Deutsche Hydrographische Zeitschrift
German Journal of Hydrography
Volume 48 (1996) Number 3/4

ISSN 0012-0308

The NOWESP Research Data Base

G. RADACH, J. GEKELER, G. BECKER, P. BOT, P. CASTAING, F. COLIJN, P. DAMM, D. DANIELSSEN, L. FØYN, J. GAMBLE, R. LAANE, J.P. MOMMAERTS, D. NEHRING, K. PEGLER, W. VAN RAAPHORST, J. WILSON

Summary

In the NOWESP project historical data from the Northwest European Shelf were compiled and evaluated to estimate the variability and trends in water movements, concentrations of dissolved and particulate constituents, and fluxes of the relevant substances across the shelf. As an integral part of the project, the NOWESP Research Data Base was created as a research tool to provide the data and data products needed for the analyses within the project. The tasks of the NOWESP Research Data Base group were the acquisition of the relevant data sets, with the intensive support of all partners, organization of the data sets in the NOWESP Research Data Base, merging of the specific data sets for the ten main state variables used in NOWESP, and the provision of data products for analysis within NOWESP.

The data compiled during NOWESP represent a unique data set for the Northwest European Shelf. The data set is sufficiently comprehensive to allow the definition of long time series at about 14 sites in eight areas. It further enables the derivation of mean annual cycles of horizontal distributions of nine main state variables. NOWESP thus has provided valuable data sets for estimating budgets and fluxes across the shelf and, in addition, important data sets for the forcing and validation of ecological shelf sea models. An overview of the NOWESP data set is given. The organization of the data base is described in some detail, and examples of the products obtained for NOWESP are displayed.

Die NOWESP-Forschungsdatenbank (Zusammenfassung)

Im NOWESP-Projekt wurden historische Daten vom nordwesteuropäischen Schelf zusammengestellt und bewertet, um Veränderlichkeit und Trends von Wasserbewegungen, Konzentrationen gelöster und partikulärer Bestandteile und die Flüsse relevanter Stoffe über den Schelf zu bestimmen. Als zentraler Teil des Projektes wurde die NOWESP-Forschungsdatenbank als Forschungshilfsmittel eingerichtet, um Daten und Datenprodukte, die für Untersuchungen im Projekt benötigt wurden, bereitzustellen. Die Aufgabe der Datenbank-Gruppe war die Beschaffung der relevanten Datensätze unter intensiver Zuarbeit aller Partner, die Organisation der Datensätze in der Datenbank, das Zusammenführen der Datensätze der zehn Hauptparameter und die Bereitstellung von Datenprodukten zur Analyse innerhalb NOWESP.

Die während NOWESP zusammengestellten Daten stellen eine einzigartige Datensammlung über den nordwesteuropäischen Schelf dar. Die Datensammlung ist hinreichend umfangreich, um lange Zeitserien von etwa 14 Positionen in acht Regionen aufzustellen. Sie erlaubt weiterhin das Ableiten mittlerer Jahreszyklen der horizontalen Verteilung von neun Hauptparametern. So hat NOWESP wertvolle Datensätze zur Bestimmung von Bilanzen und Flüssen über den Schelf sowie wichtige Datensätze für den Antrieb und die Validierung ökologischer Schelfsee-Modelle geschaffen.

Es wird ein Überblick über die NOWESP-Datensätze gegeben. Die Organisation der Datenbank wird im Detail beschrieben und Beispiele von Produkten, die für NOWESP hergestellt wurden, werden dargestellt.

1 Introduction

The NOWESP project is aimed at describing and understanding the function and role of the Northwest European Shelf as a link between land and ocean. In the NOWESP project historical data from the north-west European shelf have been compiled and evaluated to estimate (1) the variability and trends in water movements, concentrations of particulate and dissolved constituents, and primary production on the shelf, and (2) the fluxes and transports of relevant substances, such as suspended particulate matter, nutrients and plankton, across the shelf. (LAANE et al. [1996b], NOWESP [1994, 1995, 1996]). The area of the Northwest European Shelf that has been considered is shown in Fig. 1; it is bounded by the 200 m depth contour and covers the French shelf, Irish Sea, Celtic Sea, the Channel, North Sea, the shelf west of the British isles, the Norwegian Trench, Skagerrak, Kattegat, and the westernmost part of the Baltic Sea.

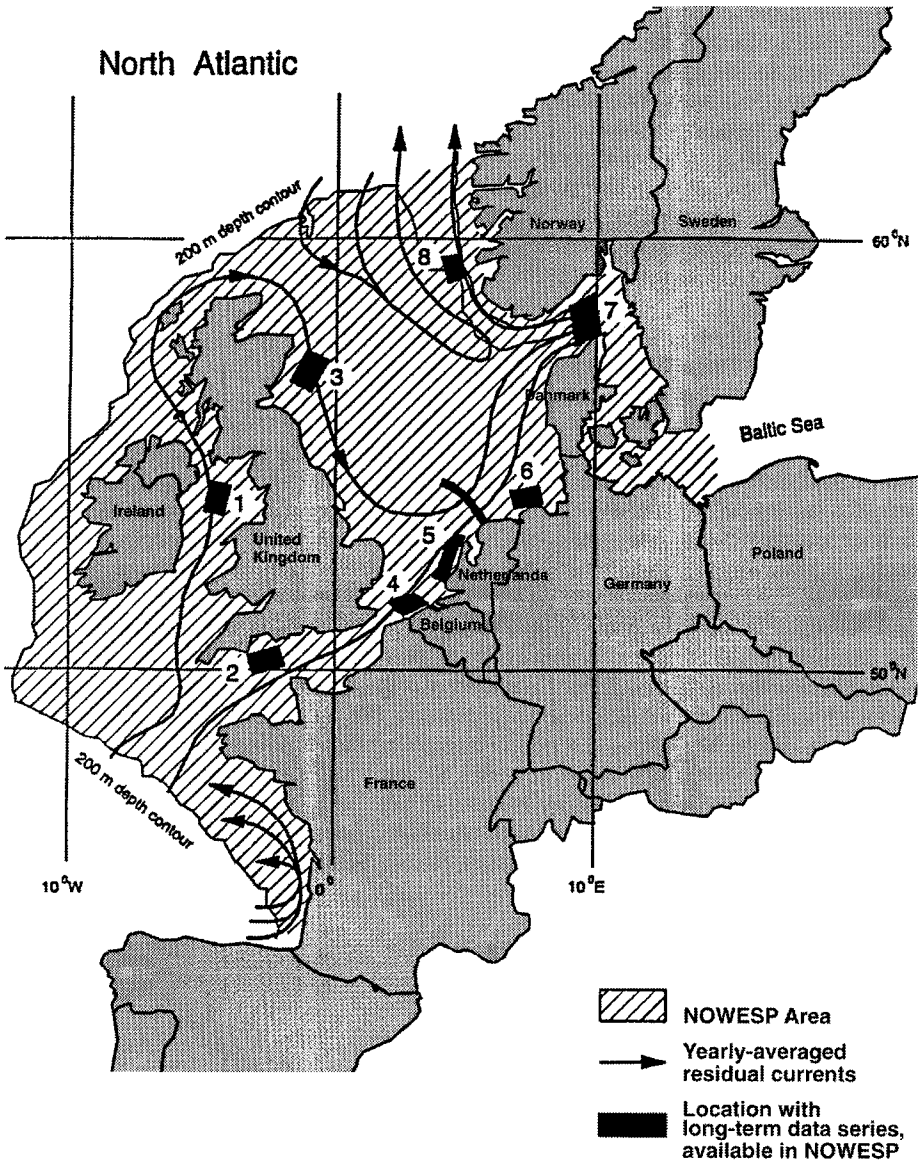

Fig. 1: Northwest European Shelf

The NOWESP Research Data Base was created as an integral part of the project. It served as a research tool to provide the data and data products that were needed for the project. The NOWESP Research Data Base was located at Institut für Meereskunde in Hamburg (IfM); it was defined with the relational data management system ORACLE. The database has an organizational form allowing it to react flexibly to changing requirements in the course of the project.

As the development and maintenance of a project-oriented research data base for marine data had to be achieved within the 3-year duration of the project, we took care to avoid double work. We undertook this task only because the products we wanted could not be provided otherwise. The NOWESP Research Data Base has drawn on existing data centres and other data bases. It should be noted that this task did not represent a duplication of other developments at the time. Although a few data centres started to provide research data bases for projects, none of the existing data centres could and would have done all the work that was needed by NOWESP; they could have provided the data management tools for storing the data and the distribution of compiled data, but were not ready at the time to produce and deliver the products that NOWESP needed. The essential advantage of the NRDB was its flexible reaction to the needs of the project in providing the products, as will be described later. This was in contrast to data centres where the main task is archiving and maintaining the data holdings, and their delivery to users as, e.g., NOWESP, but not the production of statistical data products.

The special tasks of the NOWESP Research Data Base group were:

1. acquisition of the relevant data sets, with the intensive support of all partners,
2. organization of the data sets in the NOWESP Research Data Base,
3. merging of the specific data sets for ten main state variables used in NOWESP and the provision of data products for the analysis within NOWESP.

Data acquisition was achieved in a great joint effort. Data organization was based on an existing research data base at Institut für Meereskunde of Hamburg University. The different data sets were merged for each investigated variable to be evaluated uniformly.

To visualize the data sets so-called "Data Reports" were developed as graphical output. The data and data products were then distributed in a unified format amongst the project partners for analysis of the data with respect to trends and variability in space and time on the basis of statistical methods which all partners had agreed to use (Van Leussen and Radach [1994]).

This paper gives an overview of the NOWESP Research Data Base, data acquisition, data organization, and the production of data products for the NOWESP partners. In a separate paper, experiences made in the process of data acquisition, organization and provision of data products are described and discussed (Radach and Gekeler [1996]).

2 Data Acquisition

Data acquisition was organized in such a way that all partners had to contribute quality-controlled data sets from their home institutions. In a second attempt the NOWESP partners acquired further data sets from other institutions and made them available to NOWESP. Contact persons were nominated for the acquisition of specific data sets which were believed to be of importance to NOWESP. The acquisition of data continued nearly throughout the project.

The data sets comprise not only measured data but also modelled data sets. Hydrodynamical model simulations from three institutes were also kept in the NOWESP Research Data Base. The long-term hydrodynamical model simulation provided by the MAST project "European Regional Seas Ecosystem Model (ERSEM)" by the partner IfM (Hamburg) covers the whole north-west European shelf and lasts from 1955 to 1993. The simulation of the circulation by the physical part of the "Norwegian Ecological Model (NORWECOM)" also covers an area larger

than the North Sea (1987–1993). Both models are three-dimensional shelf sea circulation models. The vertically integrated model by Proudman Oceanographic Laboratory (Bidston) covers the North Sea and lasts from 1955 to 1993 (SMITH et al. [1996]).

2.1 *Data Sources*

The NOWESP Research Data Base contains data from about 220 originators (mostly individual scientists) working at nearly 50 institutes and data centres. Tab. 1 lists the main data originators in alphabetical order by the names of the institutions, together with the numbers of data for ten main variables used in NOWESP. A few major data originators provided the bulk of the data. The acronyms DOD (German Oceanographic Data Centre) and ICES (International Council for the Exploration of the Sea) represent numerous originators who are not known to us because the data centres' policy was to provide data sets without naming the originators. Part of the data were collected before the NOWESP project at IfM and part of it were compiled during the NOWESP project; further data sets were provided by the MAST project ERSEM, from which we were able to include the public domain data.

The big data sets were obtained by single institutes in their area of interest. Additional data sets from other institutions were obtained especially during the second year of the project. The spatial distributions of a few of the main data sets are given in Fig. 2.

- Biologische Anstalt Helgoland provided observations from the German Bight (Fig. 2a).
- The British Oceanographic Data Centre (BODC) provided the data from the NERC North Sea Project on CD-ROM (Fig. 2b).
- Bundesamt für Seeschiffahrt und Hydrographie provided monitoring data from the German Bight (Fig. 2c).
- HELCOM provided data for the Baltic Sea and eastern North Sea (Fig. 2d).
- The Netherlands Institute for Sea Research (NIOZ) obtained mainly SPM data in the southern North Sea.
- The Management Unit of the Mathematical Models of the North Sea (MUMM) obtained data off the Belgian and Dutch coasts.
- The Sir Allister Hardy Foundation for Ocean Science (SAHFOS) provided their data holdings of zooplankton data obtained in the Continuous Plankton Recorder Surveys.
- ICES contributed several data deliveries over the years to the ECOMOD data base, and also during NOWESP ICES data were included in the NOWESP RDB (Fig. 2e).
- The surveys of Université de Bordeaux 1, Département de Géologie et Océanographie (CRESO) resulted in data sets for T, S, and SPM off the Gironde estuary.
- The western Baltic Sea and the entrances to the North Sea were covered by observations from Institut für Ostseeforschung (IOW) in Warnemünde (Fig. 2f).
- The Institute for Marine Research (IMR) in Bergen provided the largest nutrient data set for the North Sea (Fig. 2g).
- The ZISCH and TOSCH surveys performed by Hamburg University and others cover the entire North Sea during two 6-week periods (1985, 1986); a great variety of parameters were obtained simultaneously (Fig. 2h).
- The monitoring programme of the National Institute for Coastal Marine Management (RIKZ) resulted in a 15-year data set containing many time series stations off the Dutch coast (Fig. 2i).

2.2 *Data Holdings*

The data holdings consist mainly of partner's data (Tab. 1). The spatial and temporal coverage is very heterogeneous (RADACH et al. [1996]; RADACH AND GEKELER [1997]). As can be seen from the NOWESP Inventory (see NOWESP [1996]), a huge amount of additional (non-partner) data was incorporated in the NOWESP Research Data Base. The total amount of data compiled is considerable. More than 3 million observations have been stored up to now in the NRDB, as listed in detail in Table 1 for the main parameters.

Table 1

List of main data originators and numbers of data in the NOWESP Research Data Base for the merged data sets

State variables	T	S	PO_4	NO_3	NO_2	NH_4	SiO_4	SPM	Chl
Originator	Number of data								
BAH, Hamburg	15658	13496	9234	7877	7189	8005	5290	543	2702
BFA, Hamburg	24610	15624	994	0	0	0	0	0	0
BODC, Bidston	152328	151341	6268	0	5848	4968	6191	99907	110286
BSH, Hamburg	37128	26644	4255	0	0	0	0	5203	279
DOD, Hamburg	0	0	1496	1632	984	999	119	0	0
ESU, Dublin	290	291	295	0	0	228	0	150	0
GPI, Hamburg	430	450	977	308	697	337	971	409	0
HELCOM	15948	15861	14873	14540	14392	11719	9737	0	1389
IAB, Hamburg	0	0	477	0	0	0	513	0	5335
IBLC, Hamburg	0	0	288	0	0	0	0	0	0
ICES, Copenhagen	34334	30882	60293	41087	8037	20160	26707	0	8557
IFM, Kiel	10419	7795	5802	0	0	0	0	0	271
IMR, Bergen	58061	56322	67569	66114	54276	7535	60163	0	9533
IOCB, Hamburg	0	0	4983	1491	2462	2342	2487	0	0
IOW, Warnemünde	58297	47521	50850	39419	42371	22827	0	0	29688
LWK, Kiel	1182	691	1386	0	0	0	0	0	0
MBA, Plymouth	6498	6478	4307	1722	84	588	3871	0	573
MUMM, Brussels	45163	36472	270	91	91	261	303	2009	0
NIOZ, Texel	231	1088	0	0	0	0	0	1099	176
NLW, Hildesheim	342	167	401	0	0	0	0	0	146
PML, Plymouth	0	0	303	0	303	0	303	240	0
RWS, Den Haag	24135	20804	24640	4567	15403	21974	20279	23851	19436
RWTH, Aachen	0	0	0	0	0	0	0	0	496
Port Erin Mar. Lab.	6059	2359	5770	2613	2853	89	3104	0	810
Univ. Liege	0	0	0	0	0	0	0	0	1281
VUB, Brussels	0	0	572	375	0	556	375	0	328
Other institutions	58314	57407	33	0	0	850	7	17677	0
Sum	549463	491693	266336	181836	154990	103438	140420	151088	191286

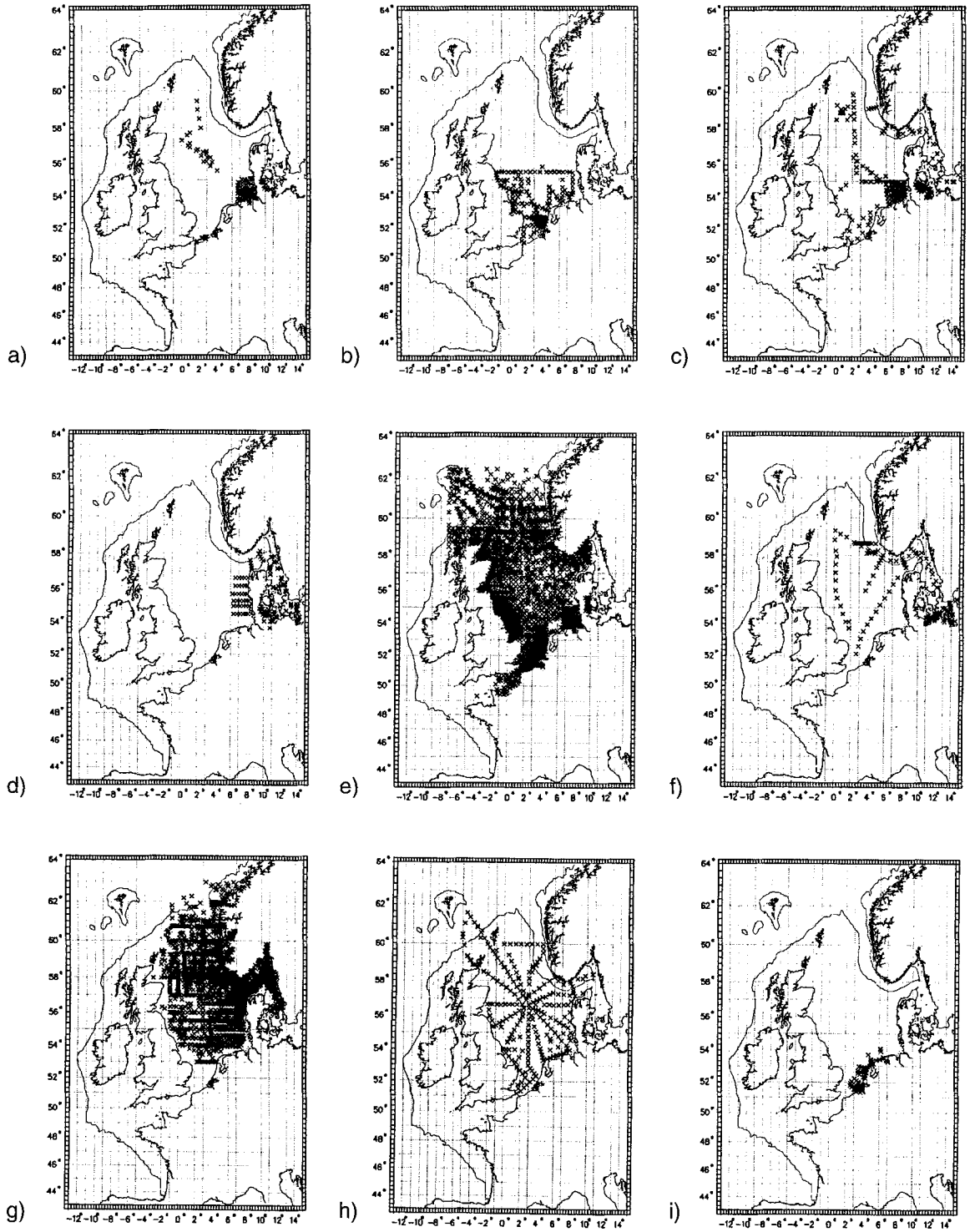

Fig. 2: Spatial distribution of the main data sets: Stations for the data set of a) Biologische Anstalt Helgoland, Hamburg; b) British NERC North Sea Project, BODC, Bidston; c) Bundesamt für Seeschiffahrt und Hydrographie, Hamburg; d) HELCOM; e) International Coucil for the Exploration of the Sea, Copenhagen; f) Institut für Ostseeforschung, Warnemünde; g) Institut for Marine Research, Bergen; h) Hamburg University, and others (ZISCH and TOSCH); i) Rijkswaterstaat, Den Haag.

3 Data Organization

3.1. *The NOWESP Research Data Base*

The NOWESP Research Data Base is part of the Ecological Modelling Data Base (ECOMOD), which is organized by means of the Relational Data Base Management System (RDBMS) ORACLE. This system was installed on a SUN workstation in 1992 to host the ECOMOD data base of the department "Mathematical Modelling of Marine Ecosystems" in the Institut für Meereskunde at Hamburg University. The NOWESP Research Data Base is defined as a special view on the ECOMOD data base. For each project a partition of the data set is defined to which only those users have access who work on the project and have the permission to use the data sets of this partition. Only NOWESP partners have access to the data holdings of NOWESP. The ECOMOD has been described earlier (RADACH AND HERBIG [1995]; LENHART, HERBIG AND HUFNAGEL [1993]). There are now different ways of accessing the data base, one for the MAST project NOWESP (North-west European Shelf Programme) and one for the MAST project ERSEM, and others.

The NOWESP Research Data Base provides the possibility to store data sets from different origins in a uniform manner and to merge these data according to scientific needs whenever necessary. The data base allows data of the same parameter to be grouped for different spatial and temporal windows in a flexible way. The structure of the ECOMOD data base was presented in detail by RADACH AND HERBIG [1995].

3.2 *The Data Base Scheme for ECOMOD*

The data organization is based on tables related to one another by means of the data base scheme which has been developed in the group at IfM especially for the storage of marine data from all disciplines. The implemented data base scheme (LENHART et al. [1993]) contains many different tables (Fig. 3). For instance, there exist tables containing the observations, positions, dates and times, the names of the parameters (state variables), the originators, cruises, and so on.

The important tables in the data base scheme are the tables PARAMETER, MESSWERTE, ORT, ZEIT, TIEFE and FAHRT. In the table PARAMETER name and method of measuring the state variable is stored, together with the unit and extreme values. The table MESSWERTE contains the observational values combined with parameter code, originator code, position and depth code. The tables ORT and ZEIT keep the information about station and time of observation, respectively. The table FAHRT contains information about the cruises, the ship's name, the geographical coordinates of the area investigated during the cruise, and others.

In addition, several supporting tables have been introduced. The tables WIND and TIEFE contain information about wind velocity and direction as well as the actual depth at the location of the station. The table GNAME describes groups of parameters which shall be treated uniformly. The table GRUPPE connects the table PARAMETER with the table GNAME. The table PROJEKT enables data to be combined for a special project (like NOWESP) or for a special problem. The purpose of the table LADELAUF is to keep a protocol of the loading of specific data. The two tables ARSPEC and LZRORT, used to specify data from automatic recording devices and for the location of long time series, were added to avoid redundancies within the corresponding tables for the measurement values, ARWERTE and LZWERTE, respectively. More information about the data base scheme is given by the report on the ECOMOD data base (RADACH AND HERBIG [1995]).

3.3 *Coding*

The parameter code developed allows a characterization of the variables (Tab. 2). The code itself consists of a number of sub-codes. The first digit gives the class to which the parameter belongs (physical oceanography, meteorology, marine

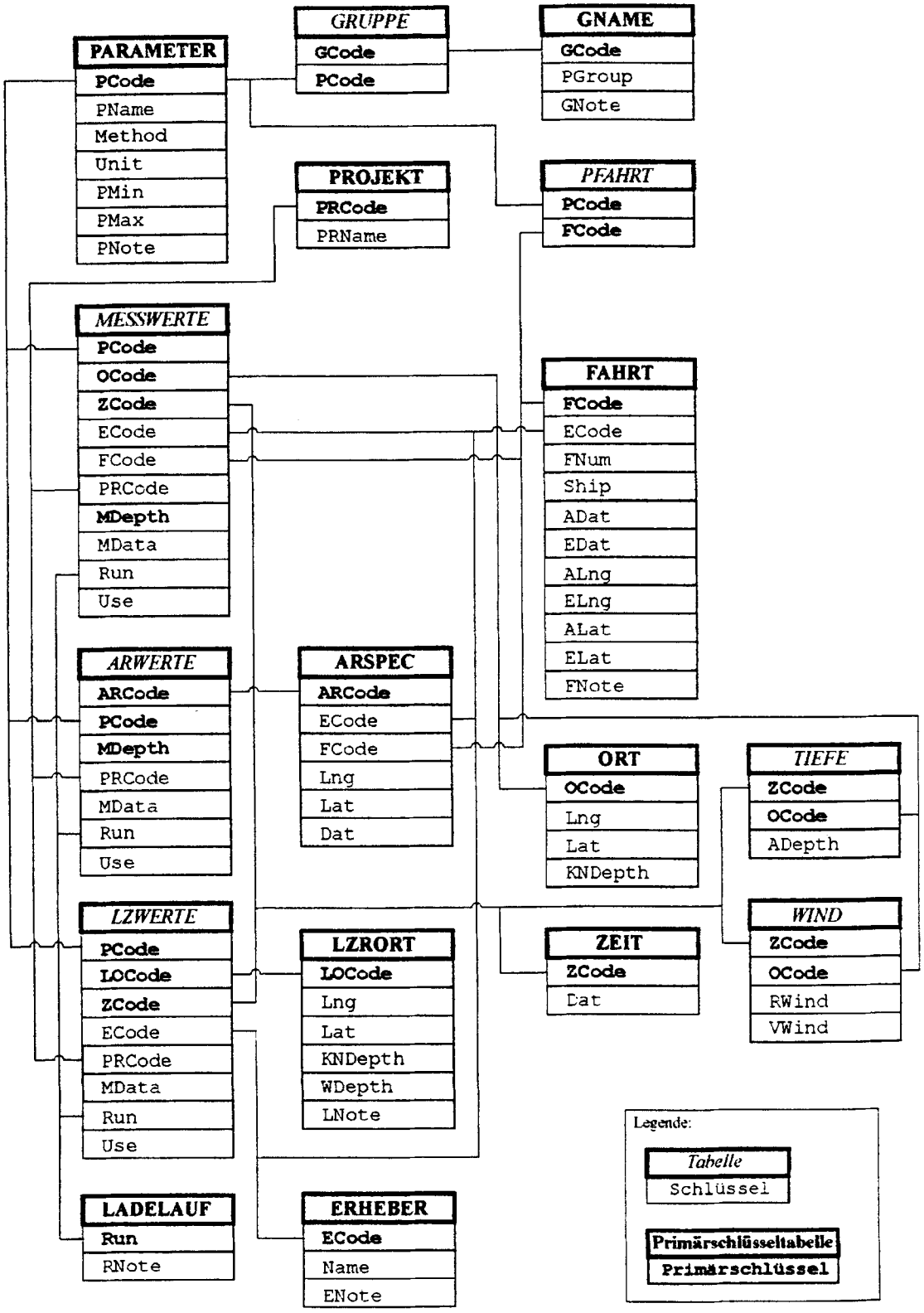

Fig. 3: Organizational scheme of the ECOMOD Data Base.

fauna, marine flora, nutrients, other chemicals, and geology). This is followed by the code number for the parameter name within the group, together with the methods code and the code for the substrate where the measurement took place (water, sediment, interstitial water, sea surface, air etc). The unit and method were added to the respective lists. Therefore, it may occur that the same (or a similar) entry is made several times. This is a practical, not a puristic approach serving its purpose; the main requirement was a clear separation of the data sets from one another, and this was achieved.

Table 2
Structure of the code for the state variables ("parameters") PCODE

Digit of PCODE	1	2	3	4	5	6	7	8	9	10
Information	CLASS	PNAME character A80			UNIT character A20		METHOD character A20		SUBSTRATE	
Actual contents	Physical oceanography	Temperature			Centigrade		CTD		Water	

Abbreviations for classes:
1 Physical oceanography 2 Meteorology 3 Marine fauna
4 Marine flora 5 Nutrients 6 Other chemicals
7 Geology

3.5 *Quality Control*

All NOWESP data sets were delivered to the NOWESP RDB as quality-controlled data; they were then treated uniformly. The data sets for each of the state variables stem from many sources. Before the data were loaded into the data base, they were again quality-controlled for obvious errors; e. g. negative values (which occurred as typing errors) were eliminated, and the data were checked with respect to the basic information, as indicated in Tab. 3. In fact, this second check proved to be necessary.

The former checks were made during the computerized conversion of the data sets from the format in which the data arrive to the data base format which is equal for all kinds of data. Further checks were performed by visual inspection concerning the ship' s name, cruise number, parameter code, unit, and originator. If inconsistencies or errors were found, they were corrected by manually changing the entries in the data base, mostly after contacting the data originator again. The data were then checked in order to exclude double data, which is important for correct statistics.

3.6 *Working with the Data Base*

During the project only the absolutely necessary software developments were made. They relate to the conversion and loading of the data sets, production of the data products needed by the project partners, and to the performance of the data base.

The data sets were loaded in two steps. For NOWESP an entry table was defined, into which the new data were read in the NOWESP Format (Tab. 4). This table served as the data source from which the data were loaded into the NOWESP Research Data Base. During this procedure the additional quality checks were performed (see section 3.5).

Table 3

Examples of quality checks for incoming data

consistent date?:	1950	≤	year	≤	1994	
	1	≤	month	≤	12	
	1	≤	day	≤	31	
consistent time?:	0	≤	time	≤	24	(hours)
consistent depth?:	0	≤	depth	≤	actual depth	(m)
	0	≤	depth	≤	5000	(m)
consistent coordinates?:	−180	≤	longitude	≤	+180	(°)
	− 90	≤	latitude	≤	+ 90	(°)
consistent area? are latitudes and longitudes within prescribed ranges?:						
	LO1	≤	longitude	≤	LO2	(°)
	LA1	≤	latitude	≤	LA2	(°)

Table 4

Entry table for data to be loaded into the ECOMOD data base for the projects NOWESP, ERSEM, EUTRONOST, KUSTOS, JGOFS: variables and their formats for loading into the data base

Variable (parameter)	Name of code	Column	Type of variable	Format
First header				
Parameter code	PCODE	1: 10	NUMBER	2I5
Parameter name	PNAME	11: 90	CHARACTER	A80
Unit	UNIT	91:110	CHARACTER	A20
Second header				
Latitude	LAT	1: 13	NUMBER	E13.6
Longitude	LNG	14: 26	NUMBER	E13.6
Zero depth in map	KNDEPTH	27: 39	NUMBER	E13.6
Year	YEAR	40: 41	NUMBER	I2
Month	MONTH	42: 43	NUMBER	I2
Day	DAY	44: 45	NUMBER	I2
Hour	HOUR	46: 47	NUMBER	I2
Minute	MIN	48: 49	NUMBER	I2
Actual depth	ADEPTH	50: 62	NUMBER	E13.6
Ship's name	SHIP	63: 82	CHARACTER	A20
Cruise number	FNUM	83: 90	NUMBER	I8

Table 4 cont.

Originator	ECODE	91: 95	NUMBER	I5
Number of observ.	NUMDATA	96:100	NUMBER	I5
Depth of measurement	MDEPTH	101:113	NUMBER	E13.6
Amplitude of data	MDATA	114:126	NUMBER	E13.6
Originator of data	ORGINATOR	127:146	CHARACTER	A20
Method of observ.	METHOD	147:226	CHARACTER	A80
Data records				
Depth of observ.	MDEPTH	1: 13	NUMBER	E13.6
Observ. value	MDATA	14: 26	NUMBER	E13.6
.....				
Depth of observ.	MDEPTH	1: 13	NUMBER	E13.6
Observ. value	MDATA	14: 26	NUMBER	E13.6
.....				

4 Provision of Data Products

NOWESP confined itself to ten state variables for which a sufficient amount of data was available whose evaluation promised to produce new findings. These variables were the following:

Temperature, salinity, phosphate, nitrate, nitrite, ammonia, silicate, chlorophyll, suspended particulate matter, zooplankton biomass.

For these variables, the bulk of the analyses was carried out using the merged data sets (see section 4.2).

4.1 *The Data Reports*

Two different graphical formats, so-called "Data Reports", have been produced in order to be able to work with the many data sets for each single variable and for the merged data sets (HEINEMANN et al. [1988]; SCHÖNFELD et al. [1988]; LENHART et al. [1993]). They allow an assessment of the distribution of the data in space and time (RADACH et al. [1997]).

The first Data Report ("Positions and data projections on time") provides a map of the positions of the stations, with the data shown on different time scales (one year, decades). Fig. 4a shows the merged chlorophyll data set as an example. The second Data Report ("Sampling frequency in space and time") gives the frequency distributions of the chlorophyll data in their spatial frame as well as the frequency distribution of the data itself and of their temporal distribution within the annual and decadal frame (Fig. 4b).

The program "Data Reports" allows to specify the region and the depth and time ranges, thus enabling the data to be zoomed for specified space and time scales. The repetitive use of the Data Reports provides the opportunity to closely look at single as well as merged data sets before embarking on a statistical evaluation. To visualize the data sets and give simple statistical properties of the data, Data Reports were produced for each relevant parameter of each separate data set (one originator, one cruise or experiment etc). A total of about 307 pairs of Data Reports were produced. They were provided to NOWESP partners as working material, containing also further information on the data sets, their use and

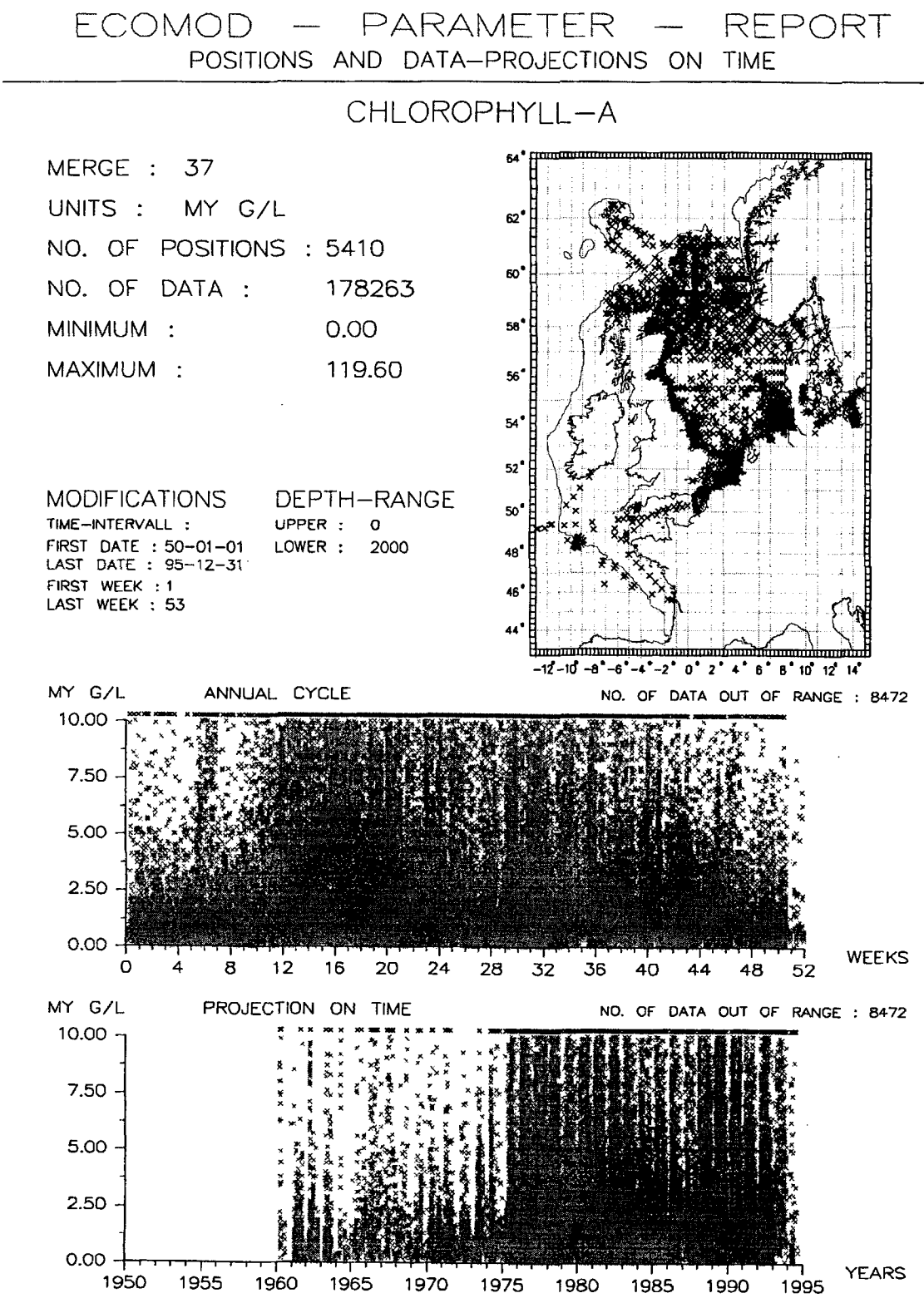

Fig. 4: The two Data Reports for the merged chlorophyll data set:
a. First Data Report "Positions and data projections on time".

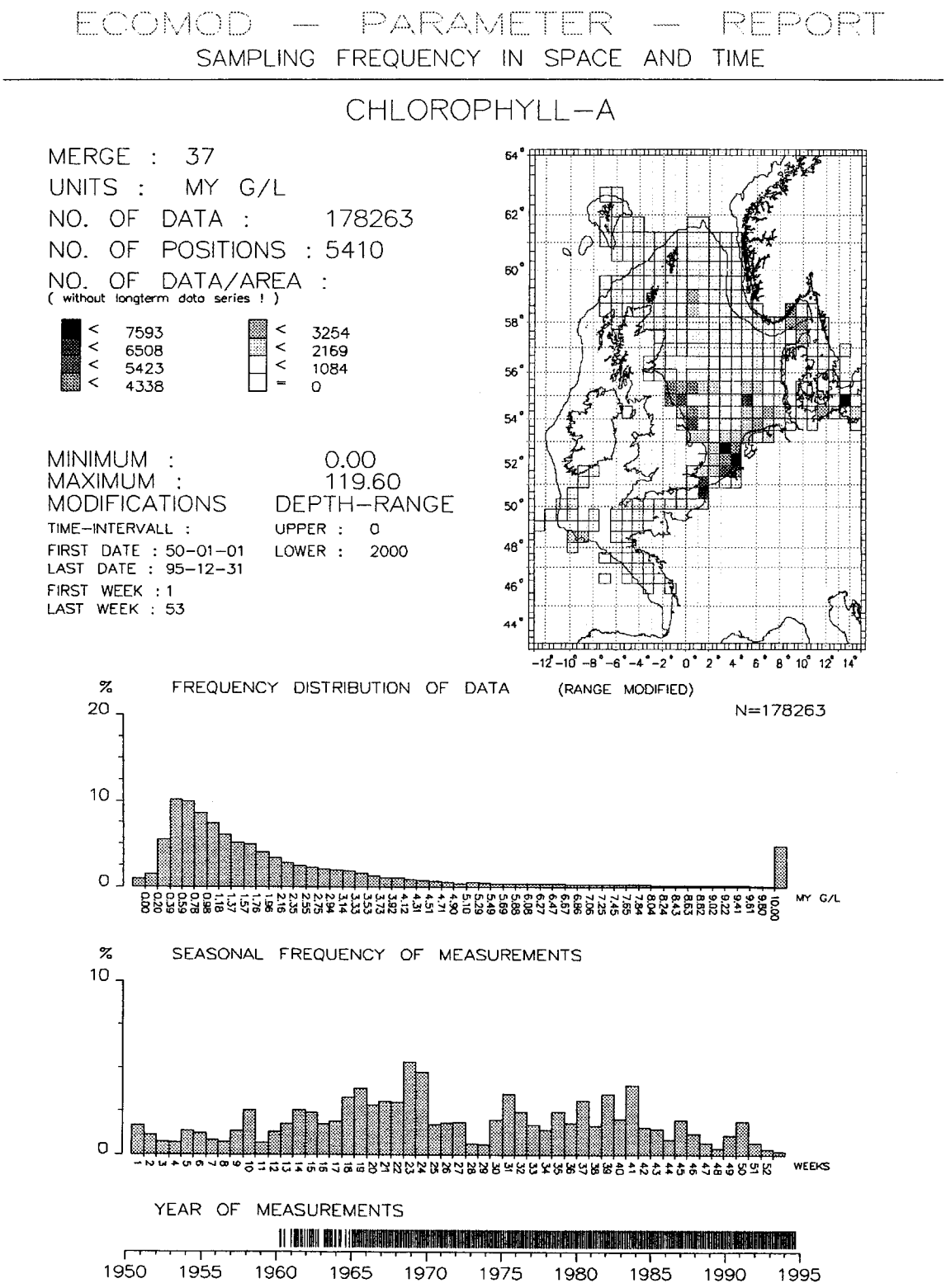

Fig. 4 b: Second Data Report "Sampling frequency in space and time".

exchange. Also for the merged data sets Data Reports were produced and included in the technical report by RADACH et al. [1997].

4.2 *Merged Data Sets*

Statistical methods were agreed upon to be used by all partners in the evaluation of the data sets (VAN LEUSSEN AND RADACH [1994]). As a prerequisite for the time series analysis, the spatial statistical analysis and the budget calculations, several steps had to be taken before working with the composite data sets. Firstly, the data sets were checked on the basis of the Data Reports (RADACH et al. [1997]) for their suitability for merging. The merging of data sets of different origins should obey certain rules. It should be taken care that none of the data sets have a bias. This may be checked by analysing the data sets where they overlap or border on each other during comparable time ranges using frequency distributions and checking their consistency. However, for many data sets these possibilities turned out to be non-existent or very restricted because there was either no suitable overlap or no sufficiently close comparable data set. During workshops the variables temperature, salinity, nutrients, chlorophyll and SPM were analysed accordingly. As had been agreed at the workshops, all NOWESP data sets for these variables were merged (Tab. 1). The data may originally have had different units, which were unified before merging them.

4.3 *Creating Time Series*

NOWESP set out to analyse long time series; the idea was that the interconnectedness between areas should be investigated. The areas line up along the residual circulation on the shelf (LAANE et al. [1996b]). The merged data sets were used to compile long time series at 14 sites in the eight defined areas, taking existing time series as core series and creating as complete and long time series as possible by utilizing the NOWESP data set in certain regions defined around the sites (Fig. 5). Several of these sites are situated at stations where data had been obtained regularly for a long time, like station E1 in the Channel, station Port Erin in the Irish Sea or the Helgoland time series from the German Bight (Fig. 5; Tab. 5). For those sites where the time series had gaps or where the series had to be created from surrounding data, programs were applied which aggregated all the data found in the defined areas around the sites. The time series were prepared by the NOWESP Research Data Base group for the upper layer of 0–10 m (Tab. 6). The time series constructed were presented in total by RADACH et al. [1997]. As an example the data from sites 6 and 7 are given in Fig. 6.

4.5 *Interpolation of the Merged Data on a Regular Spherical Grid*

To estimate fluxes and budgets, the data sets had to be interpolated using a fixed regular grid. The interpolation of data had to take account of the patchy and irregular distribution of the original data. When interpolating, the properties of the spatial and temporal distributions of the data sets had to be preserved by the interpolation method. The gridding of NOWESP data sets resulted in monthly horizontal distributions of the concentrations in the surface layer (0–30 m) and bottom layer (30 m-bottom). The nitrate distribution is shown as an example (Fig. 7). For the interpolation of the different data sets onto regular spherical grids preliminary investigations were carried out using the kriging method. In the kriging algorithm an underlying spherical model-semivariogram was assumed. The big variability in space and time turned out to be a problem when gridding irregularly distributed data sets by kriging, and finally an exponential interpolation was used (RADACH AND GEKELER [1996]).

Finally the interpolated data sets became available on a grid of about 20 km grid size. In combination with, e. g., simulated flow fields the advective transports of various constituents (water, salt, nutrients, SPM) across the shelf were estimated (LAANE et al. [1996a]) using balance equations formulated earlier (YU, MONBALIU AND BERLAMONT [1995]).

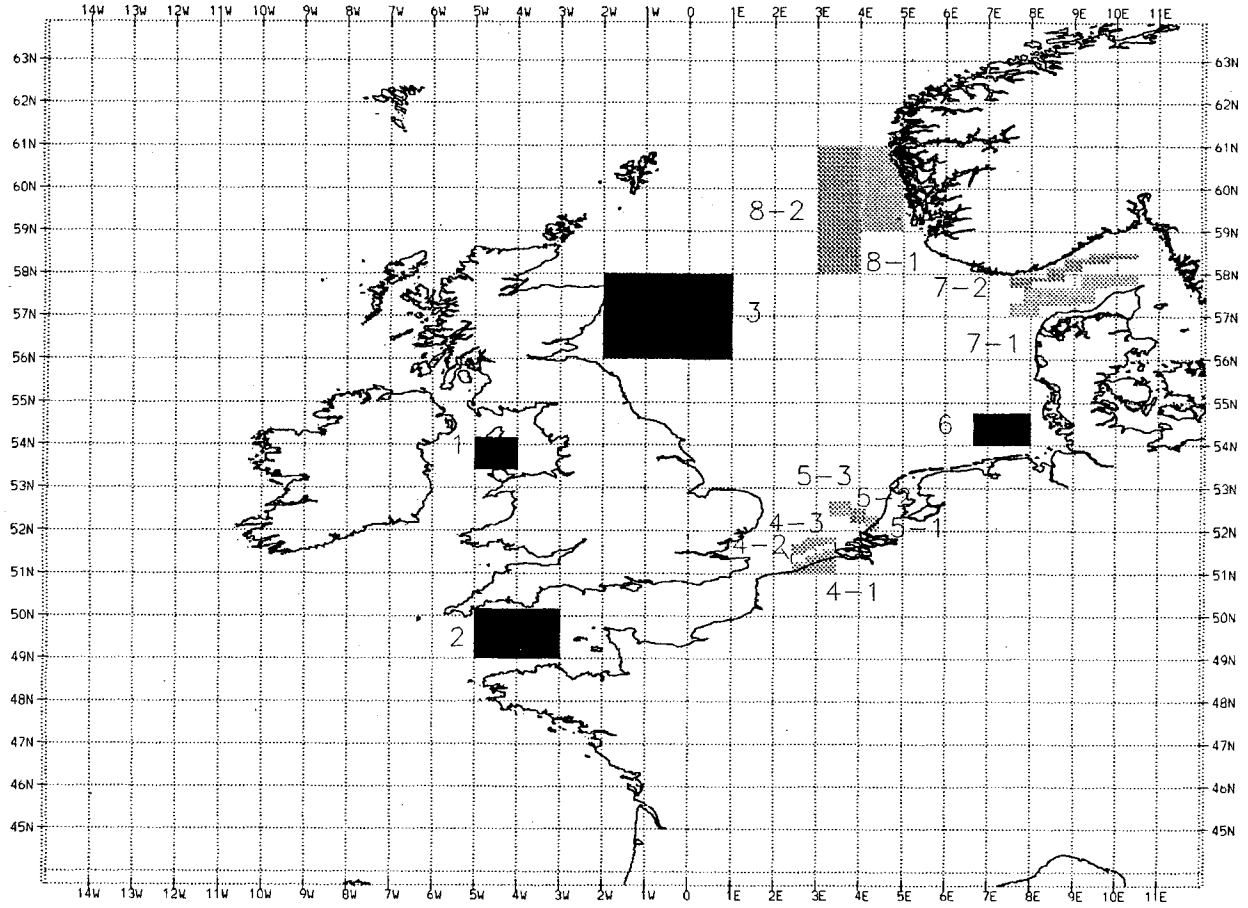

Fig. 5: Sites for NOWESP time series: boxes 1–8.

Table 5

Coordinates of the areas and sites for defining the NOWESP time series

Site	Longitude	Latitude
Box 1:	5° 00.0' W– 4° 00.0' W	53° 25.0' N–54° 10.0' N
Box 2:	5° 00.0' W– 3° 00.0' W	49° 00.0' N–50° 10.0' N
Box 3:	2° 00.0' W– 1° 00.0' W	56° 00.0' N–58° 00.0' N
Box 4-1:		
sub 1:	2° 25.0' E– 2° 45.0' E	51° 00.0' N–51° 17.5' N
sub 2:	2° 45.0' E– 2° 58.5' E	51° 00.0' N–51° 25.0' N
sub 3:	2° 58.5' E– 3° 10.0' E	51° 00.0' N–51° 28.0' N
sub 4:	3° 10.0' E– 3° 27.0' E	51° 00.0' N–51° 34.0' N
Box 4-2:		
sub 1:	2° 25.0' E– 2° 40.0' E	51° 17.5' N–51° 27.0' N
sub 2:	2° 40.0' E– 2° 45.0' E	51° 17.5' N–51° 30.0' N
sub 3:	2° 45.0' E– 2° 50.0' E	51° 25.0' N–51° 32.0' N
sub 4:	2° 50.0' E– 2° 58.5' E	51° 25.0' N–51° 34.5' N
sub 5:	2° 58.5' E– 3° 10.0' E	51° 28.0' N–51° 38.0' N
sub 6:	3° 10.0' E– 3° 27.0' E	51° 34.5' N–51° 42.0' N
Box 3-4:		
sub 1:	2° 25.0' E– 2° 40.0' E	51° 27.0' N–51° 42.0' N
sub 2:	2° 40.0' E– 2° 45.0' E	51° 30.0' N–51° 47.0' N
sub 3:	2° 45.0' E– 2° 50.0' E	51° 32.0' N–51° 52.0' N
sub 4:	2° 50.0' E– 2° 58.5' E	51° 34.5' N–51° 52.0' N
sub 5:	2° 58.5' E– 3° 10.0' E	51° 38.0' N–51° 52.0' N
sub 6:	3° 10.0' E– 3° 27.0' E	51° 42.5' N–51° 52.0' N

Site	Longitude	Latitude
Box 5-1:	4° 08.0' E– 4° 28.0' E	52° 02.0' N–52° 22.0' N
Box 5-2:	3° 48.0' E– 4° 08.0' E	52° 12.0' N–52° 32.0' N
Box 5-3:	3° 18.0' E– 3° 48.0' E	52° 22.0' N–52° 42.0' N
Box 5, CPR:	3° 30.0' E– 4° 30.0' E	52° 00.0' N–53° 30.0' N
Box 6:	6° 40.0' E– 8° 00.0' E	54° 00.0' N–54° 45.0' N
HR:	7° 54.0' E	54° 11.3' N
Box 7-1:		
sub 1:	7° 30.0' E– 7° 50.0' E	57° 00.0' N–57° 20.0' N
sub 2:	7° 50.0' E– 8° 10.0' E	57° 00.0' N–57° 40.0' N
sub 3:	8° 10.0' E– 9° 10.0' E	57° 15.0' N–57° 40.0' N
sub 4:	9° 10.0' E– 9° 30.0' E	57° 20.0' N–57° 58.0' N
sub 5:	9° 30.0' E– 9° 50.0' E	57° 40.0' N–57° 58.0' N
sub 6:	9° 50.0' E–10° 30.0' E	57° 45.0' N–57° 58.0' N
Box 7-2:		
sub 1:	7° 30.0' E– 8° 00.0' E	57° 40.0' N–57° 55.0' N
sub 2:	8° 00.0' E– 8° 45.0' E	57° 50.0' N–57° 55.0' N
sub 3:	8° 20.0' E– 8° 45.0' E	57° 55.0' N–58° 10.0' N
sub 4:	8° 45.0' E– 9° 10.0' E	58° 05.0' N–58° 23.0' N
sub 5:	9° 10.0' E– 9° 50.0' E	58° 15.0' N–58° 23.0' N
sub 6:	9° 20.0' E–10° 30.0' E	58° 23.0' N–58° 30.0' N
Box 8-1:	4° 00.0' E– 5° 00.0' E	59° 00.0' N–61° 00.0' N
Box 8-2:	3° 00.0' E– 4° 00.0' E	58° 00.0' N–61° 00.0' N

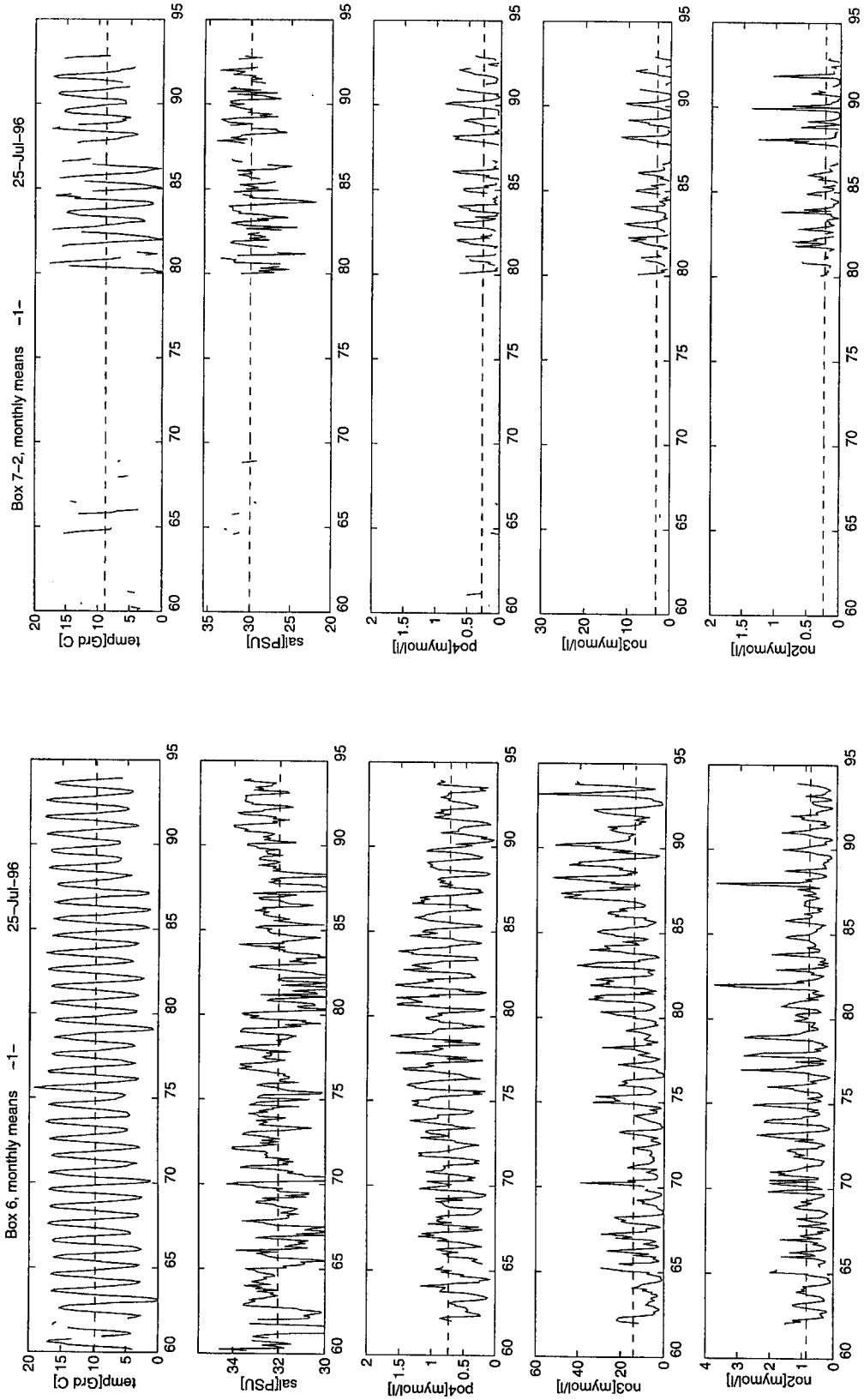

Fig. 6: Examples of time series of monthly means a) in the German Bight (site 6) and; b) in the Skagerrak (site 7): temperature, salinity, phosphate, nitrate, nitrite (top to bottom).

Table 6

Periods for which monthly mean data are available at the sites 1 to 8;

note: sporadic data were ignored when indicating the time range

Site number	Trans-port	T	S	SPM	Chl	POC	PO_4	NO_3	NO_2	NH_4	SiO_4	Zoo-plankton
1	1955–1993	60–94	60–94	no data	66–94	no data	60–94	60–85	60–91	92–94	60–84, 90–94	71–87
2	1955–1993	60–85	60–85	no data	74–86	no data	60–85	66–86	no data	75–86	60–87	58–93
3	1955–1993	60–94	60–94	no data	no data	no data	ncts	ncts	no data	ncts	ncts	72–93
4-1	1955–1993	75–94	75–94	75–93	75–93	87–93	75–93	75–93	75–93	75–93	75–93	no data
4-2	1955–1993	75–93	75–93	75–93	75–93	87–93	75–93	75–93	75–93	75–93	75–93	no data
4-3	1955–1993	75–93	75–93	75–93	75–93 ncts	87–93	75–93	75–93	87–93	75–93	75–93	no data
5-1	1955–1993	75–93	75–93	75–93	75–93	87–93	75–93	75–93	75–93	75–93	75–93	no data
5-2	1955–1993	75–89	75–89	75–89	75–82	no data	75–89	75–93	85–89	75–84	75–90	no data
5-3	1955–1993	75–93	75–93	75–93	75–93	87–93	75–93	75–93	85–93	75–93	75–93	no data
6	1955–1993	60–93	60–93	88–91 ncts	65–78	no data	62–93	62–93	62–93	62–93	66–93	58–78
7-1	1955–1993	80–92	80–92	no data	80–92	no data	80–92	80–92	80–92	80–88 ncts	88–92	58–74
7-2	1955–1993	80–92	80–92	no data	80–92	no data	80–92	80–92	80–92	86–88 ncts	88–92	no data
8-1	1955–1993	60–77, 79–92	60–77, 79–92	no data	no data	no data	ncts	ncts	ncts	no data	ncts	58–83
8-2	1955–1993	no data	no data	no data	no data	no data	ncts	ncts	ncts	no data	ncts	58–93

T = temperature; S = salinity; SPM = suspended particulate matter; Chl = chlorophyll; ncts = no continuous time series

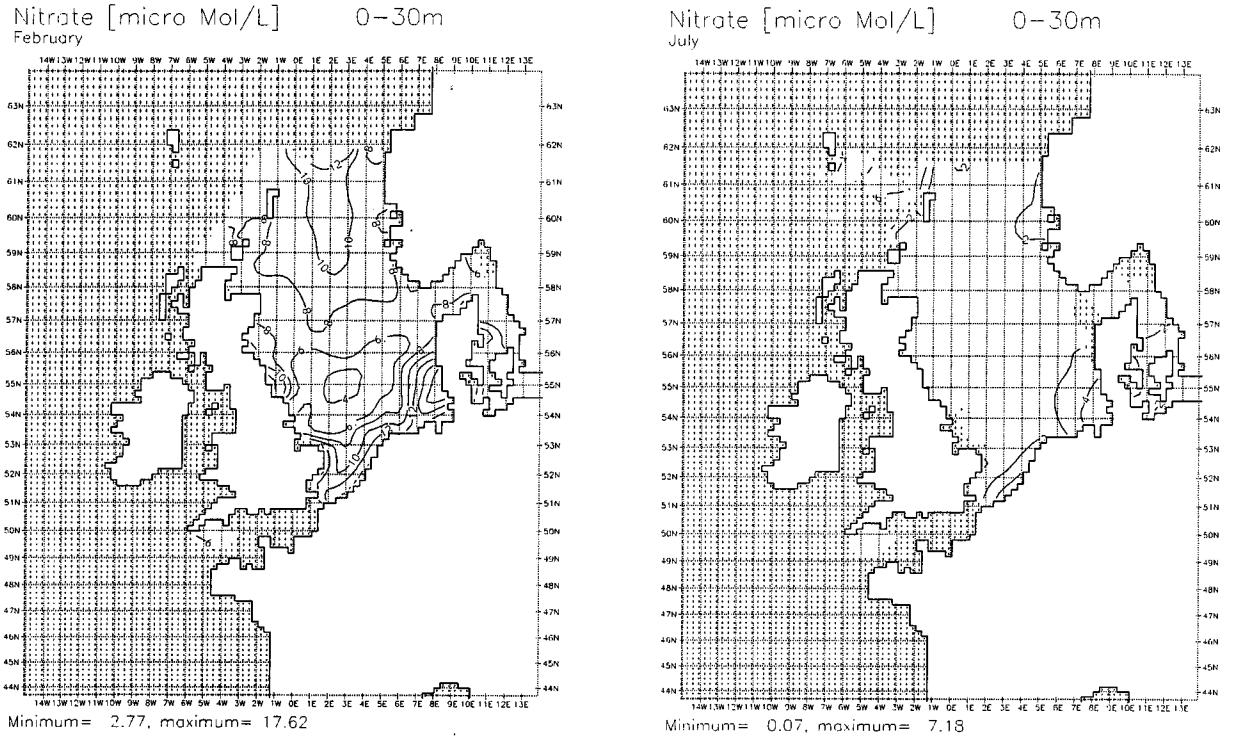

Fig. 7: Interpolated mean fields of nitrate for the months a) January and; b) July

5 Conclusions

The experiences with data management gained during the NOWESP project are discussed by RADACH AND GEKELER [1996]. At the time the NOWESP proposal was prepared, state-of-the-art project data management was restricted to the compilation, storage and dissemination of the data obtained by the project; the provision of data products derived from the data sets was not generally part of the services offered, for example, by data centres. Therefore, NOWESP decided to set up its own data base to ensure flexible provision of data products derived from the data compiled in the project.

The data compiled during NOWESP represent a unique data set for the Northwest European Shelf. The data set is sufficiently comprehensive to allow for the definition of long time series at about 14 sites in eight areas, which have been analysed by means of time series analysis. It further allows the derivation of mean annual cycles of horizontal distributions of nine main state variables. NOWESP thus has provided valuable data sets for estimating budgets and fluxes across the shelf and, in addition, important data sets for the forcing and validation of ecological shelf sea models.

The NOWESP Data Sets are made available for scientific, non-profit use. They will be published on CD ROM during the next year. Until then, the data sets will be available on the Server at the Institut für Meereskunde in Hamburg by contacting the first author.

6 Acknowledgements

The authors wish to thank all colleagues and institutions who kindly provided data to NOWESP. This research was funded by the EU via the MAST project NOWESP (MAS2-CT93-0067). Many thanks are due to Ms. O. Kleinow for immense technical support.

References

HEINEMANN, B., 1988: ECOMOD (Ecological Modelling Database) – Verbindung zwischen Messung, Auswertung und Modellierung. Techn. Ber. 4-1988, Inst. f. Meereskunde, Univ. Hamburg, März 1988, 41–61.

LAANE, R., E. SVENDSEN, G. RADACH, G. GROENEVELD, P. DAMM, J. PÄTSCH, D. S. DANIELSSEN, L. FØYN, M. SKOGEN, M. OSTROWSKI AND K. J. M. KRAMER, 1996a: Variability in Fluxes of Nutrients (N, P, Si) into the North Sea from the Atlantic Ocean and Skagerrak Caused by Variability in Water Flow. This volume, 401–420.

LAANE, R., W. VAN LEUSSEN, G. RADACH, J. BERLAMONT, J. SÜNDERMANN, W. VAN RAAPHORST AND F. COLIJN, 1996b: North-West European Shelf Programme (NOWESP): An Overview. This volume, 217–229.

LENHART, H., K. HERBIG, I. HUFNAGEL, 1993: Ein neues Schema für die ECOMOD-Datenbank; DGM – Mitteilungen 3/93, 22–28.

NOWESP, The North-West European Shelf Programme, 1994: First Annual Progress Report, August 1993 – July 1994. MAST II MAS2-CT93-0067, 226 pp.

NOWESP, The North-West European Shelf Programme, 1995: Second Annual Progress Report, August 1994 – July 1995. MAST II MAS2-CT93-0067. 216 pp.

NOWESP, The North-West European Shelf Programme, 1996: Third Annual Progress Report, August 1995 – July 1996. MAST II MAS2-CT93-0067. 181 pp.

RADACH, G., AND K. HERBIG, 1995: Die ECOMOD – Datenbank. Technischer Bericht, Inst. f. Meereskunde, Univ. Hamburg, 50 S.

RADACH, G., AND J. GEKELER, 1996: Lessons Learned from Setting up the NOWESP Research Data Base: Experiences in an Interdisciplinary Research Project. This volume, 231–240.

RADACH, G. AND J. GEKELER, 1997: Gridding the NOWESP Data Sets. Annual cycles of horizontal distributions of temperature and salinity, and of concentrations of nutrients, suspended particulate matter and chlorophyll on the north-west European shelf. Ber. Zentrum f. Meeres- und Klimaforschung, B 27: 1–375.

RADACH, G., GEKELER, J. AND O. KLEINOW, 1997: NOWESP Data Sets. Teehnical Report. RWS, Den Haag. Third edition: 1–665.

SCHÖNFELD, W., B. HEINEMANN, G. RADACH AND P. DAMM, 1988: Die ECOMOD-Datenbank, ein Hilfsmittel mariner Ökosystem-Forschung. Datenbericht 1988. Techn. Bericht, Inst. f. Meereskunde, Universität Hamburg, 1–250.

SMITH, J., P. DAMM, M. D. SKOGEN, R. A. FLATHER AND J. PÄTSCH, 1996: An investigation into the Variability of Circulation and Transport on the North-West European Shelf Using Three Hydrodynamic Models. This volume, 325–348.

VAN LEUSSEN, W. AND G. RADACH, 1994: NOWESP Manual on Statistical Analysis Techniques. Technical Report. RWS, Den Haag, 1st Ed., Nov. 1994.

YU, C.S., J. MONBALIU AND J. BERLAMONT, 1995: NOWESP Formulation of the balance equations. Technical Report, University of Leuven, Januar 1995.

Submitted: 24. 03. 1997
Accepted: 15. 01. 1998

Address of corresponding author:
Günther Radach
Institut für Meereskunde
Universität Hamburg
Troplowitzstraße 7
22529 Hamburg

A complete list of authors is given on page 437–441.