JOINT GLOBAL OCEAN FLUX STUDY

A Core Project of the International Geosphere-Biosphere Programme

JGOFS REPORT No. 29

JGOFS DATA MANAGEMENT AND SYNTHESIS WORKSHOP

24-25 September 1998
Bergen, Norway

Meeting Minutes

Roy K. Lowry and Beatriz M. Baliño
Editors

JANUARY 1999

SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH
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The JGOFS Report Series is published by SCOR and includes the following:

No. 1 Report of the Second Session of the SCOR Committee for JGOFS. The Hague, September 1988
No. 2 Report of the Third Session of the SCOR Committee for JGOFS. Honolulu, September 1989
No. 3 Report of the JGOFS Pacific Planning Workshop. Honolulu, September 1989
No. 4 JGOFS North Atlantic Bloom Experiment: Report of the First Data Workshop. Kiel, March 1990
No. 5 Science Plan. August 1990
No. 6 JGOFS Core Measurement Protocols: Reports of the Core Measurement Working Groups
No. 7 JGOFS North Atlantic Bloom Experiment, International Scientific Symposium Abstracts. Washington, November 1990
No. 8 Report of the International Workshop on Equatorial Pacific Process Studies. Tokyo, April, 1990.
No. 9 JGOFS Implementation Plan. (also published as IGBP Report No. 23) September 1992.
No. 10 The JGOFS Southern Ocean Study. September 1992
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No. 12 Report of the Second Meeting of the JGOFS North Atlantic Planning Group.
No. 13 The Reports of JGOFS meetings held in Carqueiranne, France, September 1993: Eighth Meeting of the JGOFS Scientific Steering Committee; JGOFS Southern Ocean Planning Group - Report for 1992/93; Measurement of the Parameters of Photosynthesis - A Report from the JGOFS Photosynthesis Measurement Task Team. March 1994.
No. 14 Biogeochemical Ocean-Atmosphere Transfers. A paper for JGOFS and IGAC by Ronald Prinn, Peter Liss and Patrick Buat-Ménard. March 1994.
No. 15 Report of the JGOFS/LOICZ Task Team on Continental Margin Studies. April 1994.
No. 16 Report of the Ninth Meeting of the JGOFS Scientific Steering Committee, Victoria, B.C. Canada, October 1994 and The Report of the JGOFS Southern Ocean Planning Group for 1993/94.
No. 17 JGOFS Arabian Sea Process Study. March 1995
No. 18 Joint Global Ocean Flux Study: Publications, 1988-1995. April 1995
No. 19 Protocols for the Joint Global Ocean Flux studies (JGOFS) core measurements (reprint). June 1996.
No. 20 Remote Sensing in the JGOFS program. September 1996
No. 21 First report of the JGOFS/LOICZ Continental Margins Task Team. October 1996
No. 22 Report on the International Workshop on Continental Shelf Fluxes of Carbon, Nitrogen and Phosphorus. 1996
No. 23 One-Dimensional models of water column biogeochemistry. Report of a workshop held in Toulouse, France, November-December 1995. February 1997
No. 24 Joint Global Ocean Flux Study: Publications, 1988-1996. October 1997.
No. 25 JGOFS/LOICZ Workshop on Non-Conservative Fluxes in the Continental Margins, October 1997.
No. 26 Report of the JGOFS/LOICZ Continental Margins Task Team Meeting, No 2, October 1997.
No. 27 Parameters of photosynthesis: definitions, theory and interpretation of results. August 1998
No. 28 Eleventh meeting of the JGOFS SSC; Twelfth meeting of the JGOFS SSC; and the Second meeting of the North Pacific Task Team. November 1998.

The following reports were published by SCOR in 1987 - 1989 prior to the establishment of the JGOFS Report Series:

- The Joint Global Ocean Flux Study: Background, Goals, Organizations, and Next Steps. Report of the International Scientific Planning and Coordination Meeting for Global Ocean Flux Studies. Sponsored by SCOR. Held at ICSU Headquarters, Paris, February 17-19, 1987
- North Atlantic Planning Workshop. Paris, September 7-11, 1987
- SCOR Committee for the Joint Global Ocean Flux Study. Report of the First Session. Miami, January, 1988
- Report of the First Meeting of the JGOFS Pilot Study Cruise Coordinating Committee. Plymouth (UK, April, 1988
- Report of the JGOFS Working Group on Data Management. Bedford Institute of Oceanography, September, 1988

Additional copies of the JGOFS reports are available from:

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– **JGOFS** –

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The Joint Global Ocean Flux Study of the Scientific Committee on Oceanic Research (SCOR) is a Core Project of the International Geosphere-Biosphere Programme (IGBP). It is planned by a SCOR/IGBP Scientific Steering Committee. In addition to funds from the JGOFS sponsors, SCOR and IGBP, support is provided for international JGOFS planning activities by several agencies and organizations. These are gratefully acknowledged and include the US National Science Foundation, the International Council of Scientific Unions (by funds from the United Nations Education, Scientific and Cultural Organization), the Intergovernmental Oceanographic Commission, the Norwegian Research Council and the University of Bergen, Norway.

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JGOFS Data Management and Synthesis Workshop
24-25 September 1998
Rica Travel Hotel
BERGEN, NORWAY

Local host:
JGOFS International Project Office (IPO)
University of Bergen

Attendees

Data Management Task Team

Roy Lowry	British Oceanographic Data Centre, UK (Chair)
Graham Glenn	Marine Environmental Data Service, Canada
Christine Hammond	Woods Hole Oceanographic Institution, USA
Thomas Mitzka	Institut für Mereeskunde, Kiel, Germany
Takeharu Miyake	Japan Oceanographic Data Center, Japan
Jaswant Sarupriya	Indian National Oceanographic Data Center, India
Beatriz Baliño	JGOFS International Project Office, Norway

Guests

Robin Brown	Institute of Oceanographic Sciences, Canada
Robert DeConto	National Center for Atmospheric Research, USA
Geoffrey Evans	Department of Fisheries and Oceans, Canada
Brian Griffiths	CSIRO Marine Research, Australia
Roger Hanson	JGOFS International Project Office, Norway
Eileen Hoffman	Centre for Coastal Physical Oceanography, USA
Iris Kriest	Institut für Meereskunde, Kiel, Germany
Truls Johannessen	Geophysical Institute, University of Bergen, Norway
Marie-Paule Labaied	Villefranche Oceanographic Observatory, France
Robert Le Borgne	Centre Oceanologique de Marseille, France
Nicolas Metzl	LPCM/CNRS, Pierre and Marie Curie University, Paris, France
Yutaka Michida	Japan Oceanographic Data Center, Japan
Trevor Platt	Bedford Institute of Oceanography, Canada

Address of participants are given in appendix A

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Meeting minutes

Roy Lowry welcomed all the participants. He announced that Mike Fasham and Helge Drange could not attend the meeting: Fasham because of health problems and Drange due to an imminent trip to Iceland. The agenda was then reviewed (Appendix B): the slot alloted to Drange would be filled with a presentation from Truls Johannessen (JGOFS-Norway) while Lowry would step in for Fasham and formulate on Mike's notes. Lowry also announced the presentation by Robert DeConto on the US JGOFS Synthesis and Modelling Project. Roger Hanson welcomed the group and emphasised the importance of the meeting in view of the JGOFS synthesis phase.

PRESENTATIONS

JGOFS Data Availability

1. US JGOFS data Management Office (Christine Hammond)

The DMO is located at WHOI and is responsible for the programme's data management, delivery and storage. The data status from the various aspects of the US JGOFS programme follows:

Process Studies

NABE (North Atlantic Bloom Experiment)
- April 1989-July 1989
- 2 ships, 3 cruises, 37 datasets
- *All data available on-line at http://usjgofs.whoi.edu/*

EqPac (Equatorial Pacific Process Study)
- February 1992-December 1992
- 2 ships, 5 cruises, 163 datasets
- *All data available on-line at http://usjgofs.whoi.edu/*

Arabian Sea Process Study
- September 1994 - January 1996
- 1 ship, 14 cruises, 166 datasets
- *All data available on-line at http://usjgofs.whoi.edu/*

AESOPS (Antarctic Environment and Southern Ocean Process Study)
- September 1996 - March 1998
- 2 ships, 11 cruises, all datasets
- *Available as submitted to US DMO, after a post-cruise embargo of 2 years*

Time Series data

- Bermuda Atlantic Time Series (BATS)
  BATS is located in the Sargasso Sea at 31°40'N, 64 °10'W and has conducted monthly cruises since October 1988. On-going activity.
  Data types: bottle data (nutrients, pigments and CTD data); i*n situ* primary production and bacterial growth; sediment trap flux; zooplankton biomass.
  Data availability: data through cruise 100 (January 1997) are on line at http://www.bbsr.edu/
- Hawaii Ocean Time Series (HOT)
  HOT is located in the North Pacific at 22° 45'N, 158°W and has sponsored monthly cruises since 1988.
  Data types: bottle data (nutrients, pigments and CTD data); *in situ* primary production and bacterial growth and particle flux.
  Data availability: data through cruise 88 (December 1997) are on-line at http://hahana.soest.hawaii.edu/

CO_2 survey data

The large-scale survey of carbon dioxide in the oceans has been co-ordinated with the World Ocean Circulation Experiment (WOCE). Data from the US programme is being archived at CDIAC, the Carbon Dioxide Information Analysis Centre at Oak Ridge National Laboratory (http://cdiac.esd.ornl.gov/home.html).
The US JGOFS CO_2 survey has visited approximately 23,000 stations since 1990. Of the 42 WOCE cruises involved, CDIAC has (i) data from 38 cruises; (ii) quality analysed data from 25 cruises, and (iii) made available 11 numerical data packages (NDP), i.e. quality-assured, fully documented data sets. Of these 11 NDP, 3 are from the Atlantic Ocean, 7 from the Pacific and 1 from the Indian Ocean.

Remote sensing data

- AVHRR images
  - EqPac images are available at http://satlab.soest.hawaii.edu/
  - Arabian Sea images will be available at http://usjgofs.whoi.edu/
  - AESOPS, CZCS images of interest at http://ricky.oce.orst.edu/eos/soi.html
  - BATS: images are available from the Satellite Oceanography Project at BBSR (http://www.bbsr.edu/satellite/batsat.html)
  - HOT Satellite Oceanography Laboratory (SOEST) (http://satftp.soest.hawaii.edu/satlab/hots/
- SeaWiFS (ocean colour)
  AESOPS is the first process study to benefit from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS). Images are available at http://seawifs.gsfc.nasa.gov/

Future

The DMO plans to publish all US JGOFS process study data in a series of CD-ROM.

2. German JGOFS Data Management Office (Thomas Mitzka)

The German JGOFS data management and information system is located at the Institut für Meereskunde in Kiel under the leadership of Mr. Thomas Mitzka. The system has a web interface that provides information on cruises, parameters, PI and data availability. German data policy does not allow direct access to the system. The data manager handles requests that in turn requests permission to the PI responsible for the data set. After confirmation from the PI, the data manager either extracts the data from the database or the PI submits the data set if not archived in the system. The data are delivered to the user in the requested format. This system has the advantage of being secure and personal. Main disadvantages are the long delivery time and the hindering of the user to self-analysis of the data sets before delivery. The lifetime of the system depends on financing from the JGOFS German programme, which is, as of today, secured only until the end of 2000.

Data products and compiled data sets

Atlantic moored trap data set

- From 1983 to 1996
- About 75 moorings; more than 160 traps and 1900 cups
- 5 parameters: DW, POC, PON, CaCO3, Psi
- 5200 data points
- Available on request although confirmation from PI is needed

pCO_2, TCO_2, Alkalinity, Temperature and Salinity data sets

- 1991 to 1997
- 39 cruises in the Atlantic and Indian Ocean involving 7 PIs
- No. of data sets: 21 for pCO_2, 34 for TCO_2 and 21 for alkalinity
- The data set is not complete and data are under processing. Single data sets can be made available on request upon originator's confirmation
- Data format complies with CDIAC standards.

The R/V Sonne Cruise 120 data set from the Arabian Sea

Data compiled on a CD-ROM directly during the cruise. The complete data set only available for cruise participants; i.e. they are preliminary datasets not subject for publication. Sub-sets of the data can be delivered upon request. Contents of the CD-ROM:

- About 70 Mbytes of data volume
- Profiles: CTD, XBT, spectral incident radiance
- Bottle: nutrients, oxygen, TCO_2, Alkalinity, N_2O, CH_4, Chlorophyll, bacteria, cyanobacteria
- Net hauls (100-200 μm) for zooplankton
- Experiments: grazing, serial dilution and primary production
- Surface/underway measurements: pCO_2, temperature, salinity, N_2O, CH_3, Fluorescence, PAR
- Miscellaneous: Satellite images, distribution maps, reports, documentation

JGOFS International Collection: Arabian Sea Process Study 1990-1997, CTD, XBT & SeaSoar Data

The German JGOFS Kiel Data Management Office in Kiel produced these data sets with support from data assembly efforts of the members of the JGOFS Data Management Task Team. The CD-ROM contains nearly 2,500 profiles collected on ships from six nations during 42 research cruises. Profiles of temperature plus, in most cases, salinity and, in some cases, a subset from chlorophyll, dissolved oxygen and optical attenuance are included. An html interface helps to explore the contents of the CD-ROM. Data documentation is presented in various formats (ASCII, rtf, Word, txt). The CD-ROM will be published in 1998 and requests should be sent to the JGOFS International Project Office.

Other data sets

Detailed information on 45 JGOFS or JGOFS-related German cruises in the Atlantic and Indian Oceans between 1989 and 1998:

- Continuous measurements of temperature, salinity, wind, N_2O, CH_4
- Bottle data (nutrient, oxygen, TCO_2, alkalinity, bacteria, POC, PON)
- North Atlantic: ADCP, RCM and inclinometer data from moorings
- 21 cruises with records of planktonic foraminifers and pteropods
- 3 cruises from the Arabian Sea Process Study in 1995 with Airmass trajectories
- Ship ADCP but most data sets are still uncalibrated

Future

- Organise and produce data collections for synthesis groups, at the national and international level
- Archive all metadata at the Global Change Master Directory (http://www.gcmd.nasa.gov/)
- Long-term stewardship: archive the German JGOFS data set at the National Data Centre (DOD) in Germany and the World Data Centre-A for Oceanography.

3. British Oceanographic Data Centre (Roy Lowry)

UK JGOFS data is managed and archived by the British Oceanographic Data Centre (BODC) under the leadership of Project Data Manager Dr. Roy Lowry.

Data sets published on CD-ROM

JGOFS data

- **BOFS (Biogeochemical Ocean Flux Study) North Atlantic Data Set**
  This is the UK JGOFS data set from 20W collected during 11 cruises in 1989, 1990 and 1991. The British Oceanographic Data Centre (BODC) handled the data management for these cruises. The complete data set is

still held in BODC's Oracle database in addition to the CD-ROM publication. Subsets of the data may therefore be requested from BODC or extracted from the on-line system by authorised users.

- **ARABESQUE**
  A UK contribution to the Arabian Sea Process Study. 90% of the Arabesque data has been gathered in this CD collected during two cruises on board RRS *Discovery* in 1994. Data management support was provided by BODC.

JGOFS related data

- **North Sea Project Data Set**
  Data from cruises on the southern North Sea in the period 1988 to 1989 plus a couple of follow-up cruises in 1990. It contains CTD, water bottle, underway, moored instrument and benthic data over a full seasonal cycle.
- **OMEX I Project Data Set**
  This was a multidisciplinary research project that collected data from the Norwegian Sea, Celtic Sea and Iberian Shelf break regions between 1993 and 1995.

In preparation

- **LOIS SES Data Set** (May 1999)
  Multidisciplinary data from the Hebridean slope collected in 1995 and 1996
- **LOIS RACS Data Set** (July 2000)
  Multidisciplinary data from estuaries and UK east coastal waters collected between 1992 and 1996
- **PRIME Project Data Set** (December 1999)
  Data from a mesocosm experiment in 1995 and a major Lagrangian experiment in the North Atlantic in 1996. The data set will also include a historical data set from Ocean Weather Ship INDIA.
- **ACSOE Marine Data Set** (December 1999)
  Data from 1 cruise in the North Sea and 3 cruises in the North Atlantic from 1996 and 1998 (The 1998 cruise was a major Lagrangian experiment).

Data available on request

- **BOFS Sterna Data Set**
  UK JGOFS data collected in the Southern Ocean in 1992.
- **Kiel Sea Rover Data Set**
  Sea Rover profiles, including high quality chlorophyll, collected on transects across the North Atlantic during the 1980s.
- **UK National Oceanographic database**
  Significant collection of CTD, moored instrument and sea level data collected form the middle of the last century until present
- Data from the products listed above as 'in preparation'.

Data availability at BODC

- CD-ROMS
  There is a nominal cost and receipts fund reprints but the charging policy would never obstruct data exchange (e.g. developing countries). Ordering information is available at BODC web site (http://www.pol.ac.uk/bodc/bodcmain.html)
- Non-published data
  These data are available upon request. Requests are normally charged at cost for non-UK clients but it has been agreed that these will be waived for scientists engaged in JGOFS research. BODC has limited resources available to service requests. Therefore clients are asked to be patient, plan requests well in advance, provide detailed specifications of what they need and keep requests to a reasonable scale. Contact Roy Lowry.
- The Web
  The current policy of BODC is to not distribute data via the Web (data are supplied to registered users over the Internet using Telnet). Metadata availability on the Web is patchy: good for some projects but non-existent for others. However, this policy is currently under review and a post will soon be recruited to specifically enhance what BODC delivers over the Web.

4. French JGOFS Data Management (marie-paule Labaied)

The JGOFS-France homepage (http://www.obs-vlf.fr/jgofs/html/bdjgofs.html) has been implemented and maintained by Ms. Marie-Paule Labaied at the Observatoire Océanologique, Villefranche-sur-Mer. The web site has comprehensive information about JGOFS activities in France. Since the second half of 1997, this web site gives also access to the French JGOFS database. During this initiative, the following has been accomplished:

- Collect and archive all JGOFS data gathered by French campaigns
- Centralise the documentation and mission reports (mostly in French)
- develop a web site to interface with users

Organisation

The database has the following categories:

- Geographical area
- Research programme ("Operation"): programme information and list of cruises
- Cruise ("Campagne"): information about that cruise and its data sets
- Data sets: data on-line with metadata. Can be downloaded directly. If data not available, request directly to Labaied by email.

Data accessibility

JGOFS-France data policy imposes a 2-4 years embargo on data. Appendix C shows the status of French JGOFS data sets availability as of September 1998. Between September 97 and May 98 the database received an average of 60 hits from different addresses. An overview of the French modelling activities are posted in the web (http://www.obs-vlfr.fr/jgofs/html/base/modelisation/rapp.html). In the future, products from modelling activities will also be available through this web site.

Future of the database

On October 7th 1998, the French JGOFS committee will meet to draft the further development of the database, e.g. implementation of a web graphic interface, etc.

5. Japan Oceanographic Data Centre (takeharu Miyake)

JGOFS research in Japan include

- CO_2 flux: measurements of pCO_2 in the north Pacific from ships of opportunity,
- Sub-Arctic Gyre Experiment;
- Material cycling in the western Sub-arctic pacific,
- Time series station KNOT

Data accessibility, storage and products

JGOFS-Japan has a Data Management Office (DMO) which receives all JGOFS data. After an embargo of three years, the data are transferred to JODC for archival and become public domain. JODC's database can be queried through the web.

JODC operates the homepage of the Data Management Office (DMO) at http://www.jodc.jhd.go.jp/JGOFS_DMO/index.html. The homepage of JGOFS-Japan programme is hosted at the University of Nagoya (http://pon.ihas.nagoya-u.ac.jp/)

Data products

- NOPACCS Vol. 1 (Northwest Pacific Carbon Cycle Study 1990-1997) CD-ROM in press
- CD-ROM: MASFLEX (Marginal Sea Flux Experiment in the west Pacific) CD-ROM in press
- High Temporal-Spatial Resolution Marine Biogeochemical Monitoring by Japan-Korea Ferry (June 1991-February 1993): CD-ROM published in January, 1995 by the Centre for Global Environmental Research, National Institute for Environmental Studies, Environment Agency of Japan.
- The East Asian Marginal Seas data set (NIES-CGER)

- WMO World Data Centre for Greenhouse Gases: established by the Japan Meteorological Agency (JMA) in October 1990 to collect and distribute data on the concentrations of greenhouse gases (CO_2, CH_4 , CFCs, N_2O, etc.) and related gases (e.g., CO, NO_x, SO_2) in the atmosphere and the ocean.

6. MEDS, Canada (Graham Glenn)

The Canadian JGOFS web site is located at http://www.dal.ca/~jgofs/cjgofs.htm. This web site is maintained at the Canadian JGOFS secretariat. It has a link to the Data management web site at MEDS (Marine Environment Data Service) and contains a library of documents and text of JGOFS activities including:

- Data reported to MEDS from Canadian projects.
- Project (name and description; bibliographies of project publications; list and summary of cruises/maps)
- Atlas of Canadian JGOFS cruises
- Directory of Canadian JGOFS scientists
- Executive summary and policies of Canadian JGOFS
- MEDS Oceans system for data and quality control

Canadian JGOFS has collected data in the following areas: Gulf of St. Lawrence and Grand Banks area; Mid-Atlantic and North-western Atlantic, Canadian Pacific and equatorial Pacific (non-core measurements).

Data availability and accessibility
Most data originates from research agencies carrying out JGOFS projects, e.g. a number of Universities and the Institute of Ocean Sciences.
Some data files are available on-line. There is a table of links to sub-directories of ASCII data files ordered by project name (http://www.meds.dfo.ca/jgofs/). Otherwise, data can be acquired by the MEDS offline data request system (http://www.meds.dfo.ca/)

Canadian system of biological oceanographic databases

- MEDS is Canada's National Ocean Data Centre and has an extensive archive of CTD and nutrient data (bottle data).
- At the Institute of Ocean Sciences (Pacific coast):
  - CTD plus chlorophyll and other biological data
  - Bottle nutrients
  - Time series from two stations back to 1955 (Papa and P4)
  - Plankton database for the Pacific
- Bedford Institute of Oceanography (BIO, Atlantic coast): all Canadian JGOFS data from the biological division from sampling in the North and mid-Atlantic are in Oracle databases. Areas: North Atlantic
- Other Canadian Institutes (MLI and NAFC): although non-JGOFS data are archived here they do have biological data of interest to JGOFS.

Current activities
Development and Implementation of a National Biological Database
All Canadian data (JGOFS, GLOBEC, Atlantic Zone Monitoring, and historical data sets) will be archived into specifically designed relational databases. The design of distributed database system derives from the successful "Canadian Contaminants Database System". Its main priority is to accommodate plankton data. It also contains CTD, bottle and underway data collected on biological cruises. In the future, it will be extended to contain sediment trap and benthic data. This system will both cover the short-term maintenance and long-term stewardship of all Canadian JGOFS data.

Other data system developments

At MEDS, the Oceans interactive quality assurance system called the "Waterfall Test" is being extended. The system shows water column profiles of a cruise - side by side. It displays: (i) any CTD, CTD biological, and bottle data; and (ii) track maps. Profiles are tested and flagged using objective and manual tools of other MEDS QC/QA tools.

A Data Set Dictionary is currently being developed in the Department of Fisheries and Ocean Science. It will apply to data variables from BODC and GF3 parameter codes. The MEDS' Data Set Dictionary will describe Canadian JGOFS data (metadata and documentation of methods) and it will group data into 'events'. There will be in-house documentation, database/file server; have a web accessible version. Plans are to publish a CD-ROM in March 1999. The structure of the dictionary is as follows:

- Data set index (originator and data class)
- Data dictionary (data types; codes & variables)
- Indexed & access to textual documents and data files
- Geo/temporal summary (data set class locations)

7. Indian NODC (Jaswant Sarupria)

JGOFS activities in India have so far contributed with 7 cruises in the Arabian Sea between 22^{o}-10^{o}N and 64^{o}-76^{o}E from 1992 to 1997. A cruise inventory and parameters measured during this programme are shown in Appendix D.

JGOFS data from India are archived in a relational database (RDBMS -Open Ingress) at the Indian National Oceanographic Data Centre (INODC) hosted by the National Institute of Oceanography in Goa, Dona Paula. Currently working on the development of JGOFS-India multi-disciplinary data sets on CD-ROM with user friendly selection, projection and retrieval mechanisms. Planned publication in early 1999.

The INODC is attending more than 100 data inquiries/requests a year. See appendix D for an overview of INODC data bank for the Indian Ocean.

Future JGOFS activities
Synthesis and modelling aspects based on the data collected from the Arabian Sea Process Study are in progress. A scientific symposium and a training course organised and sponsored by JGOFS will take place 18-29 January 1999 in Bangalore.
In the footsteps of the JGOFS-India programme, another major scientific programme is planned from 1999 to 2003: the Bay of Bengal Process Study (BOBPS). Its main objectives are: (i) to study the oceanographic processes controlling time varying fluxes of carbon and associated biogenic elements in the Bay of Bengal, and (ii) to study the effects of river discharge on physical, chemical and biological processes in the bay. The observational and data synthesis programme will include: (i) five cruises over a period of three years, starting in 1999 and (ii) synthesis and modelling activities over a period of two years.

JGOFS Synthesis and Modelling Plans

Roger Hanson

At the 13th JGOFS Scientific Steering Committee (SSC) in Cape Town (April 1998) a re-structure occurred to accommodate to the programme's new focus: synthesis and modelling between 1998 and 2004. Planning groups were transformed into regional synthesis and modelling groups with the SSC as the overall co-ordinator of activities. Securing JGOFS data sets at the national level will be crucial for this phase and the role of the Data Management Task Team was highlighted.

The overall goal of the JGOFS synthesis plan is to develop an integrated, quantitative view of biogeochemical cycle of carbon in the ocean, indicating the roles of biota, physical transport, air-sea exchange, particle settling and remineralisation, including estimates of uncertainties. Specific objectives include:

- Ensure that all JGOFS observations are lodged with organisations, which can guarantee long-term stewardship. Provide web-based information on the availability and access mechanisms to all JGOFS data. Encourage the development of Web-based data delivery systems.
- Create a new synthesis of ocean biogeochemical regimes from the JGOFS Regional Process, Time Series and Global Survey studies,
- Develop a hierarchy of coupled, biogeochemical-physical circulation models of varying ecosystem complexity, and use them to enhance understanding of natural variability and anthropogenic changes in the carbon cycle over dec-cen time scales.
- Assess the capability of 3-dimensional ocean carbon cycle models with biogeochemistry to simulate observed global inventories, seasonal cycles and fluxes of carbon, nutrients and functional groups, and to evaluate current rates of carbon remineralisation and ocean forcing over time scales.
- Assess the contribution of continental margins and seas to CO_2 sequestration and the horizontal flux of carbon across the ocean -continental margin boundary.
- Utilise ocean colour observations from satellites, aircraft, moorings, and towed vehicles to provide a global picture of the seasonal cycles of phytoplankton biomass, primary and new production
- Make recommendations on the development and implementation of future global ocean observing systems for detection of changes in the ocean carbon cycle and impacts on marine ecosystems, as one aspect of global change

Future activities include regional synthesis workshop through 1998 and 1999, the JGOFS Open Science meeting in 2000 and the IGBP Open Science meeting in 2001. Example of synthesis products are: (i) a brochure entitled *Ocean biogeochemistry and climate change* with highlights from 10 years of JGOFS research, and (ii) a book entitled: *JGOFS Synthesis and Related Research* with the integration of JGOFS regional synthesis and to be published in the IGBP Book Series (Cambridge University Press)

Synthesis and Modelling in France

Nicolas Metzl

The JGOFS programme in France is now called PROOF (**PRO**cessus biogeochmiquies dans l'**O**cean et **F**lux) and will be active in the coming 5 years (1998-2002). This is a break up from the regional focus that the previous JGOFS programme (1989-1997) had and the CO_2 related studies that were developed in the frame of the French program PNEDC (Programme National d'Etude de la Dynamique du Climat). The program PNEDC is now mainly coordinating the studies developed in CLIVAR.

PROOF includes five topics following:

- Air-sea exchanges
- Coupling of physical-chemical-biological processes at mesoscale
- A better description of the biological fluxes, e.g. natural vs anthropogenic fluxes (CO_2, N, P, trace), change in ecosystems, atmospheric/terrestrial input, etc.
- Study of export fluxes (water column and sediments)
- Modelling and synthesis

The field process study in PROOF is planned as follow:

Period	Region	Project	Coordinator

Jan-Feb 1999	Southern Ocean	ANTARES IV	J. Lefévre (UBO)
Summer 1999	Mediterranean	PROSOPE	H. Claustre (LPCM)
2000-2001	North Atlantic	POMME	L. Mémery (LODYC)

The time series station DYFAMED (Mediterranean Sea, co-ordinator, J.C. Marty, LPCM) and the long term carbon dioxide observations in the southern Indian Ocean (project OISO, co-ordinator N. Metzl, LPCM) are closely linked to the thematic of PROOF. Activities in ocean colour (remote sensing) will be lead by A. Morel and A. Bricaud (LPCM) while P. Monfray (LSCE) will be in charge of synthesis and modelling group in 1999. An overview of the timing of modelling activities in JGOFS-France as well as the integral model of JGOFS-France are given in appendix E.

The French Modelling activities in JGOFS began in 1988 when EUMELI and DYFAMED field studies started. Several biogeochemical one-dimensional (1D) models have been developed with the support of operational physical models that were known to represent realistic temporal variations of the mixed-layer variations and sea surface temperature (TKE schemes). These are important terms in estimating carbon fluxes at the air-sea interface, to determine the input of nutrients in the euphotic zone, to quantify the carbon export from subsurface ocean or to study zooplanktonic vertical migration. The models developed during the eighties have been shared in the JGOFS community, which permits several teams to test, improve and develop different parameterisations (biological, bio-optical, carbon/nitrogen/silicium coupling). All the observational JGOFS projects are now associated with modelling studies being closely linked. An example is the construction of an integrated coupled model to describe the carbon fluxes from the surface to the sediment (see Appendix E). At present, this coupled model is tested on the EUMELI Oligotrophic site. After validation, it is planned to apply the model on other French-JGOFS sites (DYFAMED, KERFIX) and other international JGOFS stations (BATS in the Atlantic, HOT in the Pacific).

Modelling studies in JGOFS can be described following two approaches: processes studies and biogeochemical quantifications at different time scales (from daily cycles to interannual). The first approach consists in developing, improving or simplifying the parameterisations of complex processes (e.g. biological and bio-optical models). The results are then used in the second approach (application of a coupled physical-biogeochemical models) related to the field work of JGOFS. These coupled models, in turn, are integrated in 3D applications (meso-scale and global). Three dimensional models are forced either by climatological fields or actual fields (e.g. ECMWF, ERS winds). This allows for the study of the inter-annual variability and comparison of simulations with data from corresponding years (e.g. EPOPE/EQPAC) or to compare with other methods that investigate interannual variations of air-sea CO_2 fluxes (e.g. atmospheric inverse approaches for global carbon budgets). This will allow the study of the interaction between climate and biogeochemical cycles at large scales.

Modelling is carried out at the time scale of biological processes (seconds to tens of days) and biogeochemical cycles (tens of days to decades).

Small scale processes

The study of high frequency events was the focus of the DYNAPROC project (linked to DYFAMED site in Mediterranean) where the current modelling investigations concern the coupling of physical component with the parameterisation of biological processes including vertical migration of zooplankton. Other high frequency events are investigated through simulations using measurements (primary production) obtained during 5 to 8 days fixed stations during EPOPE and EBENE cruises (equatorial Pacific).

1D view at seasonal and inter-annual variations

The majority of the 1D coupled biogeochemical models developed in France work on the seasonal scale (EUMELI, DYFAMED, KERFIX). There are some interannual application at station KERFIX (1990-1995) and DYFAMED (1993-95). Current 1D studies investigate the coupling/decoupling of C/N/P/Si/Fe. The sulfur (DMS) cycle is also under investigations.

3D meso-scale models

An important activity (including technical, computation time, validation, and assimilation of altimetry and colour of the sea) concerns the development of 3D meso-scale models (Mediterranean Sea and North Atlantic). Applications of 3D meso-scale models have been recently planned in the southern ocean (ANTARES).

Modelling the ocean carbon cycle at large scale

- Global scale models are being developed in France (LSCE/IPSL, based on the OPA/LODYC dynamical model); they include simple nutrient (e.g. HAMOCC) or NPZD, NNPZDD formulations (mostly derived from Fasham's) for representing the biological activity. Some biogeochemical applications focus on tropical sectors (Atlantic and Pacific, including interannual applications during ENSO/non ENSO events) where the dynamical model has been extensively studied in the frame of the TOGA-COARE experiment. The modelling activity at global scale is closely linked to the IGBP/GAIM/OCMIP project. Studies related to global oceanic anthropogenic CO_2 inventories (using the same models) and the coupling with atmospheric and terrestrial models for climate change analysis will be related to CLIVAR. Future activities in the frame of PROOF/JGOFS will include higher trophic level; these studies will be linked to the GLOBEC project.

The U.S. JGOFS Synthesis and Modelling Project

Robert DeConto

The goal of the US SMP is to synthesise the results of process studies, time series and global survey into a set of "data-driven" models to be used for predicting: (i) the response of the oceanic carbon system to climate change, and (ii) feedback to the climate system. The conceptual organisation of SMP elements is shown in appendix F.

Products expected from the SMP effort can be broken down into the following categories, with each category requiring international co-operation and data availability.

Level I - data synthesis: (on-line and archived data sets; initial PI publications and special issues; regional workshops and synthesis papers

Level II - Model-data comparisons and products: data products (e.g. gridded global DIC, C_{anthro}, carbon transports); new models and parameterisations (e.g. community structure controls on export; mesoscale eddy fluxes); global synthesis (limited data types) of regional data sets; model-data comparison studies

Level III - "Grand synthesis": next generation of biogeochemical models; regional and global data assimilation

The present group of SMP Principal Investigators (PIs) have formed the following working groups:

- Community synthesis and modelling
- Global-scale biogeochemistry
- Continental margins
- Large-scale data sets
- Satellite biogeochemistry
- Nitrogen fixation
- Regional testbeds

The importance of 'regional testbeds' was discussed by several meeting participants, with the objective to create regional data sets, including physical, chemical, and biological data, to be used for evaluating ecosystem models. The creation of regional testbeds will provide a forum in which different models and modelling approaches can be compared to common data sets, so that the strengths and weaknesses of those approaches can be evaluated.

Terms of reference for the US SMP PI working groups, including a more complete discussion of regional testbeds, can be found on the US JGOFS Synthesis and Modelling website, under SMP Working Group Reports, May 1998 (http://www1.whoi.edu/mzweb/smp/piworkg.htm).

The need for a coherent Model-Data Policy has been considered by the SMP. Model data encompasses the broad range of numerical and synthetic data products, such as: (i) historical data not currently available; (ii) compilations and synthesis of historical data across multiple a field programme; (iii) derived quantities and interpolated fields; (iv) calculated data products from remote sensing and satellite observations; and (v) numerical model output, code and forcing data

SMP has drafted a policy for model data whose objectives are to:
1. encourage timely distribution and exchange of relevant synthetic and model generated data sets
2. promote the ethical use of model-data
3. ensure the scientific repeatability of results via thorough documentation

This policy will be overseen by the US JGOFS Steering Committee with advice of the SMP co-ordinators. It is based on voluntary model-data exchange for the mutual benefit of SMP PIs and the broader scientific community. It not only encourages a two-way exchange between modellers and observationalists but also PIs can distribute data to anyone at any time. Model-data should be made available to other PIs no later than the time of publication (earlier exchange is encouraged) while data availability is limited to other SMP PIs for one year.

Implementation of the Data-Model Policy and Data-Model Archive
- SMP model data archive will be established within the framework of the US JGOFS Data Management System
- Passwords required for data access during one year "PI-only" phase
- PIs are responsible for data quality and accuracy
- Archived data will include model source code and "complete" documentation of protocols and boundary conditions.
- PIs will be responsible for editing "large" data sets

The complete US SMP Model Data Policy can be found under the heading “Synthesis and Modelling” on the US JGOFS Web site:
http://www1.whoi.edu/mzweb/smp/model_data_revised.html

Remote Sensing

Trevor Platt: Data requirements to improve the benefits from ocean-colour images

The procedure for the estimation of primary production from ocean colour is two-fold: (i) establish a local algorithm and (ii) extrapolate to a larger scale. For the algorithm, the following computations are needed:
- compute surface irradiance
- estimate surface biomass and define biomass-profile (the vertical distribution)
- estimate photosynthesis parameters of the model
- compute the parameters of light transmission underwater
- compute water column production

Once the local algorithm is established, the extrapolation to larger areas, e.g. biogeochemical provinces, can be carried out. A major problem is that the boundaries of these provinces are not static but are highly dynamic, exhibiting high seasonal and inter-annual variability. These "instantaneous" boundaries are indeed accessible with remote sensing, e.g. contrasting satellite images from the Arabian Sea in Jan'79 and Sept'79 show the extent of the variability of phytoplankton biomass and bloom activity in this area.

There is also a needed for predictable properties within seasons, e.g. vertical structure, biogeochemical rate constants, etc. In this way, 'templates' could be provided for application of province-specific rates and extrapolation would be more accurate. For instance, in a transect between Iceland and the Azores, vertical profiles of chlorophyll

(August-September) show the variation in the position of the deep chlorophyll maximum with depth. This shows how one can specify the parameters of the model in order to calculate primary production in the North Atlantic. Another example: the correlation between nitrate and temperature found in George's Bank during the summer shows that temperature is a good proxy for nitrate concentration in this area. Although the constants from this correlation will be the different from place to place, the second order function still holds for a variety of areas.

Conclusions:

1. Scientists would like to have access to databases that can be exploited in such a way that relationship of this sort can be discovered. The database would be also responsive to the kind of information the modellers are looking for.
2. Database can provide a basis to construct and test schemes for partition of the ocean into a suite of provinces to simplify analysis.

North Atlantic

Truls Johannessen: Flux of anthropogenic carbon in the deep Greenland Sea[1]

Measurements of the carbonate system and the transient tracers, CFC-11 and carbon tetrachloride (CCl_4) in the Greenland Sea and western Eurasian Basin were used to deduce the sources and magnitude of excess dissolved inorganic carbon in the deep Greenland Sea. The salinity in the deep Greenland Sea has increased during the last 20 years as a result of Arctic Ocean water advecting into the area. From salinity and temperature data the relative amount of advective water below 1500 m is estimated to about 2 % per year between 1982 and 1994. Data from the western Eurasian Basin, collected during the Oden 91 cruise, is used as the advective source waters. A mixing box model is applied to estimate the evolution of CFCs and anthropogenic total dissolved inorganic carbon in the deep waters of the Greenland Sea, since pre-industrial times. The source functions are the surface water concentrations of CFC-11; CCl_4 and total dissolved inorganic carbon (C_T), which are the result of anthropogenic emission. In order to explain the measured CFC data in the Greenland Sea, an annual per cent renewal by deep water formation of between 0.5 and 1.2 % is needed below 1500 m, corresponding to a mean ventilation of 0.17 ± 0.05 Sv, considering realistic uncertainties in the calculations. This ventilation gives a sequestering of anthropogenic carbon dioxide, which in 1994 equaled $2.4 \pm 0.7 \times 10^{12}$ g C y^{-1}.

Roy Lowry (for Fasham): North Atlantic Synthesis Meeting

The JGOFS North Atlantic Synthesis and Modelling Group held its first meeting 11-13 May 1998 to discuss the future tasks of the group. It was agreed to publish a special synthesis issue of Deep-Sea Research (DSR) in 1999. Synthesis data sets may arise from the synthesis papers and these should be published as a CD-ROM, to complement the DSR issue.

Data availability and products needed for the synthesis stage of the group were discussed and the following specific questions were raised for this workshop:

Q: Can the IPO web-site give hypertext links to the net sites for the climatological databases, e.g. Levitus temperatures, salinity, nutrients (nitrate, silicate, phosphate) and global ocean colour and primary production or briefly say what is available and where to get it?
A: Yes

[1] Abstract of the article of same title by L. G. Anderson,M. Chierici, E. Fogelqvist and T. Johannessen, which has been accepted for publication in the *Journal of Geophysical Research*.

Q: *Is the bibliography being kept up-to-date*?
A: This information is provided by the JGOFS publication list which is under continuous update. However, this list is far from complete and will probably never be complete.

Q: What cruises went to the area of interest?
A: This information is in the cruise inventory, which is now very large

Q: C*an we add a query language to the cruise inventory to provide a list of cruises within time and geographical bounds*?
A: No, the cruise inventory in the homepage cannot be queried in its present state. However, the IPO can query the inventory in its excel format to answer any request of this sort. Contact: Baliño. In the future, DIFs will be available for the user to acquire this and other types of information.

Q: *Can we get the data from the cruises of interest?* In principle the answer is yes but the degree of difficulty varies greatly with the nationality of the cruise. I tried to access NA data with the following results:

- US : All data easily available
- UK: No JGOFS web-site. All data from certain cruises easily available on CD-ROM. Other data sets less easy to obtain
- Germany: good web-site with cruise tracks. Data obtainable by email but it may be necessary to mail more than one PI. Could be time-consuming
- France: data available on the web
- Canada: attempt to connect to the DFO marine data service through the C-JGOFS web failed
- Netherlands: no web site or email links from the cruise inventory
- Spain: connects to WOCE or ESTOC web-sites. No data

Is this a fair summary of the situation?
A: Yes, except that data from the one Spanish-WOCE cruise are indeed on-line and the link works.

Q: *I still believe that the ideal to aim for is data available on the web. Is this an impossible dream? The French seem to have done this in a short space of time*.
A: Only partially possible. National data policies and resources are major hindrances for its realisation. Therefore, if scientists have problems in localising and/or acquiring data, contact the DMTT and the IPO for assistance.

Q: *Are we putting enough effort into making sure that all level 1 information is obtained from scientists?* It is not clear that all level 1 taken on cruises is on the web. Remember that even just a few data points on critical variables (e.g. microzooplankton biomass) can help the modellers greatly.
A: No answer given to this question

Q*: Are we doing as much as possible to bring pre-JGOFS and other data sets to the attention of JGOFS scientists*?
A: If IPO or anybody else comes cross a historical data set of interest to JGOFS research, inform the IPO and Baliño will write DIF for and announce it in the homepage. BODC is planning to database the OWS India data

Funding and resources.
Q: *Can we present the goal of a web-based data system to Brussels for EU funding?*
A: The technology is actually there; it is more a matter of lack of human resources.

Equatorial Pacific

Robert Le Borgne. Spatial and temporal variability at the equator in the Pacific Ocean: results from equatorial Pacific JGOFS cruises

The presentation included a complete view of the spatial and temporal variations in the equatorial Pacific and the state-of-art of our ability to build real time carbon budgets. The study area comprises the equatorial rich area or "cold-tongue", i.e. HNLC zone and not about the whole Pacific equatorial belt which represents 42% of the Earth's circumference. The talk focused on the comparison of information originating from cruises and from ocean colour (satellite).

1. Biogeochemical parameters maximum on, or near, the equator

A Polder imagery of the ocean colour from the first 10 days of November 1996 shows a maximum of surface chlorophyll in the equatorial band between 2°N-2°S. There is not a clear east-west variation but as one proceeds eastwards, the "rich " area extends more and more in latitude, south of the equator and extends as far west as New Guinea. Results from measurements and estimation of rates from cruise data confirm that ocean colour is thus a good proxy for biogeochemical processes which, in fact, take place in the mixed layer. Also, the maximum of CO_2 export to the atmosphere and maximum carbon export to the deeper layers occurs near or on the equator. The ORSTOM cruises along 165°E (July 87) also show that HNLC is not a permanent feature in the western Pacific. But, when there is an upwelling, its signature is clear on the salinity profile (April 88).

2. No zonal variation of biological parameters along the equator due to the presence of HNLC

The lack of zonal gradients west of the Galapagos, appears on the ocean colour imagery, although it is not yet recognised by the entire oceanographic community. The lack of zonal gradient for biochemical parameters, in spite of a clear gradient for hydrological parameters and nutrients is just an illustration of what happens in HNLC ecosystems: macronutrients do not control primary production and the rest of the food-web. A fundamental condition for the occurrence of HNLC systems is the steady state of hydrological and biological parameters (on a 24-hour period); otherwise we would have blooms, or beginning of blooms, as it was rarely observed in the equatorial Pacific.

3. The western boundary of the HNLC area

A detailed description of the western edge of the HNLC area, a necessary feature to calculate the budget, was acquired during the FLUPAC transect. Changes in surface salinity and pCO_2 were due to change between two water masses: the warm "pool" or rather, "fresh" pool to the west and the HNLC area to the east. Thus, salinity is a good indicator of the western boundary while temperature is not.

Several authors have related the longitude of the HNLC western boundary to the Southern Oscillation Index (SOI) which is the atmospheric pressure difference between Darwin and Tahiti. The best correlation confirms that the SOI can predict the position of the western boundary. This seems to be a valuable tool in carbon export budgets for the equatorial Pacific.

When using ocean colour in the delimitation of the HNLC area, one has to make sure that cloud cover does not make short-term analysis impossible in this area, because data on long periods of time would not bring the sought information.

So, the equatorial Pacific has betrayed a few more secrets. We may improve our budgets. But the processes are still mysterious, being the climatic variations or the functioning of the HNLC system.

Arabian Sea

Iris Kriest: German JGOFS synthesis and modelling for the Arabian Sea

The Arabian Sea combines eutrophic, oligotrophic and upwelling environments. Especially the latter are subject to strong seasonal oscillations in physical forcing during the Southwest Monsoon (May-September), which cause strong spatial and temporal gradients in the biological variables. Therefore, one of the major topics of the Arabian Sea Process Study is the investigation "of the seasonal-varying biogeochemical responses to the intense and regularly oscillating physical forcing in the Arabian Sea" (Arabian Sea Process Study, JGOFS Report No. 17). Other aims of the Arabian Sea Process Study are the quantification of biogeochemical flows, of the role the O_2 minimum plays in biogeochemical cycling, the role of gases relevant to climate change and the role of Quaternary monsoonal variability. The German JGOFS Arabian Sea Process Study has focused on many of these topics, which are sketched in appendix G. The investigation of the processes and their impact on biogeochemical flows has been carried out by measurements of the relevant variables and flows, as well as by modelling projects. The modelling approaches are carried out on different scales and with different model types (see table below for some examples. The overall conceptual modelling activity is shown in appendix G.) from 0-dimensional models of gas exchange for the mixed layer, over 1-dimensional biological models to 3-dimensional coupled models of ocean circulation and biogeochemistry.

The four major synthesis and modelling projects in Germany

D	Author	Title	Currency	Topics
0	Andreae & Bange (MPCH Mainz)	Cycling of N_2O and methane	N_2O	Gas exchange: coupled ocean-atmosphere N_2O mass balance for the mixed layer of the Arabian Sea
1	Bodungen & Barkmann (IOW)	Nitrogen and carbon cycling	N, C	Biogeochemistry
	Zeitzschel & Kriest (IfM Kiel)	Aggregation and sedimentation	N, particles	Biogeochemistry, aggreagation
3	Maier-Reimer, (MPI Hamburg)	Seasonal production	P, Si, C	Biogeochemistry

First results of modelling and field investigations suggest that zooplankton may be of importance especially for the upwelling area and the area influenced by the Findlater Jet. Due to the high temporal and spatial variability of this region and the strong influence of horizontal processes, climatological data sets may not be appropriate for the modelling of this area.

Southern Ocean

Brian Griffiths: Australian Southern Ocean JGOFS: Data, synthesis and modelling

1. Agencies involved in Australian JGOFS are CSIRO Divisions of Marine Research (CMR) and of Atmospheric Research; Antarctic Co-operative Research Centre (Ant-CRC); the Australian Antarctic Division (AAD); and the James Cook University. The parameters acquired by each agency are given in appendix H. Australian involvement in the SO is due mainly to the efforts of John Parslow.

2. Cruises
   Australia has taken part in repeat surveys on WOCE cruises. It has also carried out two process studies in two CMR cruises in 1995 and a major sub-Antarctic Zone (SAZ) cruise in 1998. See appendix H for dates and tracks.

3. Current data status

3.1 Types and location

Centrally processed data includes CTD, nutrients (NO_2+NO_3, PO_4 and SiO_4), oxygen, "underway" and meteorology. The individual PI's data is the PI's responsibility (see appendix H) although will be encouraged to submit his publication quality data for inclusion into the database being constructed for the Southern Ocean data.

3.2 Availability

Metadata is available through "Blue Pages" (http://www.erin.gov.au/marine/mcdd/). It gives a brief outline of cruise, area sampled, Chief Scientist and who to contact for information. The metadata entries are not yet complete. AAD and Ant-CRC metadata, and sample data will be in the Antarctic Division's database (http://www-aadc.antdiv.gov.au/). There is a 2-year embargo on Australian data from the data the post-cruise processing of the oceanographic data (CTD, hydrology) is complete.

3.3 JGOFS Database at CMR

Available on-line at http://www.marine.csiro.au/datacentre/ and includes metadata (objectives, regions and centrally processed data) and sample data. The database is being designed to take in the data from individual PIs. It uses Access to get data into an Oracle database. All equatorial Pacific data is held at CMR while SO data are held at CMR, ADD, and the University of Tasmania. It is expected to have data on-line in 18 months (mid-2000). In the meantime, formal requests for data will take a couple of days to deliver.

3.4 Data entry

Excel spreadsheets are used for most data entry. Access is used as initial database at CMR while it goes directly into Oracle database at AAD and Ant-CRC. In the future, data at CMR will be stored on an Oracle database as well.

3.5. Future

Plan to centralise all JGOFS data from Australian either in Blue Pages or at ADD + Ant-CRC. Therefore, Griffiths seeks advice from workshop participants regarding the design of the database and what type of data should go into the system; e.g. (i) raw counts? preliminary processed? or checked and verified? derived data?, and (ii) what other design criteria should we adopt before we start entering data for the JGOFS database

4. Synthesis and Modelling

A list of papers in press or in preparation give an idea of the synthesis activities under way at CMR and other institutes that have participated in the cruises, and what data is presently available (Appendix H). These show (i) the progress towards the definition of the biogeochemical provinces in the Australian region; (ii) the understanding of the spatial and temporal properties of each province; (iii) the description of key biogeochemical properties and the start of generalisations; and (iv) the understanding in the inter-annual variability in various provinces of well-sampled parameters, e.g. fCO_2

There is a small modelling group led by Richard Matear. Activities include:

- Global biogeochemical modelling (past, present and future oceanic CO_2 uptake)
- One dimensional models (Nutrient dynamics in the SAZ)
- Regional Biogeochemical Models (open-ocean continental shelf water exchanges in the Australian EEZ)

Future perspectives

Eileen Hofmann: Data, modelling and synthesis needs for the Southern Ocean GLOBEC and relationships to SO JGOFS

SO-GLOBEC will focus on krill as a target species, e.g. krill's habitat, prey, predators and competitors. It will be a year-round study, with emphasis on winter processes. The study regions for SO-GLOBEC are shown in appendix I.

SO-GLOBEC main scientific questions are:

Zooplankton: (i) aspects of krill reproduction, (ii) larval survival and recruitment, (iii) seasonal food requirements and spatial distribution, (iv) geographical distribution in relation to the physical environment.

Top predators: (i) how winter distribution/foraging ecology relate to key physical environment and prey, (ii) breeding season foraging ecology related to abundance and dispersion of krill, (iii) inter annual variation in population size and breeding success related to distribution, extent and nature of sea ice, krill availability and cohort strength.

Data issues

SO-GLOBEC adopted the data policy from the US JGOFS, as has the international GLOBEC. All PIs and programmes have accepted to: (i) timely submission of the data, (ii) recognition of data collector; and (iii) open availability to the scientific community.

Modelling issues

SO GLOBEC will develop multi-scale biological-physical dynamical models that include spatial and temporal nesting. It will be necessary to develop procedures for acquiring and assimilating data into the dynamical model (see appendix I) and to incorporate data assimilative models into Advanced Modelling and Observation Systems. In addition, SO GLOBEC will integrate dynamical models of autotroph-heterotroph interactions in the plankton in a physical setting. There is also the need to understand how mesoscale physics modulates the interactions among small- and large-scale ecosystem processes.

Finally, there is a strong need to develop procedures for archiving, storing, analysing, and making available datasets, models and analysis tools.

Previous SO Data Centre: BIOMASS (lessons learned)

Because GLOBEC has designed a nested biophysical sampling plan (Appendix I), this will produce data with all sort of spatial and temporal resolutions. It also will acquire such disparate data types (e.g. from krill to bird observations to whales), that it is necessary to have a well-designed database to accommodate this diversity.

Lessons learned from BIOMASS make the basis for the following recommendations:

- better integration of information management and science, with information management being planned into the programme from the start'
- use industry standards hardware and software- avoid "in house" solutions
- data transfers in and out of the datacenter should be format independent
- make data validation a high priority
- allow an open access protocol for data; restricted access stop a data centre from working effectively
- have a well defined data management structure
- have a user group to represent the needs of the individuals using the data centre
- ensure long-term support; financial and morale, include scientists as part of the data centre staff

Question: how can one match GLOBEC's diverse data types with existing database technology? e.g. cruise of feeding penguins to match whale and krill distribution in the mixed layer.

Answer: RDBM technology can do this: Supply the raw data to the database, then get the functions that will manipulate the data and your question will be answered.

What's next?

Since SO-JGOFS data are of considerable interest to SO GLOBEC, one has to ensure that data streams are compatible and that access to data sets from both programmes is available. There is a large amount of historical data sets for the Southern Ocean but most a form that cannot be ready usable (e.g. cabinets) by both programmes. Therefore an action is needed here. There is also a need to include data that is routinely collected from SO at land-based laboratories and by ships of opportunity. GLOBEC has to interface with SCAR, CCAMLR and other international organisations that have responsibilities for data from the SO, e.g. the International Whaling Commission (IWC).

However, there is a crucial problem here: because krill is a species of commercial value, data may not be readily available because some countries are reluctant to make SO data available, e.g. disconnect SO databases.

DISCUSSION SUMMARY AND RECOMMENDATIONS

JGOFS Metadata Catalogue

The workshop concluded that JGOFS had a most urgent requirement for a metadata catalogue. The system specification required is that a user should be able to obtain information on the extent of data availability and instructions on how to obtain the data in return for information on position, time and parameters of interest. The system would obviously be usable over the Web and, ideally, should have the capability to actually deliver the data.

An attempt by the DMTT to build such a system based on relational database technology served over the Web foundered due to lack of resource to design and build the system. The DMTT will now look at metadata systems that are available on the Web to see whether populating these would serve the JGOFS requirement.

If a suitable technology is identified it will be employed to implement a JGOFS metadata catalogue on the IPO Web site.

Communication

JGOFS synthesis will benefit significantly from enhanced communication between scientists, data managers and the IPO. A brief dialogue between scientists embarking on data synthesis and DMTT members to outline data requirements can pay dividends. Data managers may be aware of relevant non-JGOFS data sets that may be of use or may be able to save the scientist time by delivering data in a more convenient form. There is a worrying tendency to replace person to person communication by a Web trawl in the search for information on data.

In the imperfect world in which we live data sets cannot be picked up off the shelf in a form where they are ready to analyse for a synthesis paper. Effort will be required to merge, intercalibrate and format the data from a small, but significant, number of sources. It is essential that this process be managed to avoid duplication of effort. The most effective way of doing this is for scientists generating synthesised data sets to keep national JGOFS data management and the IPO informed of what they are doing.

Management of Synthesised Data Sets

Considerable effort is required to build synthesised data sets, such as composites or time series, from field data. It is important that the scientific community received the maximum benefit from such enterprises. To achieve this the synthesised data sets need to be known about and made available.

It is therefore important that entries covering synthesised data sets are included in metadata catalogues so that they may be found. Authors of synthesised data sets should also be encouraged to publish their data sets. One possible mechanism for this is through short papers in research journals describing the data set accompanied by the data themselves on a CD-ROM appendix.

The importance of the availability of the appropriate synthesised data sets to JGOFS cannot be underestimated. The JGOFS SSC has taken on the mantle of managing JGOFS synthesis through the specification of the publications that will form the main deliverable of JGOFS Synthesis. There are obvious benefits to the smooth running of JGOFS Synthesis if the SSC were to take a more proactive role in the specification of synthesised data sets and the encouragement of their development. In this way, the building of the raw material of synthesis would be a managed process rather than a hope that individuals or small groups will identify and produce what is required.

Management of Model Data

The issues of managing model data needed to be addressed. Three questions were identified that need to be asked on a case by case basis when generating a plan for the management of a given set of model data.

First, should the model data be managed or junked? Many model runs are primarily focused at model testing or development. The first stage in model data management is therefore for the modelling community to reach a consensus on the subset of model data that are to be brought into the open access, long-term stewardship domain of data management.

Secondly, how are the model data to be managed? There are two obvious strategies. Either the output from a model run may be considered as the entity for management or the model source code plus input data set may be archived. This choice obviously depends upon costing the mass storage requirement for the output versus the processing requirement to repeat the model run. The archival of source code plus input data raises the issue of metadata standards. These need to be specified and enforced. Otherwise there is a real danger of wasting resource by archiving a model that nobody knows how to use.

Thirdly, should model data, particularly high volume output, be managed by recognised data management organisations or by modelling groups? The answer to this question lies to some extent in the data volumes involved and the mass storage capacity of the data management organisation. It really comes down to negotiation between the modellers and the data managers on a case by case basis. One possible scenario is for the model data to be stored on the mass storage capacity that inevitably accompanies large-scale modelling activities. Data management then looks after the metadata, helping to develop standards and to integrate pointers to the model data into field data catalogues.

When considering the management of model data it is important to remember that whilst this is new territory for the marine science community, expertise and standards could quite possibly have been developed in other communities such as meteorology. Any model data management initiatives within marine science should start by looking at how the problem is addressed elsewhere to avoid wasting effort by reinventing the wheel.

Zooplankton Data

The modellers issued a strong plea for additional zooplankton biomass data in a form where they can be used in models. In other words, broad community measurements expressed in terms of carbon and nitrogen.

The data managers agreed that they would investigate whether the data originators held any additional data that could be made available.

Timeliness of Data Delivery

The issue of timeliness of data delivery was raised. Essentially, the more time data management has available, the more complete and higher the quality of the data product delivered. However, this has to be balanced against the fact that JGOFS Synthesis is happening now and it needs data.

This is by no means an unprecedented problem in data management. Many systems such as GTSPP, WOCE sea level data management and BODC project data management operate a strategy of fast and delayed mode data delivery. The quality and completeness of the delayed mode data set is inevitably superior.

The onus is on data managers to develop a service where they deliver as much data as possible of as high a quality as possible as quickly as possible. The onus is on scientists to recognise that the more time that data managers have available to assemble data products then the higher the quality of the result.

Relational Database Technology

Within JGOFS there are two significantly different data management technologies employed. Data are either managed as 'data sets' or are integrated into relational databases. Data set management ranges in sophistication from collections of data files posted on a Web site to the US JGOFS system that adopts an object oriented approach.

The advantage of relational database technology is that relationships between data may be investigated without reference to spatial or temporal constraints. Recent requests to the BODC database have resulted in sets of HPLC pigments versus attenuance data and temperature versus nitrate data. Both of these were required by scientists investigating processing algorithms for remotely sensed data.

The extension of the parameter set covered by remotely sensed data requires the establishment of empirical 'rules' allowing parameters that are not measured directly to be expressed in terms of those that are. Relational databases provide the potential for the determination of new 'rules' through statistical analysis of interrelated data held in the database.

The disadvantage of relational database technology is that significant skilled effort is required to populate the database from data that are inevitably supplied as a series of data sets. There is the further problem in the JGOFS data management arena that the current relational systems require skilled effort (such as knowledge of native SQL) to get the data out.

The conclusion of the workshop was that provision of the facility to explore data without constraints, especially artificial constraints such as cruises, was to be encouraged. This could be achieved either through the adoption of relational database technology, ideally with a WWW front end, or through the extension of object-oriented data set management to deliver this capability.

Protocols for Data Citation

The issue of data citation protocols needs to be addressed. It is now becoming commonplace for scientific publications to be based on data from CD-ROMs or Web sites. What happens if somebody needs to replicate published work in ten years time? It is quite feasible that an advanced model may need to be tested against the same data used for a previous benchmark run. Can this data set be located?

BODC are encouraging users to cite CD-ROMs as if they were academic publications, quoting the data originator and referring to BODC as the source of the electronic publication. This is adequate for as long as BODC continues to exist. However, the CD-ROMs do not have ISBN references and are therefore unknown to international library cataloguing.

Web sites present a more difficult problem because they are more volatile. At the very least, URLs may change and aliases get lost with time. At the very worst, Web sites can disappear.

Data management should therefore consider how this issue should be addressed. One possibility is to encourage the publication of Web sites on CD-ROM. All CD-ROM publications could then be lodged at an internationally recognised

repository such as the Library of Congress. Registration of CD-ROM products on internationally recognised metadata catalogues, such as GCMD, provides another potential mechanism providing these catalogues attain the same level of credence as libraries with the academic community.

Appendix A

JGOFS DATA MANAGEMENT AND SYNTHESIS WORKSHOP

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Appendix B

JGOFS DATA MANAGEMENT AND SYNTHESIS WORKSHOP
AGENDA

September 24th

Introduction **09:00 - 09:30**

Welcome and Domestic announcements **JGOFS IPO**
Workshop outline and objectives **Lowry**

Session 1 **09:30 - 11:00**

Data available through JGOFS data management

US JGOFS Data Management Office **Hammond**
German JGOFS Data Management **Mitzka**
British Oceanographic Data Centre **Lowry**
French JGOFS Data Management **Labaied**

Coffee **11:00 - 11:30**

Session 2 **11:30 - 13:00**

Data available through JGOFS data management

Japan Oceanographic Data Center **Miyake**
MEDS, Canada **Glenn**
Indian NODC **Sarupria**

Discussion session

Identification and cataloguing of other data sources relevant to JGOFS synthesis.

Lunch **13:00 - 14:00**

Session 3 **14:00 - 15:30**

Remote Sensing

Trevor Platt Data requirements to improve the benefits from Ocean-colour images.

Discussion session
Suggested Topics: The kinds of in-situ data required by the remote sensing community; Data organisation requirements; Challenges offered to the data management community and how these might be addressed.

Tea **15:30 - 16:00**

Session 4 **16:00 - 17:30**

Roger Hanson JGOFS synthesis and modelling plans
Robert DeConto US JGOFS synthesis and modelling project (SMP)
Truls Johannessen Flux of anthropogenic carbon in the Greenland Sea

Workshop Dinner **20:00**

September 25th

Session 1 **9:30 - 11:00**

North Atlantic

R. Lowry (for Fasham) Plans of the North Atlantic Synthesis and Modelling group and anticipated data management requirements.

Equatorial Pacific

Robert Le Borgne Spatial and temporal variability at the equator in the Pacific ocean: results from equatorial Pacific JGOFS cruises.

Arabian Sea

Iris Kriest German JGOFS synthesis and modelling for the Arabian Sea.

Coffee **11:00 - 11:30**

Session 2 **11:30 - 12:30**

Southern Ocean

Brian Griffith Australian Southern Ocean JGOFS: Data, synthesis and modelling.

Discussion session

*Suggested Topics***:** Does regional synthesis have any data supply crises? Is the management of regional synthesis outputs being addressed? Management of JGOFS composite data sets.

Lunch **12:30 - 14:00**

Session 3 **14:00 - 15:30**

Further Perspectives

Nicolas Metzl Synthesis and modelling in France.

Eileen Hofmann Data, Modelling and Synthesis Needs for Southern Ocean GLOBEC and Relationships to SO JGOFS**.**

Session 4 **16:00 - 18:00**

A Challenge and our Conclusions

Geoff Evans What an ideal NABE data product would look like and what I would do with it.

Discussion Session

Suggested topics: Is there anything more JGOFS data management can do? Roles of data managers and scientists in synthesis; Mechanisms for exchange of data between JGOFS and other IGBP programmes

Conclusions and Recommendations for Action

Roy Lowry Conclusions from the data management perspective
Trevor Platt Conclusions from the JGOFS synthesis perspective.

Close

Appendix C

STATUS OF THE FRENCH JGOFS DATABASE
as of September 1998

operation	campains	date	P=paper/books I=computer	P= public A=archive	%
ANTARES	ANTARES				
	ANTARES1	May 1993	I	P	80
	ANTARES2	February 1994	I	A	80
	ANTARES3	November 1995	I	A	95
	sediment traps				/
DYFAMED	DYFAMED				
Temporal series					
"core parameters"	water column: PAPADOC	1991 - 1997	I	P + A	90
	sediment traps	*1986 - 1995*			/
others	sediments : DYF-BENTHOS	1991 - 1997			90
Processus campains	DYF-BACTERIES	July 91 - may 96			90
	MIGZOO	May 90 - sept. 92	I	P	45
Multi-disciplinary campain	DYNAPROC	May 1995	I	P + A	80
ECOMARGE	ECOMARGE			ECOMARGE	
	ECOMARGE1	Aug. - sept. 1986	I	P	only CTD
	ECOMARGE2	Nov. - dec. 1986	I	P	only CTD
	ECOMARGE3	Jan. 1988	I	P	only CTD
	ECOMARGE4	May 1988	I	P	only CTD
	sediment traps				/
EPOPE	EPOPE			EPOPE	
	FLUPAC	Sept. - oct. 1994	I	P + A	95
	OLIPAC	Nov. 1994	I	P	80
EUMELI	EUMELI			EUMELI	
	EUMELI2	Jan. - feb. 1991	I	P	only CTD
	EUMELI3	Sept. - oct. 1991	I	P	95
	EUMELI4	May - june 1992	I	P	95
	EUMELI5	Dec. 1992	I	P + A	99
	sediment traps				/
FRONTAL	FRONTAL			FRONTAL	
	PREPOT	1988			0
	AZOMIX	1988			0
	PANACHE	1988	P	P	99
	TOMOFRONT 1-3	1988 - 1990	I	A	90
	ALMOFRONT1	1991 - 1992	I + P	P + A	90
	sediment traps				/
	ALMOFRONT2	1997-1998		ended on Feb. 1998	
KERFIX	KERFIX			KERFIX	
	KERFIX	1990 - 1995	I	A	85
	sediment traps				/
MEDATLANTE	MEDATLANTE			MEDATLANTE	
	MEDATLANTE1	Jan. 1989	P	P	CTD
	MEDATLANTE2	Aug. 1989	P	P	CTD

sediment traps They are mentionned, because it 's important to know. But at the moment they are not available in %.

Appendix D

THE JGOFS India PROGRAMME

JGOFS (India) SAGAR KANYA Cruises Summary

Sl. No.	Org. Cr. No.	No. of Stns.	Survey Period From To	Lat. Range (Deg. N)	Long. Range (Deg. E)	Sonic depth (m)	Parameters observed
1.	SK-77	27	21.09.92 - 07.10.92	2.995° - 15.372° N	65.0° - 77.73° E	140 - 4500	phy, bio, mbio
2.	SK-87	20	11.09.93 - 21.09.93	15.488° - 21.015° N	66.02° - 73.000° E	100 - 3760	phy, chem, bio, mbio
3.	SK-91	31	12.04.94 - 12.05.94	11.000° - 22.000° N	64.000° - 74.000° E	100 - 4340	phy, chem, bio, met, mbio, geo
4.	SK-99	54	03.02.95 - 04.05.95	10.000° - 21.672° N	64.840° - 75.603° E	185 - 4550	phy, chem, bio, mbio, met, geo
5.	SK-104	58	20.07.95 - 12.08.95	9.990° - 18.700° N	63.998° - 75.610° E	200 - 4000	phy, chem, bio, mbio, met
6.	SK-115	9	02.08.96 - 22.08.96	13.000° - 21.000° N	64.000° - 75.000° E	200 - 4000	phy, chem, bio, mbio, met, geo
7.	SK-121	50	06.02.97 - 25.02.97	16.761° N - 21.279° N	63.00° E - 71.943° E	660 - 3400	phy, chem, bio, mbio, met, geo

Parameter list

Biological
- Primary production (14C and oxygen based)
- Phytoplankton abundance
- POC, DOC, PON
- Zooplankton
- Microzooplankton
- Bacteria

Chemical
- Nutrients (NO2, NO3, PO4, SiO3)
- Oxygen
- TCO2
- Trace gasses (N20 & CH4)
- pH
- Alkalinity
- Radionucleids

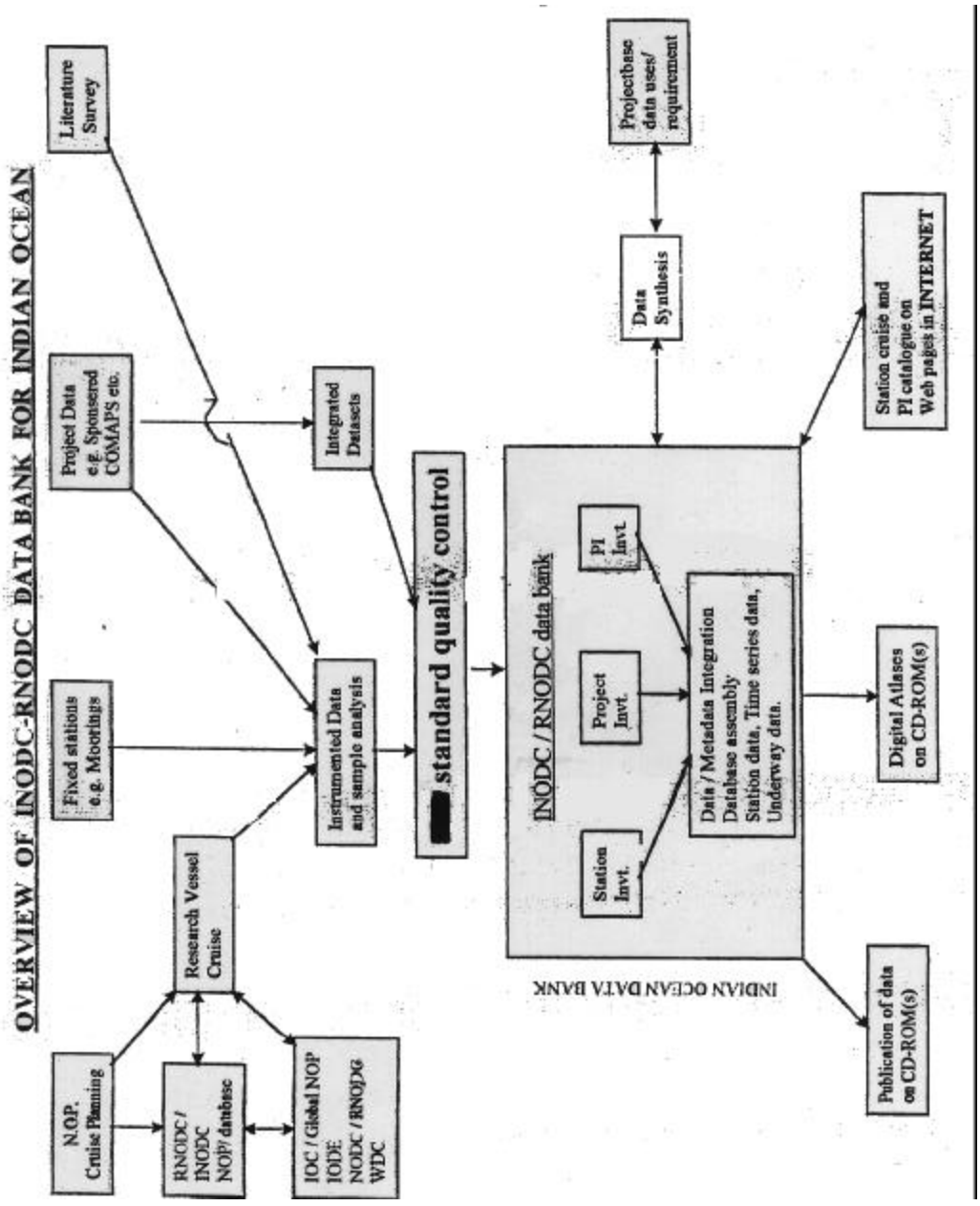
Physical
- Temperature, salinity

Meteorology
- SST
- Air temperature
- Wind speed and direction
- Humidity (dry and wet bulb)
- Atmospheric pressure

Geology
- Sediment trap samples
- Core Samples
- Calcium carbonate
- Organic carbon
- Stable oxygen
- Carbon isotopes

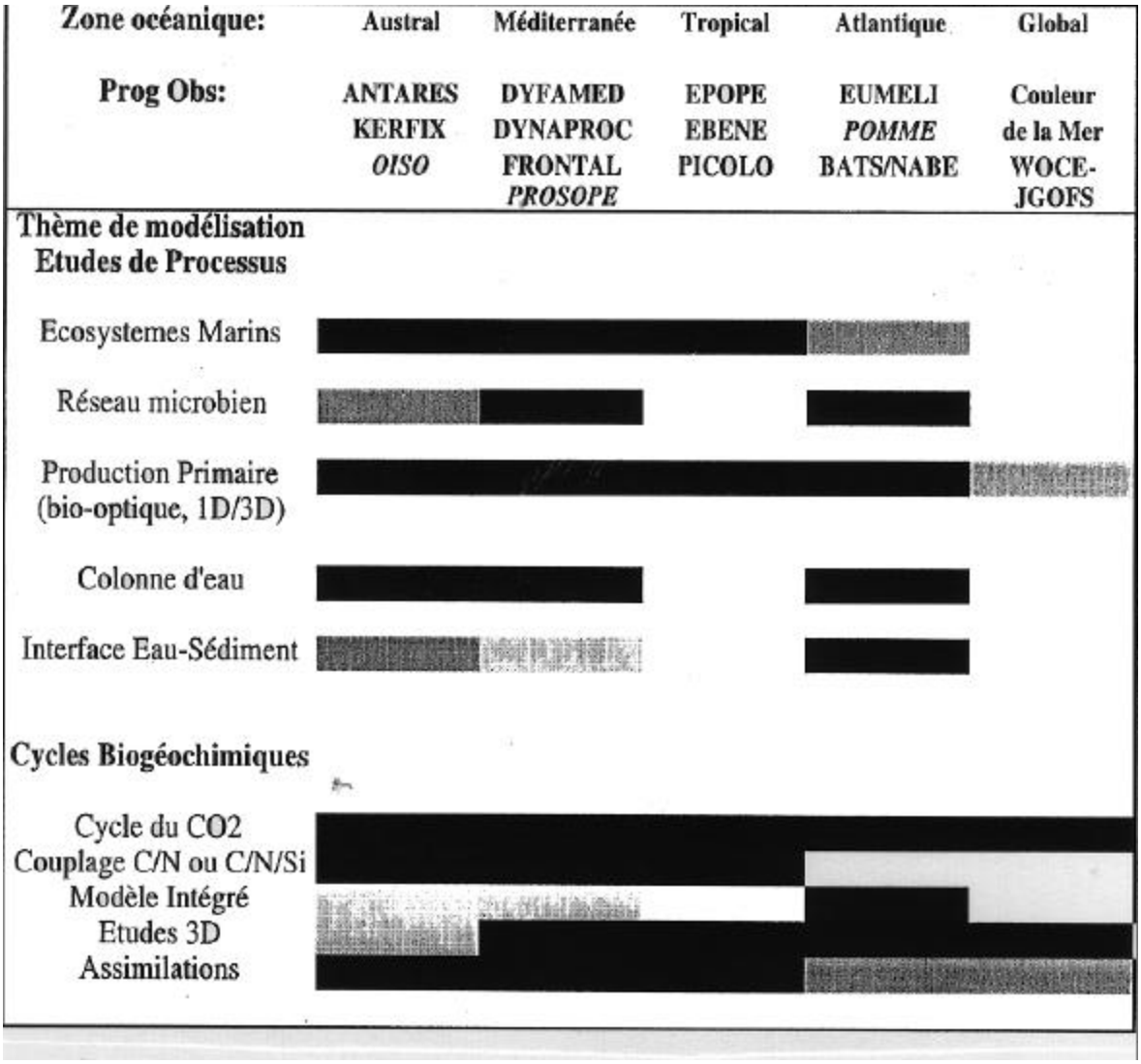
APPENDIX D (cont.)

OVERVIEW OF INODC-RNODC DATA BANK FOR INDIAN OCEAN



Appendix E

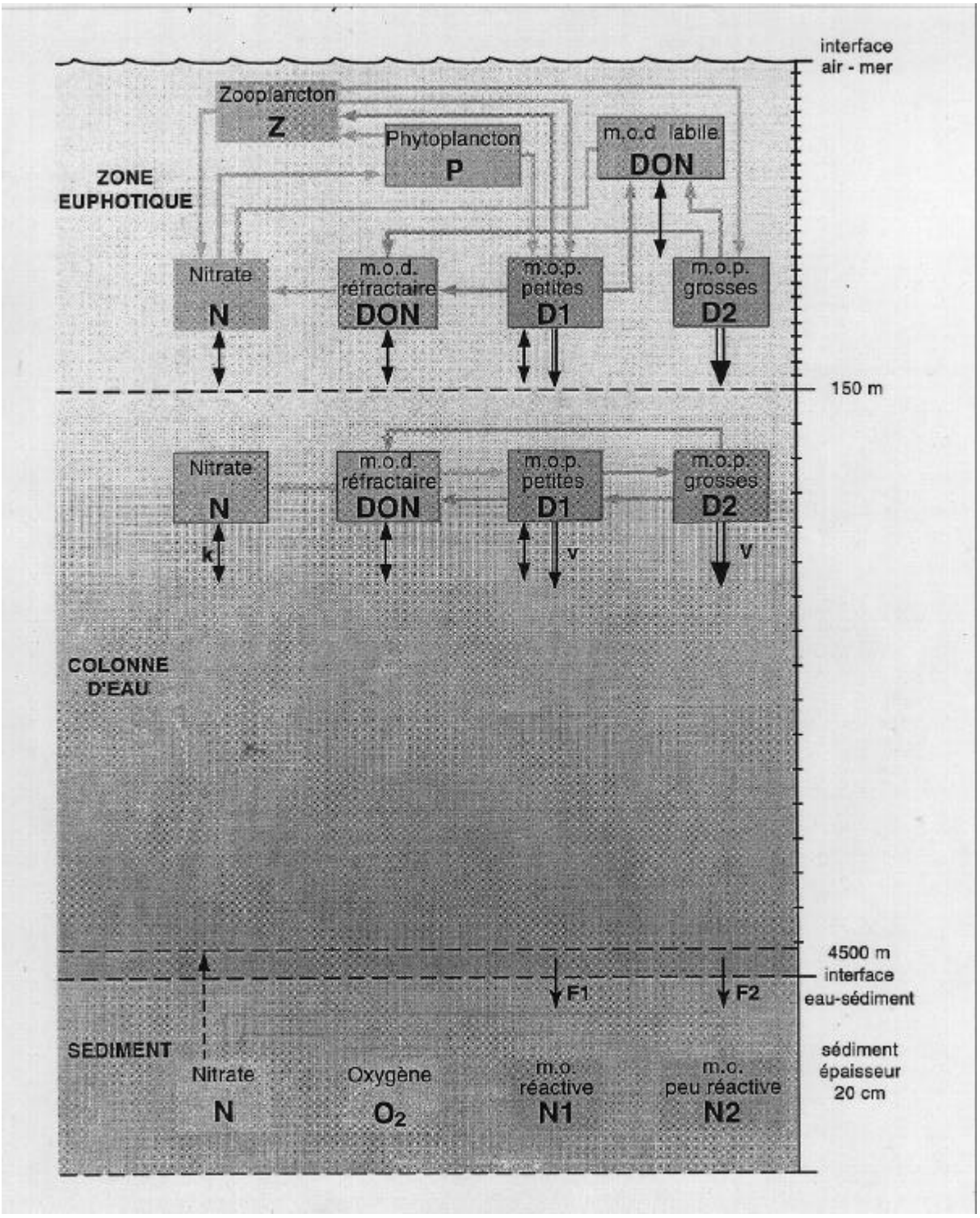
MODELLING ACTIVITIES OF JGOFS-France



1998 future work not determined

APPENDIX E (cont.)

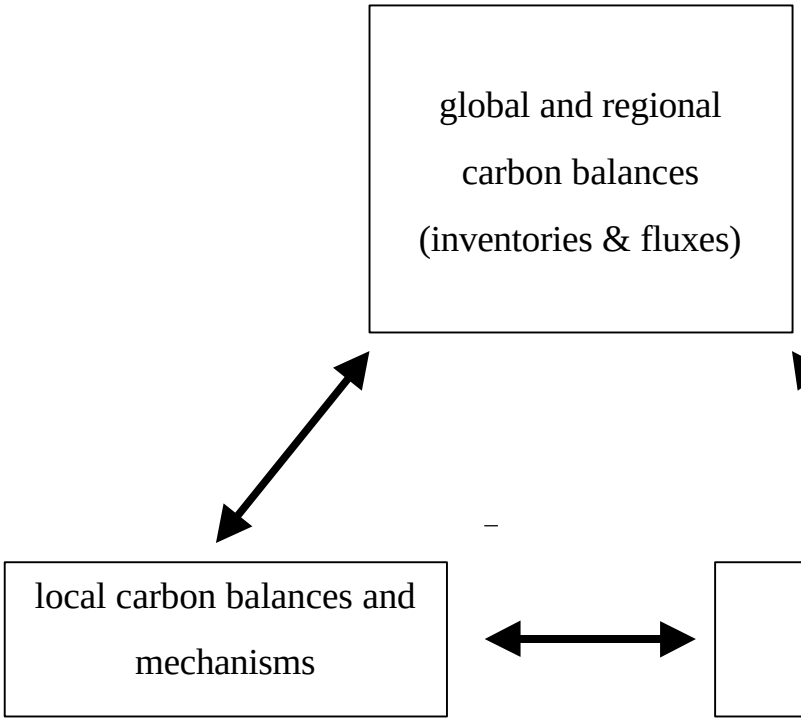
JGOFS-France
INTEGRAL MODEL



Appendix F

US JGOFS SYNTHESIS AND MODELLING PROJECT (SMP)

Conceptual organization of SMP elements



Mass balances provide the fundamental constraint on our understanding the carbon cycle

-DIC, anthropogenic carbon - mass balance and fluxes

-extrapolation of existing JGOFS data to global scales

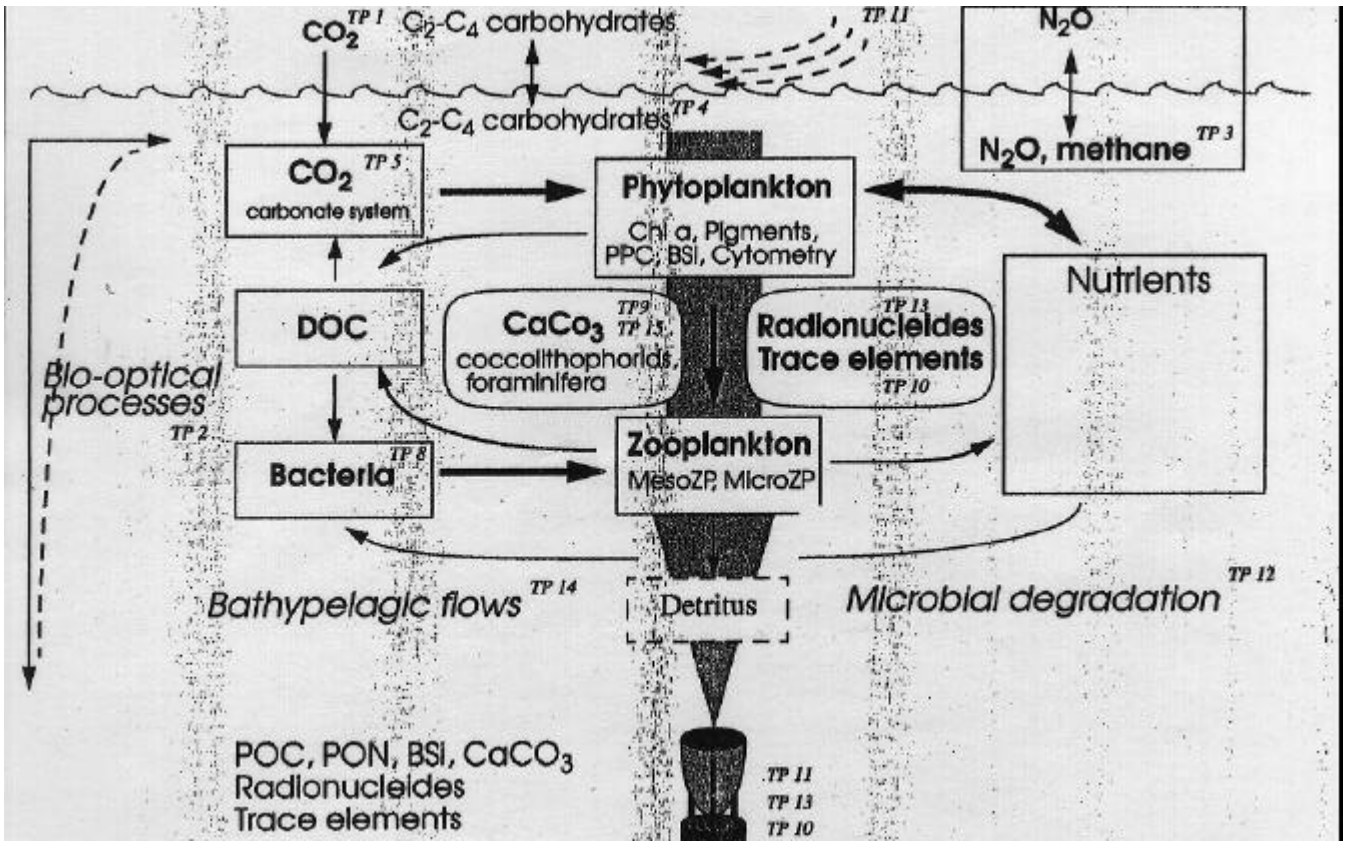
synthesis of regional scale data aimed at parameterization of larger scale processes to be included in global models

extrapolation of knowledge from field studies to larger spatial and temporal scales to predict physical and biogeochemical response of oceans to climate change models

Appendix G

GERMAN SYNTHESIS AND MODELLING FOR THE ARABIAN SEA

Conceptual model



Appendix H

AUSTRALIAN JGOFS

Ausgofs Major Participants

Research Group	Measurements
CSIRO Division of Marine Research	oceanic fCO2, DIC, Alkalinity, ^{13}C, ^{14}C, primary productivity, carbon cycle modelling, pigments, sediment fluxes
Antarctic Co-operative Research Centre	DOC, POC, ^{13}C and ^{15}N in POM, sediment fluxes, trace metals
Australian Antarctic Division	phytoplankton species composition, pigments
CSIRO Division of Atmospheric Research	atmospheric CO_2 and ^{13}C
James Cook University	DMS

CSIRO MARINE RESEARCH

Southern Ocean: survey cruises

- WOCE line SR 3 between 44S-66S, along 147E to 140E sampled on 4 biology, 3 DIC and 5 fCO2 repeats.
- WOCE line P11 (44-66S, 155E)
- WOCE line S 4: 62S, along 62S- 65S between 112E-160E
- Surface fCO2 measurements between Australia and Macquarie Island, and Mawson, Davis and Casey stations on the Antarctic mainland.

CSIRO MARINE RESEARCH

Southern Ocean: process cruises

- January and November 1995
  - along 140E between 40S-53S
  - November 1995 associated with Aerosol Characterisation Experiment (ACE-1).
  - Physical oceanography, primary production, surface-tethered sediment trap
- SAZ cruise (March 1998)
  - examined controls on primary production and fluxes, seasonal CO_2 drawdown.

CSIRO MARINE RESEARCH

Individual PI data: CO_2, NH_4, DMS

Measurement	*P-I responsible*	*Cruises*
fCO_2, DIC, alkalinity	Tilbrook	Most
Ammonia	Watson	SS1/95, SS11/95 SAZ
DMS	Curran (AntCRC) Jones (JCU) DiTullio (UC)	WOCE SS1/95, SS11/95 SAZ

CSIRO MARINE RESEARCH

Individual PI data: POC, DOC, ^{13}C, ^{15}N

Measurement	*PI responsible*	*Cruises*
POC	Clementson Trull (Ant CRC)	SS1/95, SS11/95
DOC	Trull (Ant CRC)	SS1/95, SS11/95, SAZ
^{13}C and ^{15}N	Trull (Ant CRC)	SAZ

CSIRO MARINE RESEARCH

Individual PI data: Sediment traps

Trap Type	*PI responsible*	*Dates in water*
Moored Honjo	Clementson	Nov 92-April 93
Moored Honjo	Trull (AntCRC)	Sept 97-March 98 March 98-Feb 99
Surface tethered	Clementson	Nov 92, and April 93 Jan 95
Surface tethered	Trull (AntCRC	Nov 95 March 98

CSIRO MARINE RESEARCH

Individual PI data: "Biology"

Measurement	*PI responsible*	*Cruises*
HPLC chl a and pigments	Clementson Wright (AAD)	S1/95, SS11/95 WOCE, SAZ
Optics/spectral absorbance	Parslow and Clementson	S1/95, SS11/95, SAZ
Phytoplankton species	Wright (AAD) Marchant (AAD)	WOCE, SAZ
Production (P-I)	Griffiths	All
Microzooplankton biomass, grazing	Griffiths	SS11/95, SAZ

CSIRO MARINE RESEARCH

Data synthesis: WOCE cruises

Lead Author	*Title*
Rintoul	Physical Oceanography and transport in the ACC
Tilbrook	Seasonal and interannual variation in carbon parameters (fCO2, DIC, alkalinity)
Popp	Controls on carbon isotopic composition of Southern Ocean Phytoplankton
Rintoul/Griffiths	Surface water masses and nutrients along the WOCE SR 3 line
Griffiths	Primary production along SR 3, P 11 and S 4
Wright	Chlorophyll-a, pigments, and phytoplankton species along SR 3, P 11 and S 4
Curran	DMS and DMSP in the Southern Ocean

CSIRO MARINE RESEARCH

Data synthesis: 40S-53S, 140E

Lead Author	*Title*
Jones	DMS during ACE-1
Griffiths	Physical, chemical, biological oceanography during ACE-1
Greene	Variations in phytoplankton biomass and species composition during ACE-1
Parslow	Optics, chlorophylls and pigments west of Tasmania
Sedwick	Iron and Manganese in the Subantarctic

CSIRO MARINE RESEARCH

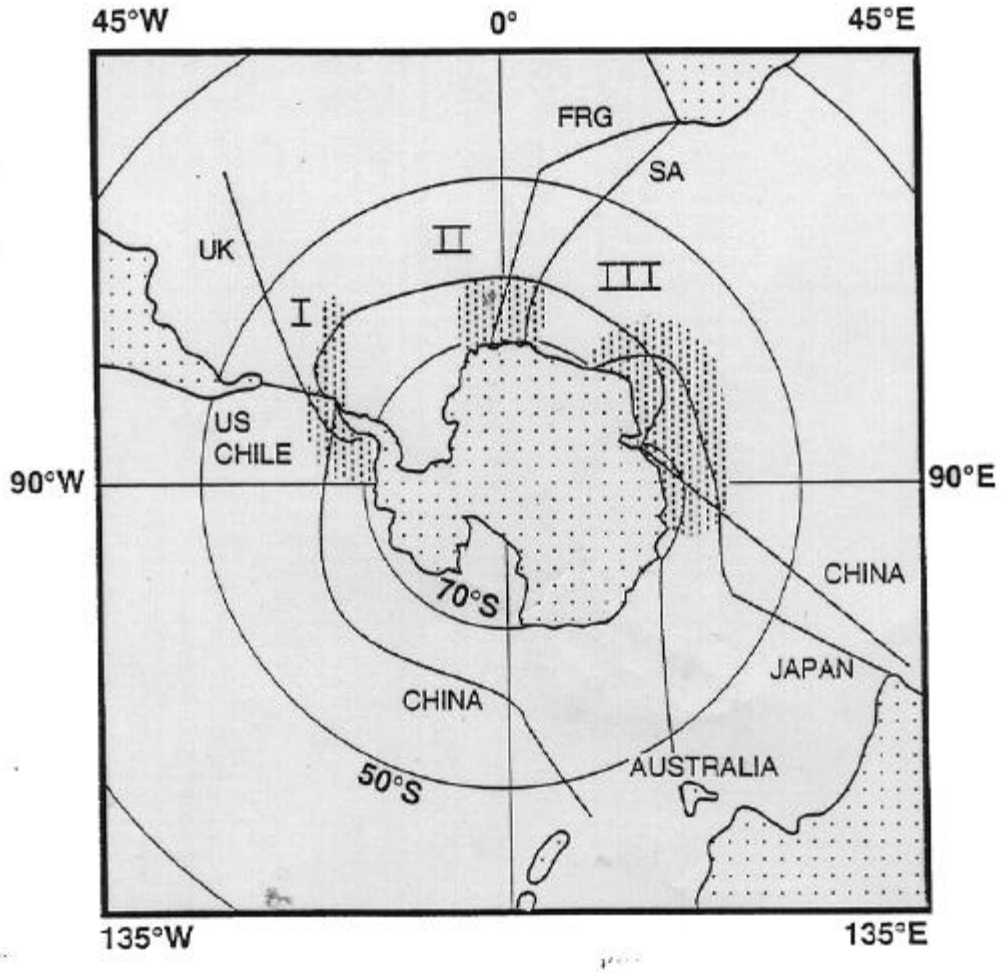
Data synthesis: SAZ cruise

Lead Author	*Title*
Boyd	Iron/light interactions and effects on phytoplankton growth rates
Sedwick	Iron/nitrate, and iron/silicate co-limitation of phytoplankton growth rates
Parslow	Optics and spectral absorbance
Wright	Chlorophyll and pigments
Griffiths	Primary production and microzooplankton grazing
Tilbrook	fCO_2, DIC and alkalinity
Trull	Descriptive oceanography
Trull	Carbon fluxes from surface-tethered, and moored sediment traps

CSIRO MARINE RESEARCH

Appendix I

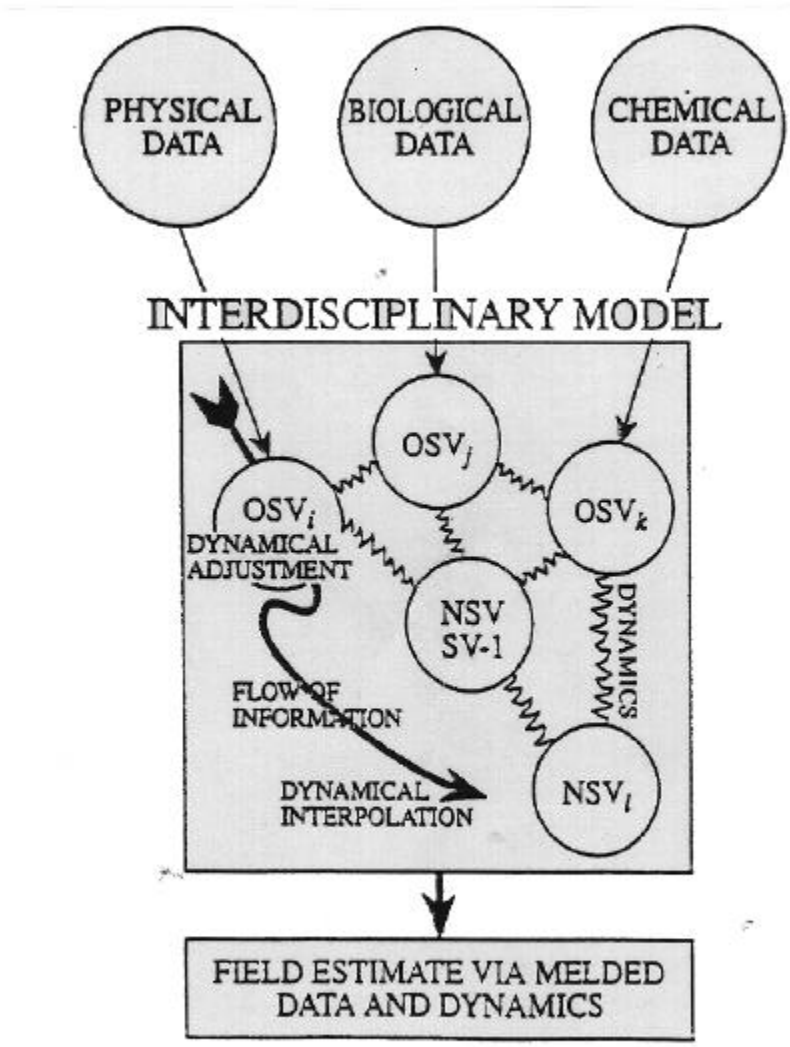
STUDY REGIONS FOR THE SO-GLOBEC FIELD STUDIES



Study regions for SO-GLOBEC field studies
I.) Antarctic Peninsula region
II.) Eastern Weddell Sea
III.) Indian Ocean sector.
Standard transit routes are shown for respective nations.

APPENDIX I (cont.)

DATA ASSIMILATION



OSV: Observed State Variable
NSV: Not observed State Variable

APPENDIX I (cont.)

GLOBEC's NESTED BIO-PHYSICAL SAMPLING PLAN