34 Minutes—27 February - 1 March 2001

U.S. JGOFS Scientific Steering Committee Meeting
Hotel Santa Barbara, Santa Barbara, CA

Attendees

SSC members: M. Abbott (chairman), R. Anderson, W. Berelson, M.E. Carr, S. Doney, H. Ducklow, E. Hofmann, G. Jackson, K. Johnson, C. Lee, M. Lewis, D. McGillicuddy, A. Michaels, J. Sarmiento, D. Siegel, S. Smith, W. Smith, R. Wanninkhof, J. Yoder

Time-series Programs: N. Bates, A. Knap, M. Lomas, BATS; J. Dore, D. Karl, HOT

Planning Office: M. Bowles, K. Buesseler, C. Chandler, D. Glover

National Science Foundation: Don Rice

National Oceanic and Atmospheric Administration: Lisa Dilling

National Aeronautics and Space Administration: John Marra

Guests: Craig Carlson, U.C. Santa Barbara; Tommy Dickey, U.C. Santa Barbara; Steve Hankin, Pacific Marine Environmental Laboratory (PMEL); Joanie Kleypas, National Center for Atmospheric Research

34.1 Introduction

Chairman Mark Abbott welcomed members of the U.S. JGOFS Scientific Steering Committee (SSC), agency representatives and guests and announced that the meeting would focus primarily on three topics, the future of ocean carbon cycle science, the Synthesis and Modeling Project (SMP) and data management matters. Executive scientist Ken Buesseler called for comments and corrections to the minutes of the previous SSC meeting and reminded participants to provide paper copies of overheads presented during the meeting.

34.2 Synthesis and Modeling Project

Scott Doney brought those attending up to date on the progress of the SMP. The list of NSF recommendations for FY 2001 grants is almost complete. Scott noted that some community activities, such as regional testbeds, are finally getting funded. He reviewed the announcement of opportunity for the latest round and showed that the newly recommended grants do indeed fit most of the recommended areas. The exceptions are trace-metal cycling, carbonate and silicate production, transportation and remineralization, mid- to deep-water particle flux, and applications of remote sensing data to the carbon cycle. NSF will be seeking advice for the FY 2002 announcement of opportunity, which will have an August deadline. This round, the last for the SMP, is expected to fund only four proposals.

Next Scott presented a summary of currently funded SMP proposals and ones that have been completed. Some 111 scientists have been funded to carry out 59 projects so far. In response to a question about the largest remaining holes in the overall SMP fabric, Scott pointed to the problem of moving up to the global scale. The global modelers are playing catch-up as they incorporate results coming out of regional syntheses. He emphasized that information about each of the SMP projects and much of the data are available via the project's web site. Proposers can look at the same figures that the SSC is seeing, he noted.

Upcoming SMP workshops include one on marine calcification, to be held in June in Woods Hole, in addition to the summer principal investigators' meeting. Also listed is an international WOCE/JGOFS ocean CO2 transport workshop, to be held in Southampton in June. An iron workshop is planned for the fall and a midwater processes workshop for the spring. Summer PI meetings will be held in 2002, 2003 and 2004, and one or two regional testbed workshops may take place over the next three years. Tony Michaels noted with approval that the workshops are largely about areas that were not much covered in JGOFS. The aim of these workshops is to get people and ideas together to write a proposal, Scott pointed out.

Considerable discussion ensued about the lack of funding for coastal margins research, the need to rescue data from DOE-supported projects that are at risk of being lost and the difficulties of including the coastal margins in global models. Hugh Ducklow pointed out that a joint JGOFS/LOICZ (Land-Ocean Interactions in the Coastal Zone) project is undertaking a global synthesis of coastal margins. Dennis McGillicuddy observed that coastal ocean observatories are springing up all over with little input from scientists interested in carbon cycling; he urged involvement.

Scott asked about including SMP investigators whose funding has ended in future summer meetings. Funds have been available so far for co-PIs and students. Eileen Hofmann noted the value of keeping the SMP group and its fruitful discussions going after the project ends. Don Rice indicated that funding would be available for ongoing interactions such as Gordon Conferences that would provide venues for continued SMP discussion.

The first SMP special issue of *Deep-Sea Research II* is in the works. All the articles submitted are out for review, and some are already back. Scott hopes to send the articles off to the editor in March. Turning to SMP management issues, he noted that Steve Hankin of PMEL and Chris Sabine of PMEL and the University of Washington have joined Scott himself and Joanie Kleypas in the next SMP management grant proposal. They will be handling the more technical aspects of data display, retrieval and storage. SMP management is coordinated with the U.S. JGOFS Data Management Office in Woods Hole as well as with Chris and Steve.

In his SMP data update, Scott pointed out that the project's web page filled the minimum access requirement, making it possible for interested parties to get access to and download data. The SMP live access server now offers centralized access to any data set, subsetting and reformatting capabilities and graphical display. The efforts at PMEL and the University of Washington will provide enhanced access with metadata searching capabilities, data fusion that allows comparison of gridded with in-situ data, improved graphics and file generation, and improved user interface and internal data structure. SMP

includes some non-JGOFS data sets in its database and provides links to a number of others.

SMP community activities include a technical report by Joanie and Scott that represents a compilation of data collected at nine JGOFS sites and preparation of Dave Halpern's satellite climatology of the surface ocean. Also suggested are a synthesis book, summer workshops for students and postdocs, expanded web pages for public use, and popular articles in general science publications. Making sure that data are archived properly will be a major community responsibility, as will the development of a community biogeochemistry model.

34.3 Ocean Observatory Initiative

Ken Johnson reported on the NSF Major Research Equipment (MRE) Ocean Observatory Initiative. He is chairman of the newly formed steering committee for this initiative, which proposes an MRE program for a global mooring array, a plate-scaled cabled observatory and coastal observatories. The committee met recently to plan a workshop or conference on the broad questions that require such an observatory network. Charges to the committee include leading scientific planning for a basic research program that emphasizes sustained time-series observations and interactive experiments in the ocean, facilitating definition of technical requirements and standards, addressing management issues, obtaining community support, exploring educational opportunities and developing links to international ocean observatory programs.

Although the initiative is included in the Presidential budget, funding is pending Congressional approval. In response to questions about hardware versus science support, Don Rice said that NSF has recognized the need for programs of this sort and that an effort was underway to make sure that there is new money for this initiative rather than allowing it to be in competition for existing funds.

34.4 Science Minute: Response of Ocean Biology to Future Climate Change

Jorge Sarmiento made a presentation on a new effort, involving six models from institutions in the U.S., Australia, the U.K., France and Germany, to assess the impact of global warming on ocean biological processes per se. Project participants looked at simulated changes in physical processes and properties, such as upwelling, mixed-layer depth, vertical density gradient and length of growing season, that have a direct effect on biological processes in the ocean. He showed results from a series of comparisons, pointing out where model output varied and where it did not. A focus of the project was on assessing the relative stability of physical features correlated with productivity in different regions.

In conclusion, Jorge noted that global warming simulations show increased stratification almost everywhere, accompanied by expansion of the permanently stratified subtropical ocean “desert”. He also noted that his empirical model of chlorophyll, developed as part of this project, shows a wide range of results in lower latitudes with a strong tendency toward higher chlorophyll in high latitudes.

34.5 Data Management

David Glover, who has recently taken over the scientific direction of the U.S. JGOFS Data Management Office, opened the presentation on data management with a discussion of support for the SMP. SMP data products need to be in a format compatible with the JGOFS live access server (LAS), he said. Gridded data will be in netCDF format, and SMP investigators will receive netCDF format instructions. DMO staff members and colleagues at the University of Washington and NOAA PMEL are working on access to non-gridded data via the JGOFS LAS. They will also provide formatting and debugging support.

The sequence of DMO activities begins with reception and quality control of field data and the establishment of robust data objects, Dave said. DMO staff develop code for merging data objects and create the merged objects. The DMO plans a beta release of merged objects in June. The office is also responsible for final product production and archiving of data.

Merged objects comprise all the measurements made with a given method on a given cruise; they include both CTD and bottle data. The next step is to merge such data for a set of cruises within a particular ocean basin. Merging is accomplished with "pointer files" that Dave creates and DMO programmer and system manager Cyndy Chandler runs through the merge process. Merged data must have the same collector, event and bottle number, and variable name and method. An audit file keeps track of mismatched attributes. The system is not currently handling duplicate samples. It is simply taking the first and dropping the second.

Next Cyndy gave a demonstration of the new interface for merged data products and showed basin-level data objects from the Arabian Sea and Southern Ocean. Data can be selected by coordinates, event numbers and more than 100 separate parameters, she said.

Hugh Ducklow asked what was different from two years ago. Cyndy noted that access is a lot faster and that she has created a lot of objects. Data users do not have to do most data merges themselves. Dave Schneider and George Heimerdinger continue to carry out quality-control checks on all parameters for the DMO. The DMO team asked SSC members to tell them what merged data products they want, what their priorities are, and what problems are most important to solve.

Steve Hankin from NOAA PMEL introduced those present to the JGOFS LAS. The DMO works on data and data management, he said, and he and his colleagues work on access. The focus so far has been on gridded data sets. The LAS is a web interface that gives transparent access to geographically referenced data sets. It is highly configurable, it can handle distributed data and variables derived on the fly, and it has data fusion capabilities. The server is in Seattle with remote access to Woods Hole. The networking framework is the Distributed Ocean Data System (DODS).

Steve showed a variety of viewing options and figures that illustrated different ways of visualizing data, including "blotch" and "waterfall" plots. Discussion ensued about how much gridding is allowable and whether data from the time-series programs could be incorporated into this system. Steve said that data in certain forms (netCDF files??) could be pulled into the system. He concluded by reminding his audience that the JGOFS LAS is a system for providing access and quick preview and that it should not be confused with an analysis and visualization system.

In answer to a question about levels of merging, Dave Glover noted that what is in the merged products is what was in the pointer files. For example, primary production numbers, which are derived from calculations, are not included. Tony argued for some means of getting at all the data collected at a given site, including "fringe" data sets that are not part of the core measurements. These do not necessarily need to be included in merged products, he said.

In response to requests for feedback from the data management team, SSC members noted two main concerns. One is the problem of units and conversions among them. The other is the question of consistency in the use of names for variables. Each name must be unique and consistently used for the same thing. Mark asked the heads of the U.S. JGOFS process studies to work with Dave and Cyndy before the beta release of merged products takes place in June.

At the end of the presentation, Dave raised the question of a final data product. He envisions a one-time release of a CD-ROM or similar item that is durable and contains data in common format from all the process studies, merged products from these data, SMP products, and time-series data and data systems. The long-term archive of U.S. JGOFS data will be located at the NOAA National Oceanographic Data Center (NODC).

Lisa Dilling asked about the CO_2 data set amassed during the global survey of CO_2 in the ocean. Raw CO_2 survey data will be included on World Ocean Circulation Experiment (WOCE) CD-ROMs, as will adjusted data sets?? Scott Doney suggested that JGOFS not take on the task of providing access to all the hydrographic data from the CO_2 survey as all such data are available via the WOCE data system.

In conclusion, Mark urged the SSC to recognize Christine Hammond for her years of service as manager of the U.S. JGOFS DMO. He asked Ken, Dave and Mary Zawoysky to come up with a suitable present for her.

34.6 NSF: Future of Ocean Carbon Cycle Research

Don Rice began his NSF report with the list of new SMP grantees proposed, cautioning that one more award is pending and that the list is not yet official. NSF received 23 research proposals in addition to the U.S. JGOFS Planning Office renewal proposal; nine of the 23 were funded. Funding for the office has been renewed through 2004.

Don turned next to the future of ocean carbon-cycle research from the NSF perspective. He reviewed previous planning efforts and noted that the GEOSCIENCES directorate of NSF is very much interested in carbon cycling in relation to atmospheric chemistry and climate dynamics. He also noted a tremendous interest across NSF divisions in linking up with the Climate Variability and Prediction Programme (CLIVAR). We are working on what the ocean component of the Geosciences effort is going to look like, he said.

The ocean sciences division has called together a group of scientists to form an Ocean Carbon Cycle Research Program (OCCRP) steering committee responsible for formulating a research vision in three areas:

- systematic investigations, including process studies and experiments
- exploratory investigations in pursuit of new, high-risk ideas
- observational investigations, including regional and global surveys and time-series studies

The committee is charged with providing advice and assisting planning at OCE regarding focus areas, program components and levels of coordination, the balance and timing of projects in OCCRP portfolio, and interactions with carbon-cycle science programs outside NSF. It will not be asked to do detailed design work on any particular program.

The members of this committee will be expected to be familiar with the Carbon Cycle Science Plan (CCSP), the NRC report on major ocean programs, the EDOCC and OCTET reports and the WOCE hydrography report, Don said. He listed the initial set of committee members (see U.S. JGOFS News, 11,2, p. 11) and noted that they would be asked to suggest others and to select their own chairman. The committee will hold its first meeting in April.

Cindy Lee, a member of the OCCRP steering committee, expressed concern that the committee does not take proper advantage of JGOFS expertise. She added that the biggest gap is in expertise in carbon measurements. Hugh expressed concern about the lack of direct links to the CCSP committee, the interagency steering committee and the IGBP. Lisa asked whether NSF would steer the group toward links with these entities; Don said yes.

At NSF, carbon cycle research falls into one of three budgetary and philosophical components, Don continued. These are the Global Change Research Program (GCRP), core programs and biocomplexity, a relatively new initiative. The OCCRP committee has to look at all three of these. Ken asked about funding commitment; Don said that some funds have been advanced from core and from biocomplexity.

Hugh pointed out that the international Surface Ocean - Lower Atmosphere Study (SOLAS) has been accepted by IGBP and SCOR and is getting underway. How will OCCRP interact with SOLAS? Others noted that SOLAS was not focused exclusively on carbon and that NOAA, NASA and NSF are funding individual scientists to participate in a US SOLAS workshop this spring. A question raised was whether SOLAS will become *de facto* the next ocean carbon program in the U.S. as it is likely to in a number of other countries.

Cindy observed that the process underway could lead to good opportunities for individual-level research or for biocomplexity research but not for planning and implementing large, complicated programs. The committee does not have equal representation of those who favor large programs and those who do not. She added that the planning process was protected during the early years of U.S. JGOFS and that this committee is not going to be planning studies. Bob Anderson commented on the costs to careers of planning process studies and argued that the cost is too high if the work goes to waste.

Lots of work has already taken place, Don said, pointing to OCTET, EDOCC and SOLAS, and the committee needs to deliberate on these things first. Jim Yoder said that NSF could request planning proposals based on the committee's recommendations on priorities. Mark suggested that SSC members think about the planning underway for future carbon-cycle research and give advice to members of the committee.

34.7 NASA Update and Carbon Cycle Initiative

John Marra began his agency report by noting that the NASA Carbon Cycle Initiative strategic implementation plan was now available on the web. Current activities of the NASA program in biology include SIMBIOS, which comprises 12 international projects. NASA will issue an ocean research announcement (NRA) in May that requests proposals by July for projects starting in January 2002. Plans are underway to develop an ocean color research team that will cross traditional boundaries and focus on issues rather than instruments. Organization of an ARGO bio-optics consortium took place at the most recent ASLO meeting. And the requested SeaWiFS extension is on track, John reported, with a good chance of getting the "data buy" extended.

Turning to the NASA Carbon Cycle Initiative, John said that Chuck McClain is heading up the effort and that Gene Feldman has taken over the SeaWiFS project. The first workshop was held in January, and others are scheduled for March and May. Recommendations from the first workshop include quantifying carbon sinks through studies of global air-sea fluxes, spatial distribution on seasonal and interannual time-scales and remote sensing. Nine study teams will be working on developing the implementation plan for the initiative, taking responsibility for issues such as calibration and validation, technology development, models and data assimilation, process studies and so forth.

John reported that MODIS data are now available. Data products include coccolith images, calcite, mixed-layer depths, sea-surface temperatures and chlorophyll and other pigments. He expressed his concern about continuity in ocean color measurements from space and argued that the best way to ensure continuity is to use satellite ocean color data products in publications.

Various plans are afoot for CO_2 sensors, although they are currently regarded as more useful over land than over water. The next MODIS satellite (AQUA) may carry such a sensor.

Hugh asked about the idea of a biological census of the ocean that was mentioned in an IGOS report that John passed around. Is NASA buying into this? John observed that it was not just a NASA document.

In answer to a question from Bob about where to locate NASA's priorities for carbon-cycle research, John indicated the ocean section of the Earth Science Enterprise (ESE) Strategic Implementation Plan. He said that the NASA implementation plan for carbon studies is based on the implementation plan of the interagency group that Lisa heads. Saying that the SMP would like to include any new NASA-funded investigators in its activities, Scott asked when he would hear about them. John indicated that it

would be the end of April or early May.

34.8 NOAA Update and Global Carbon Cycle Project

Lisa Dilling reported on the status of the NOAA global climate change program and plans for the future. Because NOAA did not have an announcement of opportunity this year, the lineup of activities looks the same as last year, she said. It includes global CO_2 survey synthesis in cooperation with DOE, global atmospheric networks in cooperation with NSF, the carbon modeling consortium, GasEx 2001 in cooperation with NSF, ocean carbon observations, COBRA in cooperation with DOE, NASA and NSF, continental scaling studies and Transcom III coordination.

Lisa anticipates a NOAA announcement for new projects in FY 2002 even if the agency does not get new funds. Looking toward 2003 and beyond, she mentioned the carbon observations ad hoc group, which involves a number of scientists active in JGOFS (see Sarmiento report below). The focus of this group is on large-scale measurements needed to address CCSP goals. Chairman is Mike Bender.

The 10-year carbon cycle interagency goals include:

- quantifying North American carbon sources and sinks and the processes controlling their dynamics;
- quantifying the ocean carbon sink and the processes controlling its dynamics;
- reporting annually on the "state of the global carbon cycle";
- evaluating the impact of land-use change and land and marine resource management practices on carbon sources and sinks;
- forecasting future atmospheric CO_2 concentrations and changes in terrestrial and marine carbon sinks;
- providing scientific underpinning for management of carbon in the environment.

Lisa noted the management challenges involved in linking the research program, which she represents, with the operational components of NOAA, reminding the group that NOAA is a mission-driven agency that needs to make research useful to managers and to the public.

In response to a question about getting access to international data from the global survey of CO_2 in the ocean, Lisa cited the huge amount of work undertaken by Dick Feely, Doug Wallace and others to bring together all the CO_2 measurements for each major ocean basin. They have been quite successful with regard to the Indian Ocean and the Pacific; getting access to data from the North Atlantic has been something of a problem, in part because there is not a lot of global survey data from that region. She added that NOAA is moving toward requiring the quick release of data.

The problems associated with NODC as the final repository of ocean data came up for discussion. All agreed that lack of scientific input hampered the effectiveness of NODC as a manager of data. Several participants cited the effectiveness of the Carbon Dioxide Information and Analysis Center (CDIAC) at

Oak Ridge in working with scientists on the management of the data from the CO_2 survey. Lisa said that NODC has recently acquired a new director, Lee Dansler.

34.9 Carbon Cycle Interagency Working Group

Lisa moved on to a review of the activities of the Carbon Cycle Science Interagency Working Group. She is co-chair of this group with Elliott Spiker of DOI/USGS. A draft implementation plan has been completed and a scientific steering committee established under the chairmanship of Chris Field of the Carnegie Institution of Washington. This committee and the interagency working group provide oversight and input to the carbon cycle science program office, which is currently occupied solely by Lisa. She then went over the basic interdisciplinary research elements of the U.S. Global Change Research Program and the 10-year carbon cycle interagency goals listed above and expressed her hope that scientists would look to the interagency working group as a resource.

34.10 International Workshops and Programs

Hugh Ducklow reviewed a number of international workshops that have taken place over the last year and the evolution of the International Geosphere-Biosphere Programme (IGBP) and its core projects. He began with the Joint E.U.-U.S. Ocean Carbon Workshop, held in Paris in September 2000 with support from a number of international programs. He noted that Lisa provided the impetus and lots of the money for the Paris workshop, which was intended to provide input for the Carbon Cycle Synthesis Workshop held in Durham, NH, the following month. IGBP, International Human Dimensions Programme (IHDP) and World Climate Research Programme (WCRP), sponsors of the Durham workshop, are jointly supporting an international carbon project (see Doney report below). Four working groups have been established, focusing on observations, prognostic models, diagnostic models and process studies. Their reports, which are expected to cover research strategies and priorities for the future, will be compiled in one volume as a JGOFS publication.

Hugh also reported on the Future of Global Ocean Biogeochemistry Workshop, convened in Plymouth, UK, in September 2000 under the sponsorship of IGBP and SCOR. A draft report is included in the briefing book. This workshop was organized in response to concerns about the lack of an IGBP core project in biogeochemistry to follow after JGOFS. Issues discussed included ecosystem structure, functioning and feedbacks, carbon storage, continental margins and fisheries. Workshop participants have formed a planning group under the chairmanship of Peter Burkill of the Plymouth Marine Laboratory. This group is charged with reviewing the extent to which current SCOR and IGBP programs cover ocean biogeochemistry, identifying and prioritizing gaps in knowledge of ocean biogeochemistry in relation to climate change, describing a research framework that would fill these gaps, showing how the proposed framework would fit into the the Phase II reorganization of IGBP, and reporting to SCOR and IGBP by the end of 2001.

Hugh concluded with a brief account of an IGBP steering committee meeting that he had attended the previous week in Chiang Mai, Thailand. The focus was on the evolution of IGBP into its second phase, which will be organized around the three themes of carbon, water, and food and fiber. The goal of Phase II

is to describe and understand the functions and dynamics of the earth system. Core projects will fall into the traditional areas of ocean, atmosphere or terrestrial research or into the "interfaces" between them. JGOFS, which was one of the first international programs to be designated an IGBP core project, will be the first to come to an end. The IGBP SSC has approved SOLAS as a new core project and sees it as occupying the ocean-atmosphere interface slot. Atmospheric chemist Guy Brasseur of the Max Planck Institute for Meteorology has replaced Berrien Moore as chairman of the IGBP SSC.

Jim Yoder asked which countries planned serious funding for SOLAS. Hugh listed Germany, France, the U.K., The Netherlands and China as countries with established SOLAS committees and noted the interest of the E.U. The proposed program has attracted enormous enthusiasm; it appears to be a idea whose time has come, he said.

Various members expressed concerns about finding a way to ensure the continued existence of long-term biogeochemical and ecological programs such as JGOFS and GLOBEC. Hugh said that although U.S. agencies and scientists do not require an international rationale to carry out programs, many other countries do. Neil Andersen saw the need for GOFS to be part of an international program and fought hard to make this happen, Tony said. Pointing out that the CCSP philosophy focuses on the carbon cycle as an integrated problem and an organizing principle, Lisa observed that the IGBP is supposed to be creating a parallel structure and set of questions at the international level.

Lisa also urged the SSC to think broadly about promoting research on the global carbon cycle as a whole rather than just focusing on the ocean. She also suggested that the group promote integrated research and avoid speaking only for JGOFS. Jorge suggested a letter from the SSC to the interagency group stressing the importance of ocean carbon-cycle questions. Mark noted that there were three arenas in which to push: the NSF and the OCCRP committee, the interagency working group, and the effort begun last fall in Plymouth under IGBP and SCOR sponsorship.

Scott Doney reported on the joint carbon project that was mapped out at the October meeting in Durham sponsored by the IGBP, IHDP and WCRP. He observed the differences in language and priorities among the attendees and the difficulties of adding questions of human perceptions and culture to an integrated science program. IGBP is making a serious effort to attract social scientists who can work across boundaries, Hugh said.

34.11 Science Minute: Autonomous Time-series Measurements

Ken Johnson and Tommy Dickey introduced the group to a wide range of recent developments in sensors for autonomous time-series measurements. Ken began with a description of a nitrate osmoanalyzer deployed by Hans Jannasch and colleagues on the HALE ALOHA mooring of the HOT program. Various figures showed the importance of capturing the small-scale temporal variation in nitrate at this site. He then described an *in-situ* ultraviolet spectrophotometer, a direct optical chemical analyzer that can measure nitrate, nitrite, bromide and other chemicals and can be deployed on a towed sampler. Ken also described a number of moored pCO_2 sensors developed and operated by several groups, including Gernot Friederich and Francisco Chavez at MBARI, Mike DeGrandpre of the University of Montana, Lilliane Merlivat of the Université Marie et Pierre Curie, Paris, and David Walt of Tufts University.

If the Argo program requires 300 floats to obtain adequate temperature and salinity measurements, what do we need to characterize nutrients or CO_2 with more complex distributions, Ken asked. Can we interpolate chemical fields from hydrographic measurements? The nitrate data from the HALE ALOHA mooring suggest that interpolation will obscure important processes, he said.

Tommy described recent progress and plans for developing new ways of carrying out autonomous three-dimensional time-series observations. He discussed the development of microsensors, autonomous sampling platforms, telemetry of broadband data sets and the integration of observations and modeling simulations. He reviewed a variety of microsamplers used to look at organisms, including micro electromechanical (MEMS) technology so small that it can be peeled off, thus avoiding biofouling problems.

Tommy also described various instruments deployed on the Bermuda Testbed Mooring at the BATS site, including the nitrate osmoanalyzer described by Ken, radiometers, bio-optical instruments, pCO_2 sensors and an *in-situ* trace element sampler (MITESS) deployed by Ed Boyle of MIT for measuring lead and iron concentrations. He showed a global map of existing and planned mooring sites and observed that the U.K., Germany, Japan and New Zealand were deploying multidisciplinary sensors on their moorings. He finished his presentation with a discussion of some of the autonomous underwater vehicles that are currently being developed.

34.12 NOAA Carbon Observations Ad Hoc Group and CO_2 Implementation Plan

Jorge Sarmiento reported on the activities of the Carbon Observations Ad Hoc Group, convened by Lisa Dilling to write an implementation plan for ocean and atmosphere CO_2 measurements over the next decade in the context of the CCSP. This committee, chaired by Mike Bender of Princeton University, comprises 15 scientists involved in measuring and modeling the distribution of CO_2 in the ocean and atmosphere. The goals of their work are to find ways of determining the fate of CO_2 released into the atmosphere by fossil fuel burning and to provide observations relevant to understanding carbon fluxes in the biosphere. They are focusing on atmosphere, sea surface and ocean interior in an effort to obtain both independent and redundant information about carbon fluxes. The committee met in February 2000 to draw up general guidelines and convened a larger meeting in November to discuss and review a draft implementation plan.

Among the activities proposed is a biannual assessment of the state of the carbon system over North America, including atmospheric concentrations, anthropogenic sources and sinks, to provide information for policymaking, research and operations.

34.13 Carbon Cycle Science Program

Jorge also reviewed the planning for management of the U.S. Carbon Cycle Science Program,

described by Lisa in her report. Guidance will be provided by both the Interagency Working Group and the U.S. Carbon Cycle Scientific Steering Group. The latter group, under the leadership of Chris Field, has 18 members. As co-chairs of the Carbon and Climate Working Group, Jorge and Steve Wofsy are ex-officio members. The functions of the steering group are to provide overall scientific guidance to ensure that the U.S. Carbon Cycle Science Program achieves its objectives, to review the interagency implementation plan and recommend priorities, to review the integration of the elements of the program and identify gaps, and to assist the interagency working group in communicating with various bodies.

Various SSC members asked about the role of this group in guiding agencies and the levels at which it functions, expressing concern about duplication of effort with other advisory groups such as the OCCRP committee. Jorge pointed out that the charge to this group is much broader than ocean carbon-cycle research and that it interacts with a number of government agencies.

Jorge then presented an inventory of agency contributions to global change research for 2000 that totaled roughly $200 million. Some $113 million of the total was for NASA hardware and $40.5 million was for NASA science. NSF total was $11.5 million, and NOAA/OGP total was $5.2 million. The current carbon-cycle research inventory list shows $19.2 million for Northern Hemisphere terrestrial sinks, $26.5 million for oceanic carbon sinks, $14.5 million for global distribution, $17.6 million for land use and land management, $4.3 million for predicting future concentrations and $4.1 million for scientific underpinning. These figures do not show the $113.6 million for satellite hardware. The U.S. Carbon Cycle Science Plan proposes $200-250 million a year, not including satellite hardware. It also proposes $135-300 million over five years for development and start-up.

34.14 SSC Discussion of Future Ocean Carbon Cycle Research

Mark Abbott opened the discussion with a number of general points.

- How do we transfer knowledge gained in JGOFS science and management into future programs and to the next generation?
- Operational observing systems are hard to undertake with individual investigator efforts.
- NSF culture is different from those of NOAA and NASA. It is harder to put together a coordinated program with NSF.
- There are several paths we could follow.

a) Do nothing for a while and let the OCCRP committee work.
b) Participate in the planning for U.S. SOLAS.
c) Write a letter to NSF raising concerns.

The interagency side is in good shape, Mark said. We have to work on the NSF side.

Dennis McGillicuddy raised some points about the U.S. SOLAS trajectory. NSF, NOAA, NASA and ONR are supporting an open workshop for U.S. SOLAS in May in Potomac, MD. Forty invitations have gone out, but more will be sent if necessary. This meeting offers an opportunity to modify the U.S. SOLAS science plan. Dennis noted that the international program has distilled 56 research ideas down to a dozen. The May meeting will be a chance to sort out what aspects of SOLAS the U.S. can buy into.

Bob Anderson noted his sense that people think that a fragmented ocean carbon research program will not achieve the goals that ocean biogeochemists want to achieve. He asked whether the consensus opinion was that several studies are less efficient than a single large coordinated program. If so, do we want to nudge SOLAS to drop the "S"?

Scott suggested that the SSC wait to see how the OCCRP committee pulls together and interacts with OCE. Cindy asked for suggestions of people who could help this committee. Several people suggested physical oceanographers knowledgeable about hydrography and large-scale ocean circulation. Cindy will communicate with other members of the committee who have worked on carbon in the OCTET and EDOCC contexts. Various SSC members urged her to reconsider her decision to decline the chairmanship of the committee.

Dave Karl asked which agency would take the lead with SOLAS funding. The answer was that there was no SOLAS money yet. Several SSC members will be attending the U.S. SOLAS meeting in May.

Sharon Smith reminded the group about the large block of money that came to NSF with the IDOE in the 1970s and urged everyone to think big and take advantage of the attention that carbon is receiving now. She also suggested that OCCRP committee members read the NAS report on the future of large ocean programs.

Hugh suggested that the letter from U.S. JGOFS concentrate on articulating what is needed to solve problems at the carbon-cycle level. Lisa encouraged the approach to political figures with an emphasis on what the community is talking about as most important.

Mark concluded the discussion by urging those invited to the U.S. SOLAS workshop to attend. The executive committee will put together a letter that clearly articulates lessons learned and philosophy, emphasizing topics such as standards, methods, data management and the value of long-term time-series studies.

34.15 Planning Office Report

Ken Buesseler began his report with an enthusiastic description of the new U.S. JGOFS home page and web site, crediting Mary Zawoysky and other staff at WHOI with its elegance and ease of use. The Planning and Data Management offices have received ongoing funding until early 2005, through the period of the final SMP grants, although the funding has been cut to 85%. He passed around the new "legacy" brochure, written for a broad audience, and solicited ideas for its distribution. It is available on the web as a complete PDF file as well as from the office.

U.S. JGOFS is planning a special issue of *Oceanography*, slated to come out in November 2001. So far 10 lead authors have agreed to put together articles, soliciting help from many co-authors. Ken asked the SSC for help with reviewing these articles and with identifying other topics for short sidebars

and features. Standards and methods will be topics of some of these smaller pieces. A "what's next" article for the end of the special issue was among the suggestions.

U.S. JGOFS will be host to the last JGOFS Open Science Conference, to be held in Washington, D. C., at NAS headquarters. Co-sponsors will be the international JGOFS SSC, the JGOFS International Project Office in Bergen and the NRC Ocean Studies Board, which will provide the NAS facility and local support. Ken asked SSC members for their ideas on the science and local committees, format, synthesis and plenary talks for this final JGOFS event. Scott suggested that data CDs and synthesis papers be available for the conference. He also observed that WOCE will be holding its final international conference in San Antonio in fall 2002 and urged that someone beside himself attend to represent carbon studies.

Hugh noted that JGOFS assistant executive scientist Beatriz Baliño has left the JGOFS IPO for a new position and that a job search is underway. Three candidates have been identified and will be interviewed.

Ken reviewed the calendar of upcoming workshops and meetings. Some discussion followed about the possibility of holding a small educational workshop and about reducing the number of SSC meetings. Ken and Tony Knap both mentioned lesson plans and educational web sites that have emerged from various JGOFS projects.

34.16 Synthesis and Modeling Project II

Scott briefly reviewed the goals of the SMP and the foci of last year's SMP announcement of opportunity before asking SSC members to advise him on the upcoming and final AO. He recommended consideration of three areas: foodweb synthesis and modeling, regional one-dimensional model testbeds, and basin and global-scale coupled ecosystem/biogeochemistry modeling. Hugh recommended that the focus be on the third item.

Bob emphasized the need for basin-scale modeling in the Southern Ocean, observing that comparisons between inverse models of production and those based on satellite chlorophyll data are miserable for that region. AESOPS data are now available to test these models, and they confirm the importance of ecosystem structure for carbon flux, he said. George also stressed the importance of including species in carbon-cycle modeling. Will and Tony Michaels both emphasized the virtues of linking modelers who work on different scales, regional to global. The goal is large-scale predictive capability, Tony said. Marlon noted the value of using models to improve the design of observing networks.

Scott will draft AO recommendations and send them around. Mark reminded everyone of the importance of building a base for future programs as well as synthesizing JGOFS.

34.17 Data Management II

With regard to data management and its oversight, Mark asked for advice for Dave Glover and Cyndy Chandler. Much will fall on the SMP investigators, he said. Dave Siegel pointed out that BATS and HOT have built master files and that it may be hard to solve the quality-control problems that are concerning Dave Glover. He suggested forming an advisory committee of people who have headed process studies. Marlon volunteered to help.

If U.S. JGOFS produces a final merged data set, it should contain the time-series data as well as the process studies, Dave Siegel said. Cyndy said that location of data is not important, format is.

34.18 HOT Science Minute: Inorganic Carbon Program at HOT

John Dore gave a presentation on the inorganic carbon program at HOT. DIC and alkalinity have been measured throughout the water column since HOT began in 1988; these data are online and ready to use, John said. He described an intercomparison of surface ocean DIC and alkalinity measurements made by HOT investigators and C.D. Keeling and colleagues at Scripps with different water samples, methods (manometric versus coulometric) and standards. DIC measurements show pretty good agreement between the two laboratories, but the alkalinity comparison shows more variability.

John also showed long-term data sets from Station ALOHA and Kahe, the coastal station that reveal a clear rising trend for DIC but no clear trend for alkalinity. The trend of rise in surface-water pCO_2 in HOT data set is slightly higher than the rise in atmospheric pCO_2. John would like to resume the pCO_2 and pH measurements that were abandoned when Chris Winn left the HOT program. He would also like to look at calcification, as there is evidence that coccoliths are becoming a more important part of the plankton community in the region.

34.19 HOT Update

Dave Karl gave the State of HOT address, beginning with the funding status of the time-series program. The JGOFS and WOCE components have regular funding through September, and an NSF "creativity award" is extending HOT for two more years to August 2003. HOT is allowed to request shiptime, he said, but long-term decisions will have to be made by February 2002.

Eleven time-series cruises plus two mooring cruises were completed in 2000, and 12 are scheduled for 2001. All cruises this year will be on R/V *Kaimikai-O-Kanaloa* (KOK). The cruise schedule is able to cover seasonal cycles in primary production, recharge of nutrients and particle flux. These are looking more and more like temperate-zone cycles and changing the way we think about the oligotrophic gyres, Dave said.

In 2002 the University of Hawaii will get the AGOR 26, a SWATH vessel to be named R/V *Kilo Moana*. The new ship can carry a scientific party of 39. The HOT mooring is on the beach at the moment, and funding looks bleak. HOT investigators are looking at the possibility of using old telephone cables that run by the station for remote access to instruments.

HOT data report for 2000 is in preparation and should be ready by July. Earlier years are all available on CD-ROM or on the web.

Dave listed the current ancillary investigators at HOT and mentioned some of the new programs. These include a biocomplexity project on N_2, P and Fe interactions (Tony Michaels and Doug Capone), oligotrophic ocean P-R balance (Peter LeB. Williams), gross ^{18}O primary production (Paul Quay et al.) and a project on ocean mesocosm studies and experiments supported by Ocean Carbon Science, Inc. and the State of Hawaii. Dave, Rik Wanninkhof, Kitack Lee and Jia-Zhong Zhang have received funding for a synthesis project on carbon export in low nitrate waters of the tropical and subtropical ocean; the aim is to get at the new production base on N_2 fixation. Cross-habitat comparisons of a number of parameters are continuing between HOT and the Antarctic.

Dave ended his report with a comment on data that are emerging from the sediment trap array at HOT. Trap measurements show that nitrogen in open-ocean blooms is isotopically light, indicating N_2 fixation. Results from deep traps show that carbon and nitrogen are rising in the deep ocean while phosphorus stays level. This is carbon sequestration, he observed.

34.20 BATS Update

Tony Knap presented the BATS report, noting the role of BBSR as an incubator for young investigators. Many of those who have moved on continue to conduct research programs there. The BATS cruise summary includes monthly time-series cruises, bloom cruises and seasonal validation cruises. Ancillary programs include BBOP, IOP, trace metals, TCO_2, O_2 isotopes, virus abundance, molecular probes, enviromental DNA and RNA and ^{15}N. Other programs include the neutrally buoyant sediment traps, EXCELL CTD head testing, O_2 isotope composition of DIP, phosphate-iron interactions and iron and *Trichodesmium*.

He also reported on the upcoming Sargasso Sea Ocean Observatory (S2O2) Workshop, scheduled for March 6-8 at BBSR. This workshop is expected to bring together some 30 scientists involved in many different time-series projects in the southwestern North Atlantic and to establish a forum for communication and collaboration among them. Another goal is to provide data, models and knowledge to the global ocean and atmospheric observing programs.

Tony ended with a few comments on the Global Ocean Observing System (GOOS). Panels responsible for health of oceans, coastal regions and living marine resources are merging into the coastal ocean observing program (COOP). Thus GOOS now has only two panels, the other being climate.

Nick Bates gave a short report on the question of sampling frequency in time-series programs. The CARIOCA buoys deployed at the BATS site have measured CO_2 flux and wind speeds over several deployments. The data capture the efflux of CO_2 in the summer and the influx in the winter. The question

is what wind speed sampling frequency is needed for pCO_2, daily or hourly? Daily averages miss the effects of short wind bursts in the Sargasso Sea, thus missing the effect of these short bursts on CO_2 flux, Nick said.

34.21 Other Time-series Matters

Dave Karl presented some information on a time-series workshop planned for September in Bermuda. The U.S. JGOFS hosts hope to attract participants from time-series programs elsewhere in the world. Tony Knap noted that they were trying to attract SCOR funds to support participants from other countries. Ken said that the planning office would help leverage the funds available.

Mark asked about the merits of another time-series oversight review. All agreed that the future of the time-series programs was not clear at the moment and that a formal review would not be of great use to program leaders at this point. Cindy described the future of the time-series programs as one of the real challenges for the OCCRP committee. NSF does not want them to end, but it has not really committed itself to protecting them, she said.

34.22 AESOPS

Before starting his AESOPS report, Bob digressed to the Arabian Sea on Sharon's behalf because she had been unable to give her report. The fourth U.S. JGOFS Arabian Sea report in *DSR II* is out now, and the fifth will come out next year. Sharon has obtained some temperature, salinity and chlorophyll data from Pakistan.

Turning to the Southern Ocean, Bob said that the first AESOPS volume of *DSR II* is out and the second is in the works. He showed a list of articles, which includes a massive paper on the benthic research done during AESOPS. The articles are to be sent to editor John Milliman by March. Bob also presented a list of 13 AESOPS articles published elsewhere. Ken thanked him and noted how hard it was to keep track of JGOFS publications.

Two reports presented at the AESOPS final data workshop in Corvallis in June 2000 led to synthesis papers at the Brest symposium. These are cornerstone works for AESOPS, Bob said, but they are not being published in the AESOPS *DSR II* volumes. Papers are starting to come in for the third AESOPS *DSR II* volume. Deadline is July 1. This will probably be the last one.

Bob concluded with an abbreviated science minute based on highlights from the Corvallis meeting. He listed the following selected set of products from AESOPS: seasonal evolution of ecosystem structure, grazing less than phytoplankton growth, microzooplankton much greater than mesozooplankton, the correlation of biomass and cell physiology with iron, and annual carbon budgets compiled and cross checked.

At the beginning of AESOPS, investigators asked a simple question important for prediction: Is growth limited by light, iron or silica? All limit in different places and times, Bob said. In a plug for big

programs, he added that a remarkable amount of extrapolation has had to go into Southern Ocean budgets and flux calculations. The full seasonal coverage of AESOPS was invaluable, as was the redundancy of processes and parameters measured by different methods.

Export efficiency is very high in the ACC, Bob said, although the average annual production is less than in the oligotrophic gyres. Carbon flux in the depths is the highest measured in JGOFS. The Southern Ocean appears to be the most efficient at exporting carbon to the depths.

A point for the SMP is that different kinds of models give different results for the Southern Ocean, though not necessarily elsewhere, Bob added. Model/model comparisons are needed as well as model/data.

Remaining tasks for Southern Ocean JGOFS on the international level are to resolve inconsistencies among models, resolve zonal heterogeneity and homogeneity, and resolve factors regulating growth, biomass, species composition, export and so forth. The Southern Ocean Synthesis Group will meet in February 2002 following the Ocean Sciences meeting in Honolulu. Ken urged Bob to keep the 2003 open science conference in mind for these synthesis efforts.

Mark brought the SSC meeting to a conclusion with a reminder to members to think about lessons learned for inclusion in the TOS volume, to give Cindy and Dennis ideas for the OCCRP committee, and to help Scott with the final SMP announcement of opportunity.