THE POST-FIBEX DATA INTERPRETATION WORKSHOP, HAMBURG 21 SEPTEMBER–9 OCTOBER 1982

by D. L. Cram and J.-C. Freytag
with the cooperation of J. W. Schmidt, M. Mall, R. Kresse and T. Schwinghammer

Berichte zur Polarforschung Nr. 8 / Februar 1983
Reports on Polar Research no 8 / February 1983

Hinweis

Die Berichte zur Polarforschung werden vom Alfred-Wegener-Institut für Polarforschung in Bremerhaven* in unregelmäßiger Abfolge herausgegeben.

Sie enthalten Beschreibungen und Ergebnisse der vom Institut oder mit seiner Unterstützung durchgeführten Forschungsarbeiten in den Polargebieten.

Die Beiträge geben nicht notwendigerweise die Auffassung des Instituts wieder.

Notice

The Reports on Polar Research are issued by the Alfred-Wegener-Institute for Polar Research, in Bremerhaven*, Federal Republic of Germany. They appear in non-regular intervals.

They contain descriptions and results of investigations in polar regions either conducted by the Institute or with its support.

The papers contained in the Reports do not neccessarily reflect the opinion of the Institute.

*Anschrift

Alfred-Wegener-Institut
für Polarforschung
Columbus-Center
D-2850 Bremerhaven
Telefon (0471) 4 90 06/7
Telex 02 38 695 polar d
Telegramm: Polar Bremerhaven

*Address

Alfred-Wegener-Institute
for Polar Research
Columbus-Center
D-2850 Bremerhaven
Federal Republic of Germany
Phone (0471) 4 90 06/7
Telex 02 38 695 polar d
Telegram: Polar Bremerhaven

Contents table

Summary

The SCAR/SCOR sponsored research programme "Biological Investigations of Marine Antarctic Systems and Stocks" is unique in having had available for its First International BIOMASS Experiment (FIBEX) a project-based system for the international exchange of multidisciplinary marine data, and a computer database management and processing system for the evaluation of data at a Workshop. The ten participating national programmes accepted informal agreements on standarization of methods; enforcement of standards; development of international data exchange formats for acoustics, net haul, biological, oceanographic and bird observation data, design of a database, and development of a data processing system. The development of the Workshop is described as well as some of the major problems together with some proposals for their avoidance in future. The Workshop met its objectives in terms of international co-operation and the production of results. Experience has shown that it is possible to successfully exchange raw multidisciplinary marine data for co-operative international evaluation at a workshop, and to produce meaningful results within a limited time.

Zusammenfassung

Das von SCAR und SCOR geförderte Forschungsprogramm "BIOMASS" (Biologische Untersuchungen mariner antarktischer Systeme und Bestände) ist insofern einzigartig, als für das "First International BIOMASS Experiment" (FIBEX) ein projektorientiertes System für den internationalen Austausch multidisziplinärer mariner Daten und ein Datenbank-Management- und Verarbeitungssystem zur Datenauswertung per Computer anläßlich eines Arbeitstreffens zur Verfügung standen. Die Forschergruppen der zehn teilnehmenden Staaten einigten sich informell über die Standardisierung von Methoden, Einführung von Eichmaßen, Entwicklung von Datenformaten zum internationalen Austausch von akustischen, Netzfang-, biologischen, ozeanographischen und Vogelbeobachtungsdaten. Weiterhin wurden eine Datenbank und ein Auswertesystem entworfen und realisiert.

Der Ablauf des ersten Arbeitstreffens (Sept./Okt. 1982) in Hamburg wird hier beschrieben, ebenso wie einige der aufgetretenen Probleme, sowie Lösungsvorschläge für die Zukunft.

Das Arbeitstreffen erfüllte seinen Zweck bezüglich der internationalen Kooperation beim Erarbeiten der Ergebnisse. Wir haben die Erfahrung gemacht, daß es möglich ist, mit Erfolg multidisziplinäre Rohdaten aus der Meeresforschung auszutauschen, bei einem internationalen Treffen gemeinsam auszuwerten und innerhalb kurzer Zeit aussagekräftige Ergebnisse zu produzieren.

THE POST-FIBEX DATA INTERPRETATION WORKSHOP, HAMBURG, 21 SEPTEMBER/9 OCTOBER 1982

by D.L. Cram and J.-C. Freytag
with the cooperation of J.W. Schmidt, M. Mall, R. Kresse and T. Schwinghammer

1. Introduction

In mid 1975, the Scientific Committee on Antarctic Research (SCAR) re-created one of its sub-Committees as a Group of Specialists, with wide-ranging terms of reference in Antarctic marine science. Later that year, the Scientific Committee on Oceanic Research, agreed to co-sponsor this group, at the invitation of SCAR. In 1976, this Group developed a proposal called Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS). The principal objective of this programme is "to gain a deeper understanding of the structure and dynamic functioning of the marine antarctic ecosystem as a basis for the future management of potential living resources". A detailed description of the approach to be used is given in the BIOMASS Research Proposals (1). The practical implementation of this proposal rests on two international multidisciplinary cruise programmes: the First International BIOMASS Experiment (FIBEX) held in 1980/81 and the Second International BIOMASS Experiment (SIBEX) to be held in 1983/84 (2).

FIBEX was a collectively organized experiment involving ten National Southern Ocean cruise programmes, those of Argentina, Australia, Chile, The Federal Republic of Germany, France, Japan, Poland, South Africa, The Union of Soviet Socialist Republics and the United States of America, and was accomplished between December 1980 and March 1981. Planning commenced in earnest in 1978 with the establishment of a number of Committees whose broad objective was to translate the BIOMASS research proposals into a coherent international cruise programme. This work was accomplished in the fields of acoustic survey techniques on krill (3,4,5) krill biology (6), fish biology (7,8), bird biology (9,10) and oceanography (11). These reports summarized the state of knowledge in the field and made concrete recommendations on worthwhile avenues of further study. Any recommendations arising from these groups were used by national programme research Committees or in the design and implementation of FIBEX.

2. The First International BIOMASS Experiment - FIBEX

The objectives of FIBEX were established in mid-1980 and were set at two levels. The primary objectives were to obtain a synoptic assessment of the abundance of krill in the South West Atlantic and South West Indian Ocean sectors of the Southern Ocean; to map the distribution of krill in these areas, and along two meridional lines in the Pacific sector, and if possible, relate it to water-mass distribution; and to study the methodology for assessing the abundance of the total krill population. The secondary objectives included an intensive multidisciplinary examination of a "krill patch", and other physical, chemical and biological oceanographic sampling within the framework of BIOMASS (12).

To achieve the primary objectives, FIBEX was structured as a multiship acoustic survey operating in the two main areas of the Southern Ocean. A survey grid was drawn up for both these areas (13) and various sub-areas allocated for coverage by each nation. It was anticipated that the survey would last about 28 days with 150-180 nautical miles covered each day by each

vessel. The acoustic data were to be collected by analog and/or digital integrators over the 24 hours wherever possible. In addition, data from echograms were required. Net hauls were to be made as often as possible to identify acoustic targets, plus one haul near noon each day. The range of sampling gear available was impressive: Hensen net, Bongo, IKMT, RMT, commercial trawl, KOC-A, KYMT, MOCNESS, many of which were equipped with opening and closing mechanisms enabling multiple hauls to be made.

To meet both primary and secondary objectives, two stations were to be accomplished each day, at noon and midnight. At the noon station a CTD/STD cast would be made from 0-200 m; light penetration measured (Secchi disc); water samples taken from 8 light depths (100% - 0.01% extinction) for measurement of salinity oxygen content, nutrients, chlorophylls, phaephytins and phytoplankton. Additional work could include primary production and zooplankton sampling. The midnight station was designed to be similar except for a deep STD/CTD cast, down to 1000 meters, where possible. The recommended underway sampling included fluorimetry, bathythermographs and expendable bathythermographs. In addition, visual observations would be made for the International Survey of Antarctic Seabirds and for a scheme of visual observations of krill swarms.

One important element of FIBEX concerned the intensive study of krill swarms or "patches". An extremely comprehensive plan of repetitive sampling of acoustic, net-sampling, microbiological, optical, physical, chemical, biological and biochemical parameters was drawn up to study the composition, morphology, density and environmental conditions of such patches. It was recognized that, due to the dispersion of vessels throughout the Southern Ocean, the opportunities for collective study would be very restricted.

Another very significant aspect of the planning of FIBEX was that a data interpretation Workshop would be held in August or September, 1981 for the purpose of co-operative evaluation of the data collected during FIBEX. The major product of the Workshop was to be a single report containing a detailed interpretation of the data presented to the Workshop and jointly attributed to all Workshop participants. It was recommended that the fisheries information management system developed at the University of Hamburg and demonstrated at the BIOMASS Data Workshop be used for this purpose (12).

This paper describes the development and execution of the post-FIBEX Data Interpretation Workshop and sets it in the context of the First International BIOMASS Experiment.

3. Requirements for data management

Although well co-ordinated, the national expeditions participating in FIBEX were controlled by national authorities, so that the relevant data would reside in separate institutes in different countries. There are a number of excellent facilities existing for the international exchange of certain marine research data but although the World Data Centres in Washington D.C. and Moscow are able to store biological data, world-wide systems of exchange of marine biological data are not yet in operation. In any case, data usually take two or three years to reach national or international data centres; until then, it is not available for exchange other than by institute or regional agreements. The situation with the excellent world-wide referral systems is roughly similar, whilst bibliographic or other information exchange systems usually rely on the publication of results in Journals.

Whilst these international data exchange procedures would perform their function successfully in the long-term, particularly if coupled with a BIOMASS Data Centre (14), they would not meet the short-term requirement of FIBEX, namely that the data be amalgamated into one coherent entity for co-operative international evaluation at the Workshop to be held some 6-8 months after the end of FIBEX. In order to achieve this objective, and to answer the multi-disciplinary questions posed in the BIOMASS "Research Proposals" (1), BIOMASS, and FIBEX in particular, needed a system of project data management involving informal international agreements on standards for data collection, formats for data storage, data exchange procedures, methods of storing the multidisciplinary data as a single entity, methods of co-operative processing of the data, and eventual production of reports.

4. The background to the post-FIBEX Workshop

In 1978, a project on "fisheries databases" began at the Institute for Sea Fisheries in Hamburg with a grant from the Alexander von Humboldt Foundation, Bonn, with an agreement that the computer work would be done at the Fachbereich Informatik, University of Hamburg. The first published result of this work was a discussion of the management of acoustics survey data using a database management system to store and manipulate the data. This database, named "ECHODB", was purely an experimental system intended to demonstrate the importance of the database management system in relation to digital acoustics data (15). The satisfactory development of this experimental database suggested that, with a suitable database design, the database management system and associated computer programmes developed at the Fachbereich Informatik, could be applied to the acoustics data from FIBEX (4). As this idea gained in acceptance, it was decided to hold a meeting of the BIOMASS Working Party on Acoustic Estimation of Krill in Hamburg in May 1980 (5) and to demonstrate the acoustics part of the "fisheries database" under development to the members and observers in a three-day BIOMASS Data Workshop (16).

The "fisheries database", known as FISHDB, was well developed by the time of the BIOMASS Data Workshop. In addition to the acoustics part, it was possible to demonstrate the entire multidisciplinary FISHDB involving net hauls, biological sampling and other data, which has been fully described elsewhere (16,17). Also, a powerful library of query programmes had been assembled to demonstrate the capability for making repetitive selections on multidisciplinary data and to subject the selected data to simple processing algorithms.

Recommendations that the system could be used for FIBEX as a whole were endorsed by the BIOMASS Technical Groups on Programme Implementation and Co-ordination (12) and Data, Statistics and Resource Evaluation (14) and the concept of a "Post-FIBEX Data Workshop" came into existence. Finally, towards the end of 1980, the development of the Workshop became a joint project of the Alfred Wegener Institute for Polar Research and the Fachbereich Informatik of the University of Hamburg, with some financial support from the Scientific Committee for Antarctic Research (SCAR).

5. The Workshop

A decision was made upon what constituted the FIBEX data set for Workshop purposes, namely, all acoustics data, the relevant net haul and biological data, relevant oceanographic data and bird observation data. The integration of these data into one entity for co-operative processing required that solutions be found to a number of problems in data collection methods and

standards, data formats, data exchange methods, system analysis, database design and computer programming.

a) Agreements on methods and standards

Wherever possible, existing international standards were used, for example, those for physical oceanographic data and for chlorophyll determination. Where none existed, project-based standards were developed for data collection methods and equipment calibration. At an early stage, agreements were reached on calibration methods for acoustic equipment (18) and there were a number of less formal agreements on intercalibration of acoustic equipment between ships at sea. From the methodological side, common methods of scaling echo-integrator outputs were established (19) and a large number of agreements were reached on measurement methods and definitions concerned with echo-integrator intervals and krill aggregations (5). Substantial progress was made towards standardizing the relatively complex biological data from net hauls, biological samples, biological data, and length frequency distributions (6,20). The ISAS 10-minute forms for bird observations at sea were used.

b) Data exchange

Considerable effort has been expended in developing national data collection formats, so it was impractical to develop a universal BIOMASS-FIBEX format. It was clear that the national forms contained an identical core of information, so assurances were obtained that "missing"data items could be incorporated into national forms for FIBEX purposes. It was not possible for data to be sent to the Workshop in national formats, as this would cause a serious re-formatting problem. Instead, an exchange format was developed which took into account the needs of the data and of database to be used at the Workshop, as well as the needs of the user (21). The format of the transmission of data to the Workshop was designed as a series of 80 byte records ordered in a sequence roughly corresponding to the structure of the database. Transmission was intended to be by magnetic tape, although the format permitted cards to be used.

c) Data validation

Data validation is the responsibility of the orginator. Whilst FIBEX participants made every effort to validate their data, they were hindered by lack of time between the end of the cruise programmes and the beginning of the Workshop. The first step of the validation process checked the data tape to ensure that it conformed to the agreed data exchange format. The second step inserted the correctly-formatted data into a replica of the main database and checked each value for correctness within a likely range of values. Within this step, the users could receive maps and statistical evaluations, so assisting further in the detection of errors. In both steps the originator was responsible for checking the errors detected against the original data. Data validation was a laborious task which occupied nearly two weeks of the Workshop.

d) Data quality

The quality of data was very good, with only few problems being encountered. Within the acoustics data, echo-integrator values were not always in the agreed units and interval lengths were different. Conversion factors were developed to standardize these data as far as possible. Multichannel digital integrators had been set to different depth channels which were not always compatible with each other or the analogue integrators. It was decided by the

users to lump all data into a single depth channel, and much valuable data were lost as a result. The attribution of biological samples from net hauls to integrator intervals was omitted from the input format, although a programme was written to remedy this fault before analysis commenced. Definitions of what constituted a krill aggregation had been firmly established, but, without a digital system, it was very time-consuming to make the measurements from the echo-gram, so only four nations supplied these very useful data.

Net hauls and biological data were handled very well, but a serious problem was introduced by the presence in the BIOMASS literature of two incompatible systems for staging the maturity of krill. Unfortunately, both systems were used quite unintentionally during FIBEX, so during the Workshop it was necessary to re-structure the maturity data to achieve minimum comparability. This caused the Workshop to lose information gathered with months of hard work. Subsample and sample numbers were often duplicated and/or incorrectly assigned to net hauls and/or samples and/or length frequency distributions. The units assigned to net hauls, samples, sub-samples and length frequency distributions were different within and between national data sets. Weight, count and volume units were all used.

Oceanographic data contained relatively few errors, probably because there is a long history of international data exchange using formats designed for computers. Where data were supplied in observed depths, they were converted to standard depths with an interpolation programme.

The principal problem with bird observation data was the naming of species. Names were misspelt; common names, family names, generic names, species names were all used, and had to be corrected.

e) The computer-based data interpretation system

The terms of reference of the Workshop demanded that the entire FIBEX data had to be made available to the originators at the same time, and it was recommended that the standard software developed by the Database and Information Systems Research Group at the Computer Science Department of the University of Hamburg be used, together with ad hoc applications programmes. A relational database management system was used with supports and controls all storage and retrieval processes on relational databases, maintains access paths and the physical integrity of the data, and is responsible for back-up in case of failures (22). A relational database named KRILLDB was developed from the existing Fisheries Database (FISHDB), specifically to store the data for the Workshop. The programming language PASCAL/R was used. This allows flexible access to a relational database through its powerful data selection and manipulation statements (23). Because of this integration of data management and computational facilities, PASCAL/R is a powerful and easy-to-use tool for those database-intensive applications like the Workshop where complex, structured, data sets must be efficiently stored, accessed, and transformed by complicated computations. PASCAL/R was used to develop the interactive query system which the Workshop participants could use on their own for the stepwise evaluation of the whole FIBEX data. The interactive database query and update facility DIALOG which was used primarily by the database administrators for error correction and for providing tabulations of various data selections in response to ad hoc requests. Other applications software used included the highly sophisticated oceanographic data contouring programme CMO, generously provided by the Canadian Department of Fisheries and Oceans, and statistical procedures which were written as required.

f) The interactive system for processing queries

The way in which the FIBEX data were to be processed was defined by the Workshop participants. Based upon these requirements an interactive query processing system was written which prompted the user, in plain language, to select from the FIBEX data what was required and to process it according to the pre-arranged methods. The system allowed the user to choose one of two main query programmes, then to make selections of the data, and subsequently to refine the selection step by step until the required data set was ready for processing. At each step the data could be displayed as tabulations, "printer maps" or short descriptions of how many items were selected. As an economy measure, plots could be displayed on a graphics screen to check their quality before they were sent to the plotter. In addition to its selection and processing functions, the query library provided a local password system (for identification and authorization to use the query system), automatic labelling of all output with the local user name, automatic formatting of printer and plotter output, and specific routines for controlling the complex contouring programme.

The first query permitted analysis of spatial distribution and statistical properties of any data (oceanographic station, net haul, echo-integrator, krill aggregation, bird observation). Having selected a data type, the user was led through a number of steps until the desired end was reached. All data were selected initially according to desired latitude-longitude area, data and time ranges, and wether or not from an individual vessel. These steps could be repeated until the right data were selected, which could be easily determined by viewing simple "printer map" displays or viewing tabulations. After this selection stage, more specific selections on each data type, could occur before processing.

For oceanographic data, further selection was possible on station details, then the parameter could be chosen, within a chosen range of values, and a depth or depth range selected. The results were displayed on a screen. If sensible, they could be contoured. The contouring programme required the user to specify the map projection, the contour interval, and wether the data points should be clumped or not. The remainder of the complex controls of CMO were either calculated from the data selected, or pre-set by the database administration.

For hauls, further selection was possible on conditions under which the haul was made, then hauls made with specific nets could be chosen, within a specified depth range, and net trajectory. This completed the basic selection of hauls, and their positions could be mapped. The next option was to select biological data from the chosen hauls. The biological parameter could be chosen (e.g. maturity stage or larvae name), the upper and lower bounds of modal size could be set, and a minimum percentage of animals in the sample could be set to exclude samples which could not be statistically processed. The selected biological data could then be analysed by a standard statistical package which calculated the number of data values, total sum, modal values (as many as were there), median, mean, standard error of mean, standard deviation, variance, minimal value, maximal value, range, skewness (Pearsson), skewness (third moment), and kurtosis. The selected length frequencies could be displayed, and the standard statistics done, then the distribution of maturity stages could be shown as a histogram, and the standard statistics done on them.

Echo-integrator intervals could be selected from specific equipment types, from a specified depth range, or those with a specific krill density parameter.

The positions of the intervals could be mapped, and the standard statistics accomplished on the integrator values.

Aggregations could be chosen from a depth range, according to their thickness, horizontal dimension, density parameter type or classification (swarm, layer, super-swarm etc.). Their positions could be mapped and their parameters analysed with the standard statistics.

Bird sightings could be further selected according to sighting details, ships activity, bird species, bird age and bird behaviour. The position of these sightings could then be plotted before continuing with computations of bird species diversity, bird species richness, total abundance and total biomass.

This query gave the greatest flexibility in selecting and presenting data. In addition to the facilities already described, an "overplot" facility could be used to combine selections from one data set with selections from any three others to produce compound maps. For example, the position of krill aggregations could be superimposed on a contoured oceanographic parameter and a vessels cruise track.

The second main query permitted the calculation of krill abundance and statistical parameters from echo-integrator data. Being complex yet compact, this interactive query programme clearly demonstrates the relationship between the user, the query programme and the database (Table 1).

The third query programme was relatively small, being used to perform regression analysis on aggregation parameters (e.g. depth versus time to study vertical migration). The standard statistics and histogram subroutines could be used.

g) Methods

The way the Workshop ran differed sharply from the way it was planned to run. There was an initial period of uncertainty whilst data were being validated, errors being discovered and corrected, programmes being completed, modified or written, and with many enthusiastic users all requiring access to the database simultaneously. With the emergence of the Working Groups regularly reviewed progress or needs and delegated the responsibility for action to a few of its members. These had booked time on the computer terminals, accomplished the work and returned to the Working Group for the next round of decisions. This procedure worked well.

A variable number of terminals were available to the Workshop, and they were connected permanently to the active database and query system for approximately 18 hours a day, usually seven days a week, for nearly three weeks. The time taken to respond to a query varied enormously with the size or complexity of the data selection or the complexity of the computation. In general, a major data selection would take a number of minutes with all subsequent selections taking a number of seconds. The computation of contours took about ten to fifteen minutes, with an additional ten to twenty minutes to draw the map. In both these cases the amount of computer time used was substantially less than the waiting time, as the machine was sharing time with other jobs, not necessarily from the Workshop.

Initially, all programmes were available interactively, but this permitted too many contouring jobs to be created, so placing an excessive burden on the already heavily used computer. After a few days, all requests for a contoured map were placed in a queue and run at night. This removed a heavy burden

from the computer and gave the users a much faster response to the rest of the query system.

Student programmers were intended to work with the Working Groups, but, due to circumstances, spent much of their time on error correction and re-programming. As this was done whilst participants were using the system a double load was unintentionally placed on the machine. More unfortunate was that the Working Groups were deprived of expert assistance.

Conclusions

The Workshop performed its function within FIBEX. It was held on schedule in September 1981, and all FIBEX participants attended and provided their data. These were combined into a single entity and subjected to co-operative international evaluation. A summary of the results was published in a single report on the Workshop (25).

The international exchange of multidisciplinary marine biological data proceeded smoothly. This was because the data originators were closely involved in the development of agreements on formats, standards and exchange procedures and then adhered to these agreements.

The amalgamation of the ten FIBEX data sets and some of the historical data collected by the Discovery Committee, was accomplished rapidly once the necessary validation of the data was achieved. The decisive factor was the use of a database management system to ensure that the data stored according to the database design retained its integrity and availability at all times.

How the co-operative evaluation of the data was to proceed was difficult to envisage in advance. Being the first of its kind, no standard methods or procedures were available to use as a model, so everything had to evolve at the Workshop. In the event, this co-operation arose spontaneously, according to the will of the participants, as they gradually became familiar with the data and processing systems at their disposal. Informal Working Groups arose, and worked at their own speed towards objectives which they set for themselves.

This "self-organization" produced important results which will be reported elsewhere. Those results summarized in the Workshop Report (25) are briefly reproduced here. Estimates of the biomass of krill (and the variance) were obtained from the South West Atlantic, South West Indian Ocean and Pacific sectors of the Southern Ocean. This is the first time such quantitative estimates of krill abundance have been made. In the Atlantic and Indian sectors, krill density showed a generally increasing trend from west to east, although abundance tended to be highest over slopes and ridges, and around islands. Abundance calculated from day values did not differ significantly from that calculated from lumped day and night values. The estimates were presented as totals from sub-areas so the quantitative distribution of krill was clearly visible. Coupled with this, the analysis of samples from net hauls with a wide variety of nets showed the distribution of modal length and maturity within a krill population of known size. Emphasis was given to the differences in length and maturity stage of animals captured by commercial trawl as compared with those captured by scientific nets, and to the longitudinal (and latitudinal) differences in these parameters. A relationship between krill distribution and temperature and silicate gradients was discerned in the Bransfield Strait and western end of the South Shetland Islands. In addition, comparison of two data sets showed an intrusion of Weddell Sea water into the Bransfield Strait during late February and early March, which appeared to have an effect on the distribution of krill. In the Indian Ocean sector it was

suggested that the observed results reflected mixing of separate population cohorts endemic to the area, and the presence of a number of spawning areas including the North Weddell Sea and around the Kerguelen-Gaussberg ridge. The bird observation data was the most complete, as circum-polar coverage was obtained. Concentrating on the FIBEX survey areas, bird species diversity, bird species richness, abundance and biomass were calculated for rectangles of 5 degrees of latitude by 15 degrees of longitude. In the Indian Ocean, values were lowest between 60-70 S, except between 60-90 E where abundance and biomass between 65-70 S where higher than elsewhere. In the Atlantic, the values between 65-70 S were also lower than elsewhere. The grid around South Georgia had the highest value of all four parameters. In general, values in the Atlantic sector were slightly higher than in the Indian Ocean sector. This brief summary does not justice to the results obtained from co-operatively processing the ten FIBEX data sets. The new knowledge on krill is especially valuable to BIOMASS as a part-fulfilment of the objectives of FIBEX and for planning the Second International BIOMASS Experiment.

Overcoming the many problems which were found during the production of these results taught many valuable lessons. Perhaps the most important was that processing methods have to be stated clearly well in advance of the Workshop, so that programmes can be prepared and tested. Just as important is that the data be fully validated by the originator and sent to any workshop well in advance. If this were to be done in future, then the bulk of the pre-processing and the production of standard data products could be accomplished beforehand and even circulated to data originators, so that more time would be available at the Workshop to concentrate on analytical work.

Many may think that the educational experience provided by the Workshop for participants and organisers was the most important of all. From experience, participants know that to achieve international comparibility, all standardization of methods must occur before the work is accomplished. The value of orderly data collection with a view to computerization to international standards is well understood. Outstanding experience has been gained in successful international exchange of acoustics, biological, bird, net haul, and oceanographic data. It has been seen that there is great value in the use of a database to integrate and manage multidisciplinary data, whilst using a high-level programming language to make repetitive selections on these data as part of the step-wise refinement of queries.

In future, a data interpretation Workshop should be viewed in the context of a complete data management plan developed well before data collection commences. Such planning is becoming increasingly important as major expeditions are tending to follow one another very closely indeed, not only in the field of Antarctic marine research. In order to obtain meaningful results from data acquired ar enormous expense, it is necessary to complete analyses very rapidly. Otherwise, the planning of the next expedition has to start before the processing of existing data is brought to a satisfactory conclusion.

This shortness of time makes it essential that computers be used as described above to achieve results co-operatively and on schedule. If this approach is to succeed fully, all aspects of data acquisition and handling must be designed to make data management and processing by computer as easy as possible. Within these limitations, any future workshop should be tuned to allow prospective participants adequate time to prepare their data, and the Workshop organisers adequate time to prepare and test the computer programme system. This data management plan would include all the necessary

protocols which are now known to be necessary for effective international co-operation at the level of sharing raw data.

The post-FIBEX Data Interpretation Workshop was a milestone in marine research, made possible by international co-operation and trust in the sharing and processing of new unpublished data of great scientific importance. In this sense, it was unique.

Acknowledgements

The success of the Workshop was due to the co-operation of numerous colleagues from Argentina, Australia, Canada, Chile, France, the Federal Republic of Germany, Japan, Norway, Poland, South Africa, United Kingdom, Union of Soviet Socialist Republics and the United States of America, some of whom collected data during FIBEX, some gave the benefit of their experience of marine science, others gave help with computer science, and others with organization. It is not possible to acknowledge this at a personal level. The direct costs of the Workshop were borne by the University of Hamburg, the Alfred Wegener Institute for Polar Research and the Scientific Committee for Antarctic Research (SCAR). All co-operated to ensure the success of the Workshop.

7. References

1. "Biological investigations of Marine Antarctic Systems and Stocks: Vol. 1, Research Proposals". SCAR/SCOR Group of Specialists (Convenor S.Z. el Sayed). SCAR Secretariat, SPRI, Lensfield Road, Cambridge, U.K. 1977.

2. "Meeting of the Group of Specialists of the living resources of the Southern Oceans, Kiel, FRG May 1978". BIOMASS Report Series 1. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1978.

3. "Acoustic estimation of Krill". BIOMASS Report Series 2. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1978.

4. "Acoustic estimation of Krill II, Horten, Norway. September, 1979". BIOMASS Report Series 9. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1979.

5. "Krill abundance estimation, Hamburg FRG 30-31 May, 1980". BIOMASS Report Series 11. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1980.

6. "Antarctic Krill Biology". BIOMASS Report Series 10. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1979.

7. "Antarctic fish biology". BIOMASS Report Series 3. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1979.

8. "Antarctic fish biology, Dammarie-les-dys, France 27-31 May, 1980". BIOMASS Report Series 12. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1980.

9. "Antartic bird biology". BIOMASS Report Series 8. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1979.

10. "Antarctic Bird Biology II". BIOMASS Report Series 18. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1980.

11. "Physical and Chemical Observations". BIOMASS Report Series 17. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1980.

12. "FIBEX Implementation and Co-ordination, Dammarie-les-dys, France, 4-6 June, 1980". BIOMASS Report Series 13. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1980.

13. "FIBEX Acoustic survey design, Dammarie-les-dys, France, June 1980". BIOMASS Report Series 14. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1980.

14. "Data, Statistics and Resource Evaluation, Cambridge U.K.". BIOMASS Report Series 16. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1980.

15. Cram D.L. and M. Mall, 1979. In Suomala, J.B. ed "Managing Acoustic survey data". Meeting on Hydroacoustical Methods for the Determination of Marine Fish Populations, 25-29 June, 1979, Vol. 2b, pp 697-716. Charles Stark Draper Laboratory Inc., Cambridge, Mass. U.S.A., 964 pp.

16. "The BIOMASS Data Workshop". BIOMASS Report Series 15. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1980.

17. Cram D.L. and M. Mall, 1980. "Some experience with a fisheries-orientated database". International Council for the Exploration of the Sea, Copenhagen C.M. 1980/D:4 September, 1980.

18. Nielson R. et al, 1980 "Calibration of hydroacoustic instruments". BIOMASS Handbook 1, 55 pp. SCAR Secretariat, SPRI, Lensfield Rd. Cambridge, U.K.

19. Ehrenburg J., 1980 "Calculation of the constants need to scale the output of an echo-integrator". BIOMASS Handbook 7, 11 pp. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K.

20. Makarov R.R. and C.J. Denys, 1980 "Stages of sexual maturity of Euphausia superba DANA". BIOMASS Handbook 11. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K.

21. Cram D.L., 1981 "Methods for the transmission of data to the post-FIBEX Workshop". BIOMASS Handbook 16. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K.

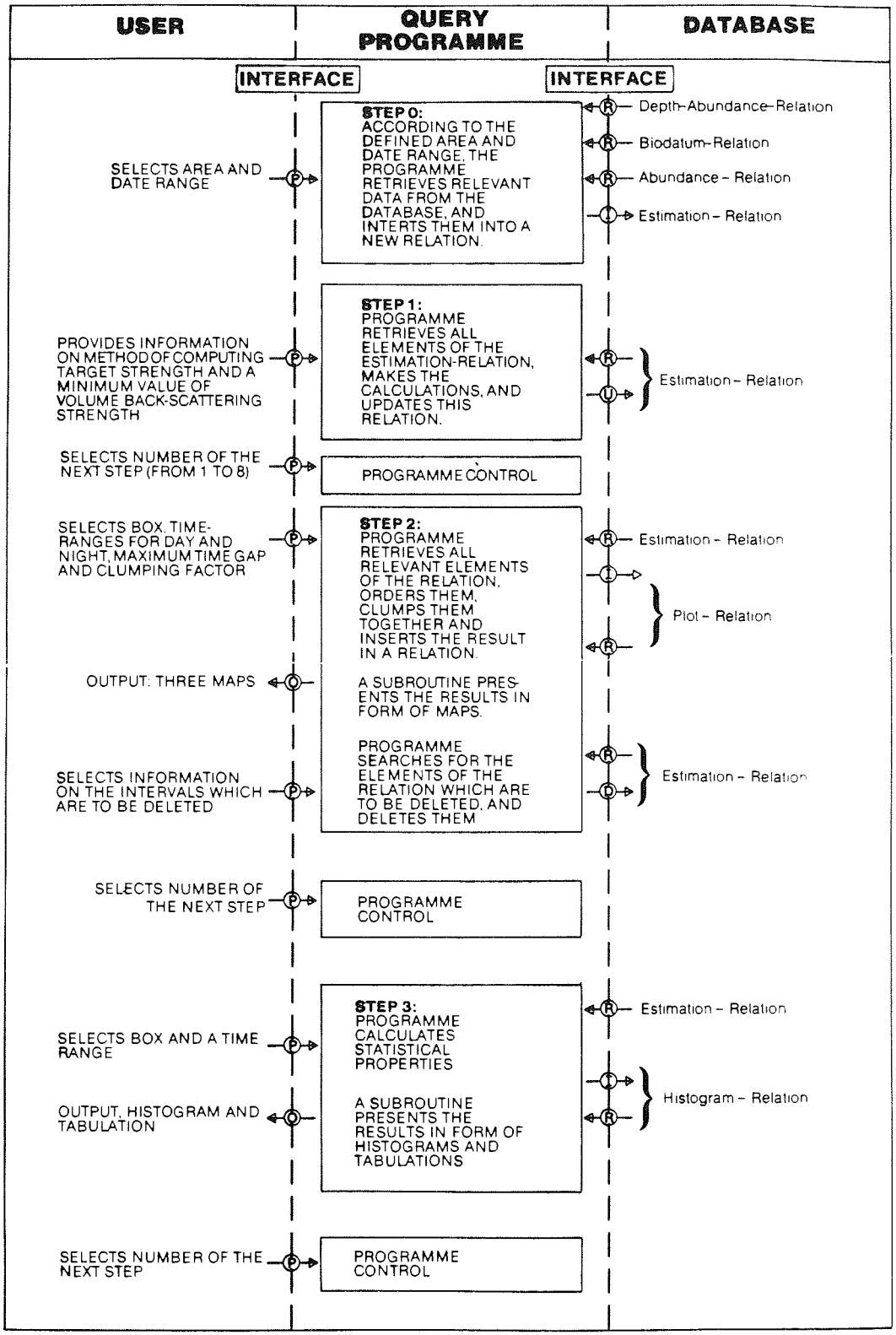
22. Codd E.F., 1970 "A relational model for large shared databanks". Communications of the ACM 13.6 June 1970.

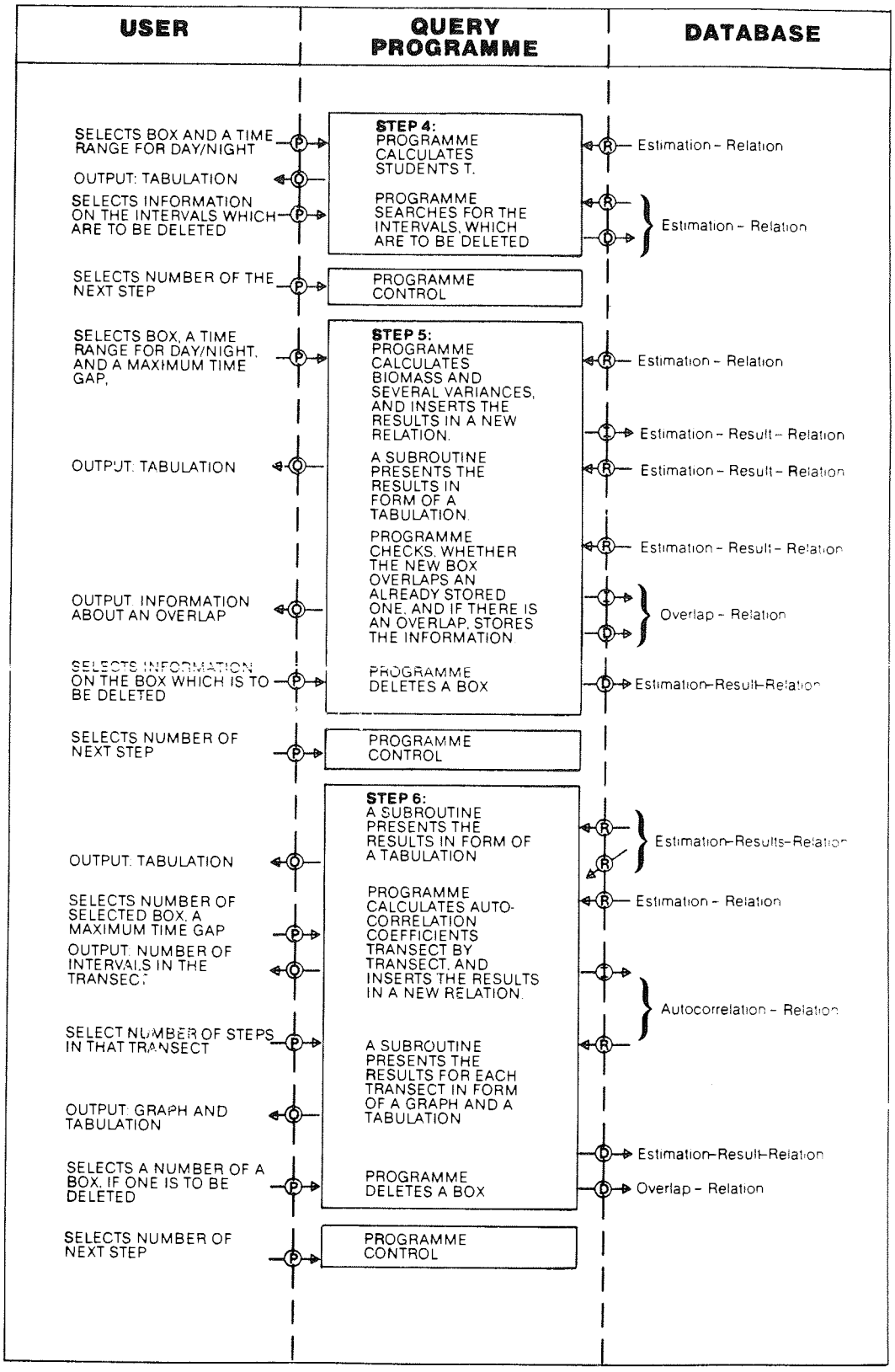
23. Schmidt J.W. and M. Mall, 1980 "PASCAL/R Report". Bericht Nr.66 Fachbereich Informatik, University of Hamburg, January, 1980.

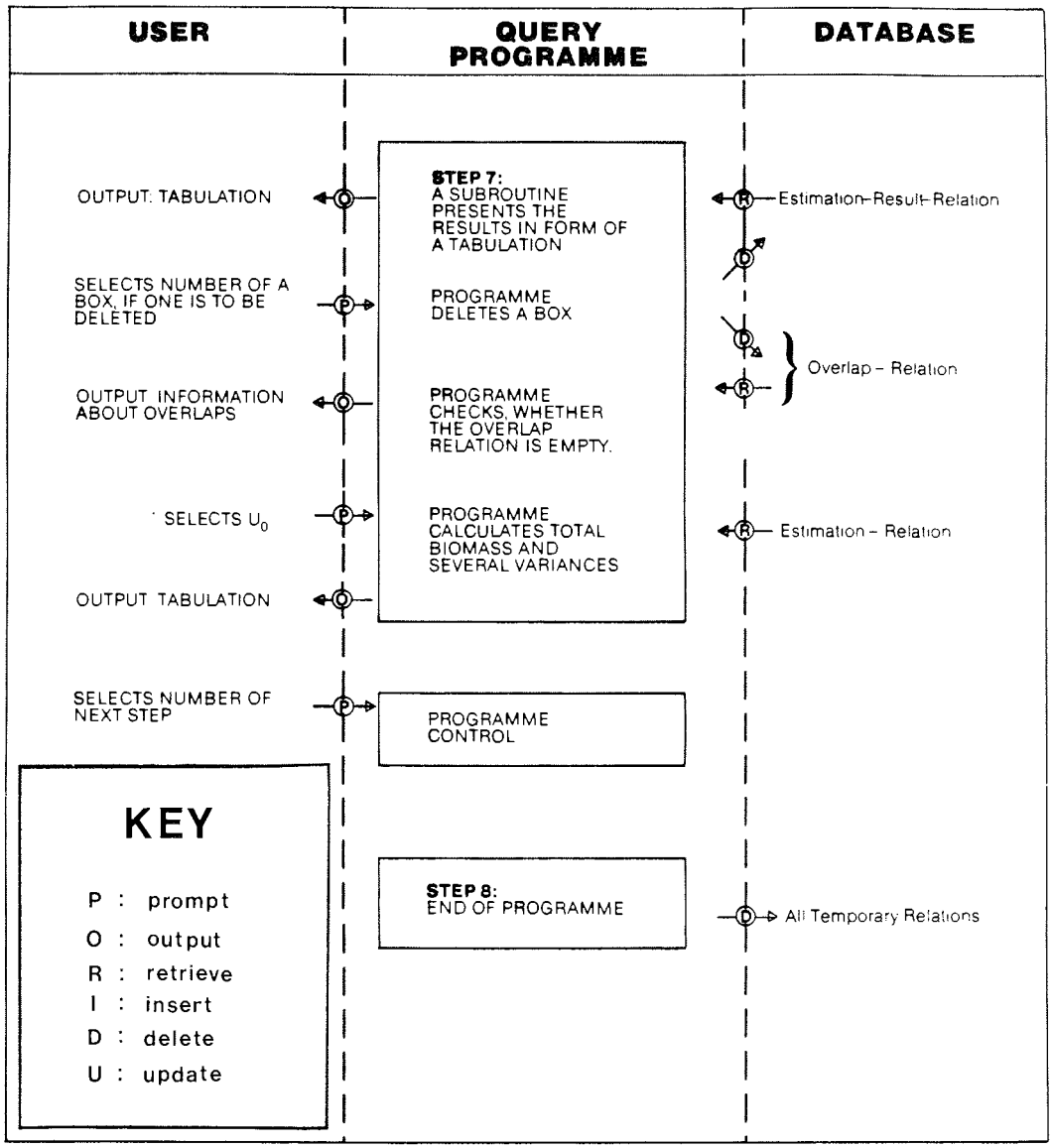
24. Cram D.L. et al, 1982 "The management of acoustics survey data from the first BIOMASS Experiment". ICES Symposium on Fisheries Acoustics, Bergen, Norway, 21-24 June, 1982, Paper No. 14. ICES, Copenhagen.

25. "Post-FIBEX Data Interpretation Workshop. Hamburg, FRG 21 September - 9 October, 1981". BIOMASS Report Series 20. SCAR Secretariat, SPRI, Lensfield Rd., Cambridge, U.K. 1981.

Table 1 The second query (acoustics). A chart of the processing steps and interaction between the user, the query programme and the database (24).


USER
QUERY PROGRAMME
DATABASE
INTERFACE
INTERFACE
STEP 0:
ACCORDING TO THE DEFINED AREA AND DATE RANGE, THE PROGRAMME RETRIEVES RELEVANT DATA FROM THE DATABASE, AND INTERTS THEM INTO A NEW RELATION.
Depth-Abundance-Relation
Biodatum-Relation
Abundance - Relation
Estimation - Relation
SELECTS AREA AND DATE RANGE
STEP 1:
PROGRAMME RETRIEVES ALL ELEMENTS OF THE ESTIMATION-RELATION, MAKES THE CALCULATIONS, AND UPDATES THIS RELATION.
Estimation - Relation
PROVIDES INFORMATION ON METHOD OF COMPUTING TARGET STRENGTH AND A MINIMUM VALUE OF VOLUME BACK-SCATTERING STRENGTH
SELECTS NUMBER OF THE NEXT STEP (FROM 1 TO 8)
PROGRAMME CONTROL
STEP 2:
PROGRAMME RETRIEVES ALL RELEVANT ELEMENTS OF THE RELATION, ORDERS THEM, CLUMPS THEM TOGETHER AND INSERTS THE RESULT IN A RELATION.
Estimation - Relation
Plot - Relation
SELECTS BOX, TIME-RANGES FOR DAY AND NIGHT, MAXIMUM TIME GAP AND CLUMPING FACTOR
OUTPUT: THREE MAPS
A SUBROUTINE PRESENTS THE RESULTS IN FORM OF MAPS.
PROGRAMME SEARCHES FOR THE ELEMENTS OF THE RELATION WHICH ARE TO BE DELETED, AND DELETES THEM
Estimation - Relation
SELECTS INFORMATION ON THE INTERVALS WHICH ARE TO BE DELETED
SELECTS NUMBER OF THE NEXT STEP
PROGRAMME CONTROL
STEP 3:
PROGRAMME CALCULATES STATISTICAL PROPERTIES
Estimation - Relation
Histogram - Relation
SELECTS BOX AND A TIME RANGE
OUTPUT: HISTOGRAM AND TABULATION
A SUBROUTINE PRESENTS THE RESULTS IN FORM OF HISTOGRAMS AND TABULATIONS
SELECTS NUMBER OF THE NEXT STEP
PROGRAMME CONTROL


USER
QUERY PROGRAMME
DATABASE
SELECTS BOX AND A TIME RANGE FOR DAY/NIGHT
OUTPUT: TABULATION
SELECTS INFORMATION ON THE INTERVALS WHICH ARE TO BE DELETED
STEP 4: PROGRAMME CALCULATES STUDENT'S T.
PROGRAMME SEARCHES FOR THE INTERVALS, WHICH ARE TO BE DELETED
Estimation - Relation
Estimation - Relation
SELECTS NUMBER OF THE NEXT STEP
PROGRAMME CONTROL
SELECTS BOX, A TIME RANGE FOR DAY/NIGHT, AND A MAXIMUM TIME GAP,
OUTPUT: TABULATION
STEP 5: PROGRAMME CALCULATES BIOMASS AND SEVERAL VARIANCES, AND INSERTS THE RESULTS IN A NEW RELATION.
A SUBROUTINE PRESENTS THE RESULTS IN FORM OF A TABULATION.
PROGRAMME CHECKS, WHETHER THE NEW BOX OVERLAPS AN ALREADY STORED ONE, AND IF THERE IS AN OVERLAP, STORES THE INFORMATION
PROGRAMME DELETES A BOX
Estimation - Relation
Estimation - Result - Relation
Estimation - Result - Relation
Estimation - Result - Relation
Overlap - Relation
Estimation-Result-Relation
OUTPUT: INFORMATION ABOUT AN OVERLAP
SELECTS INFORMATION ON THE BOX WHICH IS TO BE DELETED
SELECTS NUMBER OF NEXT STEP
PROGRAMME CONTROL
STEP 6: A SUBROUTINE PRESENTS THE RESULTS IN FORM OF A TABULATION
PROGRAMME CALCULATES AUTO-CORRELATION COEFFICIENTS TRANSECT BY TRANSECT, AND INSERTS THE RESULTS IN A NEW RELATION.
A SUBROUTINE PRESENTS THE RESULTS FOR EACH TRANSECT IN FORM OF A GRAPH AND A TABULATION
PROGRAMME DELETES A BOX
Estimation-Results-Relation
Estimation - Relation
Autocorrelation - Relation
Estimation-Result-Relation
Overlap - Relation
OUTPUT: TABULATION
SELECTS NUMBER OF SELECTED BOX, A MAXIMUM TIME GAP
OUTPUT: NUMBER OF INTERVALS IN THE TRANSECT
SELECT NUMBER OF STEPS IN THAT TRANSECT
OUTPUT: GRAPH AND TABULATION
SELECTS A NUMBER OF A BOX, IF ONE IS TO BE DELETED
SELECTS NUMBER OF NEXT STEP
PROGRAMME CONTROL


USER
QUERY PROGRAMME
DATABASE
OUTPUT: TABULATION
STEP 7:
A SUBROUTINE PRESENTS THE RESULTS IN FORM OF A TABULATION
Estimation-Result-Relation
SELECTS NUMBER OF A BOX, IF ONE IS TO BE DELETED
PROGRAMME DELETES A BOX
OUTPUT: INFORMATION ABOUT OVERLAPS
PROGRAMME CHECKS, WHETHER THE OVERLAP RELATION IS EMPTY.
Overlap - Relation
SELECTS U_0
PROGRAMME CALCULATES TOTAL BIOMASS AND SEVERAL VARIANCES
Estimation - Relation
OUTPUT TABULATION
SELECTS NUMBER OF NEXT STEP
PROGRAMME CONTROL
KEY
P : prompt
O : output
R : retrieve
I : insert
D : delete
U : update
STEP 8:
END OF PROGRAMME
All Temporary Relations

Folgende Hefte der Reihe „Berichte zur Polarforschung" sind bisher erschienen:

Sonderheft Nr. 1/1981 – „Die Antarktis und ihr Lebensraum"
Eine Einführung für Besucher – Herausgegeben im Auftrag von SCAR

Heft Nr. 1/1982 – „Die Filchner-Schelfeis-Expedition 1980/1981"
zusammengestellt von Heinz Kohnen

Heft Nr. 2/1982 – „Deutsche Antarktis-Expedition 1980/1981 mit FS ‚Meteor' "
First International Biomass Experiment (FIBEX) – Liste der Zooplankton- und Mikronektonnetzfänge
zusammengestellt von Norbert Klages

Heft Nr. 3/1982 – „Digitale und analoge Krill-Echolot-Rohdatenerfassung an Bord des Forschungsschiffes ‚Meteor' " (im Rahmen von FIBEX 1980/81, Fahrtabschnitt ANT III)
von Bodo Morgenstern

Heft Nr. 4/1982 – „Filchner-Schelfeis-Expedition 1980/81"
Liste der Planktonfänge und Lichtstärkemessungen
zusammengestellt von Gerd Hubold und H. Eberhard Drescher

Heft Nr. 5/1982 – "Joint Biological Expedition on RRS 'John Biscoe', February 1982"
by G. Hempel and R. B. Heywood

Heft Nr. 6/1982 – Antarktis-Expedition 1981/1982 (Unternehmen „Eiswarte")
zusammengestellt von Gode Gravenhorst

Heft Nr. 7/1982 – Marin-Biologisches Begleitprogramm zur Standorterkundung 1979/80 mit MS „Polarsirkel" (Pre-Site Survey) – Stationslisten der Mikronekton- und Zooplanktonfänge sowie der Bodenfischerei
zusammengestellt von R. Schneppenheim

Heft Nr. 8/1983 – The Post-Fibex Data Interpretation Workshop
by D. L. Cram and J.-C. Freytag with the collaboration of J. W. Schmidt, M. Mall, R. Kresse, T. Schwinghammer

Heft Nr. 9/1983 – Distribution of some groups of zooplankton in the inner Weddell Sea in summer 1979/80
by I. Hempel, G. Hubold, B. Kaczmaruk, R. Keller, R. Weigmann-Haass

Kopien dieses Reports können bezogen werden beim
Copies of this report can be received from

Alfred-Wegener-Institut für Polarforschung
Columbus-Center
D-2850 Bremerhaven
Bundesrepublik Deutschland