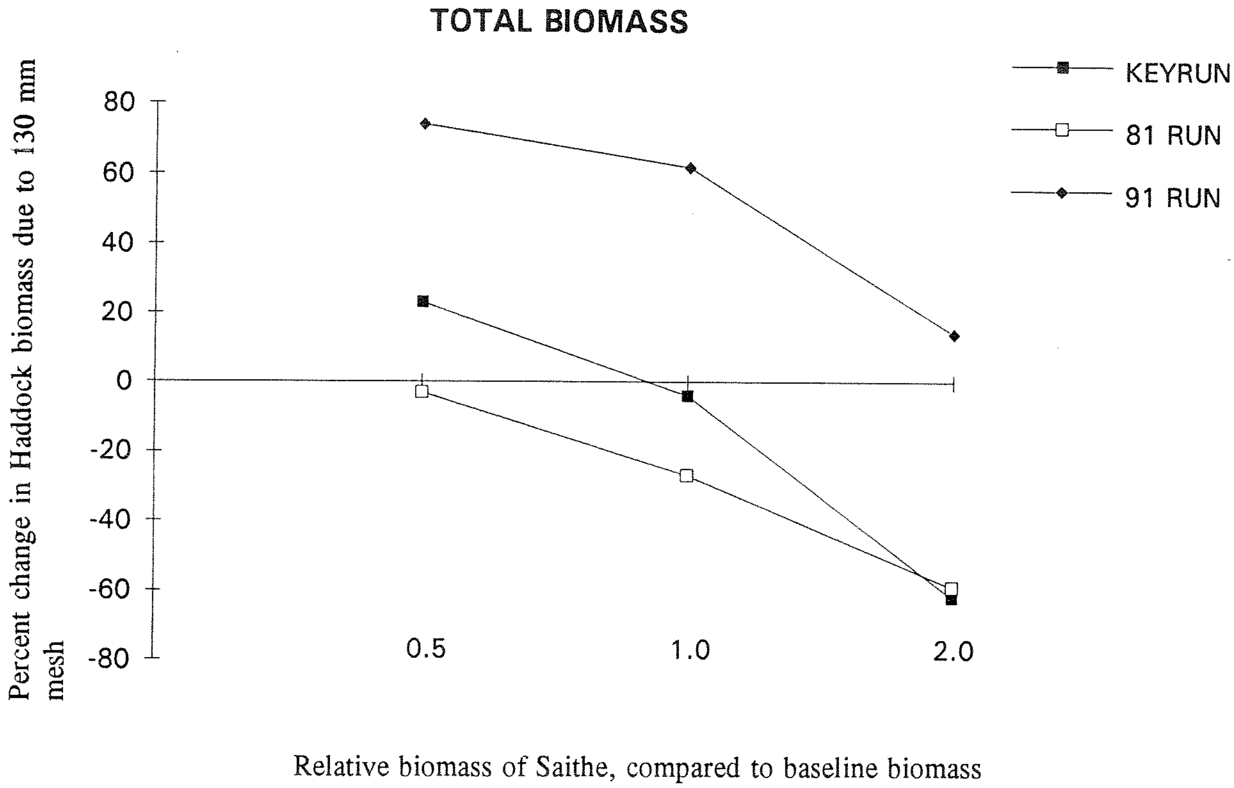


Figure 6.10.13

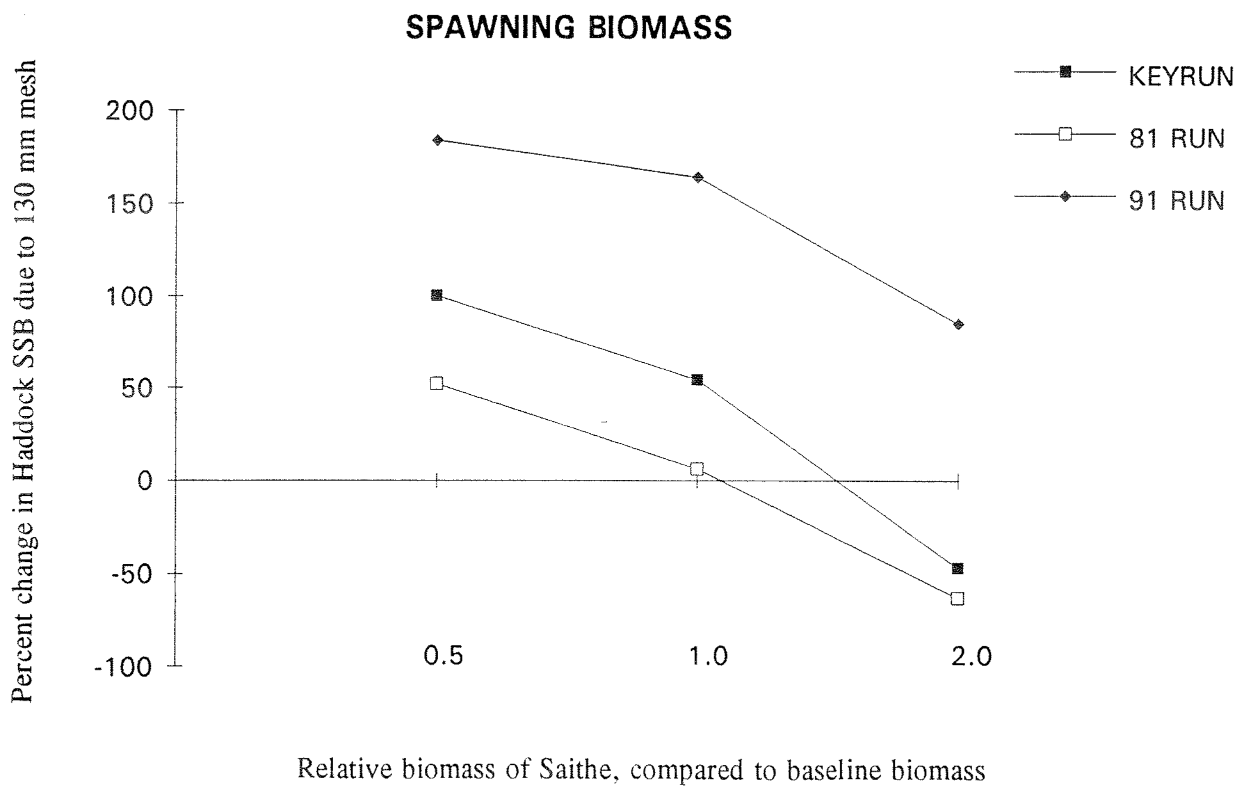


Figure 6.10.14