31 Minutes March 22-24, 1999

U.S. JGOFS Scientific Steering Committee Meeting

National Center for Atmospheric Research, Boulder, Colorado

Attendees

Scientific Steering Committee Members: M. Abbott, R. Anderson, W. Berelson, S. Doney, H. Ducklow (chairman), P. Falkowski, M. Follows, D. Hansell, E. Hofmann, G. Jackson, K. Johnson, M. Lewis, J. McCarthy, D. McGillicuddy, A. Michaels, J. Murray, R. Najjar, P. Quay, S. Smith, W. Smith, R. Wanninkhof, J. Yoder

Time-series Programs: C. Carlson, A. Knap, BATS; L. Tupas, HOT

Planning Office: M. Bowles, K. Buesseler, D. Schneider, M. Zawoysky

National Science Foundation: Kendra Daly

Guests: Richard Barber, Duke University Marine Station; Raleigh Hood, Horn Point Environmental Laboratory; Joanie Kleypas, National Center for Atmospheric Research; Edward Laws, University of Hawaii

31.1 Introduction

Chairman Hugh Ducklow opened the U.S. JGOFS SSC meeting and introduced local host Scott Doney, who reviewed logistics and welcomed meeting participants to the National Center for Atmospheric Research (NCAR). Hugh welcomed new members Mick Follows and Ken Johnson and returning member Eileen Hofmann to the SSC. He then reviewed agenda changes necessitated by the absence of Peter Brewer, Cindy Lee and Don Rice. Both Cindy and Don have been ill, and Hugh expressed the hopes of all at the meeting that they make good recoveries.

Hugh listed two major objectives for the SSC meeting. One was to review the status of the Synthesis and Modeling Project (SMP); the other was to define U.S. JGOFS priorities in the context of planning for future ocean biogeochemical programs. He reminded members that Don Rice has given the SSC permission to provide input for the planning process.

The minutes from the previous SSC meeting were accepted without comment.

31.2 Arabian Sea

Sharon Smith reviewed the status of the special volumes of Deep Sea Research II that are coming out of the Arabian Sea Expedition. The first volume is out, and the second is at the printer now. Some 26 more manuscripts are out for review, and more may be coming in. Sharon would like to have an Arabian Sea workshop focused on synthesis and modeling next year, if possible.

She touched on a number of highlights from these publications, including evidence of the importance of physical factors such as upwelling, convection and eddies in controlling level of production. Production is higher year-round than was previously thought, and blooms are controlled by grazers.

Sharon reported on the JGOFS symposium and workshop held in Bangalore, India, in January, which attracted 65 participants. U.S. JGOFS supported five U.S. students who attended the workshop. Shubha Sathyendranath of Dalhousie University did a superb job of organizing these events, and the Centre for Mathematical Modelling and Computer Simulation (CMMACS) in Bangalore was an excellent local host, she noted.

The JGOFS Indian Ocean Synthesis Group met during the Bangalore meetings. Sharon reviewed the availability of data from various national participants in the Arabian Sea study. German data are not available yet, although an inventory has been compiled. British data are only available through the British Oceanographic Data Centre. JGOFS India has made available a CD-ROM with Indian Ocean data on it. U.S. data are all available at this point. Both the German and the British programs have special issues coming out. The German data management office is putting together a CD-ROM with Indian Ocean data from most of the JGOFS national programs that will be out soon.

Hugh asked whether the synthesis group was taking a position on data availability. Sharon said no. She agreed with George Jackson's suggestion that a statement from the U.S. JGOFS SSC would be a help. Views on availability of data vary widely among national programs. Hugh noted that international JGOFS policy has not been able to support the concept of online access to data.

31.3 Southern Ocean

Walker Smith opened the presentation on the Antarctic Environment and Southern Ocean Process Study (AESOPS) with a report on recent conferences. The most recent ASLO meeting included three sessions on the Southern Ocean, which were well attended. Papers covered a full range of biological, chemical and physical topics. A recent Gordon Conference on the Southern Ocean was very good as well. Walker noted that links between AESOPS and other programs are increasing steadily.

Bob Anderson led a discussion of a number of data issues. Difficulties with data submission are not a new story, he observed. Although an inventory is available that shows what data were collected on which cruises, some of the data from cruises two years ago have not yet been submitted.

Some data are served at the U.S. JGOFS Data Management Office (DMO); some are served from other sites. Mark Abbott, for example, is serving AVHRR and SeaWiFS results from his work station. Dave

Schneider spoke briefly about the quality-control procedures he undertakes at the DMO. There is inevitably a little time between submission and serving of data, he said, adding that some investigators have to submit their data to two different managers.

Hugh Ducklow asked about progress in moving data into the public domain as NSF requires after two years. Bob said that he and Walker and Don Rice as well were putting pressure on investigators. Dave noted that these efforts were producing results; data sets were coming in. Sharon Smith pointed out that pressure from program managers at NSF has had good efffects on delinquents in the past. Paul Falkowski asked whether program managers could legally refuse to consider proposals from those who have not abided by data submission requirements. Kendra Daly said that NSF program managers have discussed the problem but that there is no good answer to the question.

SSC members also discussed the long-term disposition and availability of the data sets and the maintenance of their links to related databases. "What happens to our database in 2002?" Bob asked. Ken Buesseler noted that awards during the last couple of years of U.S. JGOFS can extend several years into the future. Dave Schneider described plans to archive data on CD-ROMs.

Bob next addressed the issue of making AESOPS data available to SMP investigators. The AESOPS strategy is to post a cruise inventory in the public domain on the U.S. JGOFS web site and to encourage those interested to look at it and to contact the investigators who collected the data directly, he said, stressing the importance of encouraging personal interactions. He asked how many wanted to use AESOPS data. Scott indicated that a small number of SMP investigators want access to these data.

Bob then raised the question of sharing data between AESOPS and ROAVERRS (Research on Ocean-Atmosphere Variability and Ecosystem Response in the Ross Sea) investigators and mentioned a workshop in May. The emphasis of the ROAVERRS program, which only comprises some seven or so investigators, is on atmospheric and oceanic forcing, not on biological activity or all parts of the ocean carbon cycle. ROAVERRS is a small ongoing program supported by the Office of Polar Programs. Although AESOPS and ROAVERRS investigators have been interacting informally since both programs began, no formal data-sharing arrangement has been set up as yet.

The AESOPS data set has gaps in the full seasonal cycle of physical forcing and biogeochemical response, Bob noted. Both groups are interested in putting their data together to get the best possible picture of seasonal changes. Bob and Walker plan to meet informally with the ROAVERRS investigators, and Walker is trying to get non-JGOFS funding for the upcoming workshop.

The next topic was the possibility of merging the data sets from the two programs. The ROAVERRS program has no data management system, web site or planning office. The question is whether ROAVERRS data could be served by the U.S. JGOFS data management office and made available via the U.S. JGOFS home page. The ROAVERRS investigators are willing to consider this possibility, Bob said, adding that he had talked with Chris Hammond about the idea. Its feasibility depends in part on whether the data are ready to be served.

Paul asked whether serving the ROAVERRS data would imply JGOFS endorsement of the data set and pointed out that Department of Energy (DOE) ocean margins data sets are sitting in archives all over the country, not accessible via the web. Can we extend this service to other data sets? Bob observed that a valuable SMP exercise would be to bring together, synthesize and make available such data sets.

Would inclusion of ROAVERRS data give investigators in that program automatic access to U.S. JGOFS field data? Walker pointed out that some ROAVERRS investigators were also SMP investigators. Scott reminded everyone that only SMP investigators who have submitted field data to the data management office have access to all U.S. JGOFS data during the two-year proprietary period. Any who have not must get in touch with the investigators who collected the data. Tony Michaels argued that consistency required sticking to the rule about access to proprietary data. ROAVERRS investigators should be treated like SMP investigators. Bob pointed out that ROAVERRS investigators would be familiar with the way that AESOPS data were collected and any potential shortcomings. SMP investigators would not necessarily know as much about the conditions under which the data were collected.

Further discussion centered around the question of quality control. The issue is whether the U.S. JGOFS data management office should serve data that might not meet U.S. JGOFS quality control standards. Noting that the quality control provided by the U.S. JGOFS office is extremely good, Jim McCarthy observed that one of the original issues for JGOFS was the quality of the data set to be produced. He urged that U.S. JGOFS look closely at any data set proposed for inclusion. Dennis Hansell suggested that U.S. JGOFS could provide access to the ROAVERRS data set without incorporating it. Bob agreed.

The consensus of the discussion was that the SSC was open to the idea of including other data sets in the U.S. JGOFS database but that it had reservations about merging them with U.S. JGOFS data sets directly.

The final data topic was a request to include AESOPS data in a proposed World Ocean Circulation Experiment (WOCE) atlas. The organizers of the atlas are interested in obtaining Southern Ocean data from all the JGOFS programs as well as others in that region. Bob is in favor of the proposal. A question was raised about the length of time it would take WOCE to complete quality control procedures and get the atlas out.

Walker continued the AESOPS presentation with an update on the first Deep Sea Research II volume. Although it is coming along, the editors are having a hard time getting the manuscripts in. Half of the papers will be focused on the Ross Sea, and half will not. The editors hope to receive all the papers this spring and have them reviewed by next fall.

Walker then took up the topic of a paper by Kevin Arrigo and colleagues on productivity in the Ross Sea that was published in the Jan. 15 issue of *Science*. A number of AESOPS investigators are critical of the nutrient ratios in that paper. Walker and others pointed out a number of flaws in both the logic and the data presented in the paper and argued that its conclusions about links among changes in stratification,

species assemblages and carbon storage were not supported.

Bob pointed out that the report of the Carbon and Climate Working Group cites Arrigo's conclusions; he is worried about the influence of fallacious results on planning for global climate change programs. Walker and others have sent a response to Arrigo's article to *Science.*

Bob went on to review plans for the second and final AESOPS data workshop, which will be held in Keystone, Colorado, in August. Feedback from the Knoxville workshop participants has stimulated a reduction in the number of plenary talks scheduled and more time for posters and informal interaction among individuals. The organizers plan to continue the strategy of having two different sets of working groups, the first organized by type of data, the second organized by synthesis topics.

In answer to a question about international cooperation among Southern Ocean programs, Bob said that the JGOFS Southern Ocean Synthesis Group meets every year and is good about focusing on the general questions that were first raised at the 1990 meeting in Brest, France. The Southern Ocean symposium scheduled for 2000 in Brest will be like the ones held five and 10 years ago. But there are no plans for a regional workshop like the Indian Ocean one in Bangalore, he said. Committee members encouraged Bob to ask for discussion of an international Southern Ocean workshop as an agenda item for the next JGOFS SSC meeting, which will be held April 11-12, 2000, in Bergen.

Hugh expressed frustration with difficulties in getting access to Southern Ocean data from other national JGOFS programs and asked Bob's advice. Some French data are being served from a web site in Brest, Bob said. Other national programs seem to be more focused on archiving data than on making them available via a web site.

31.4 Other Data Matters

Dave Schneider spoke briefly about data availability. He said that it would be possible to provide access to ROAVERRS data and that AESOPS data are available in open form up through the third Ross Sea process cruise. He is asking investigators about updates and expects to have almost all of the data by the time of the summer workshop.

Asked about Equatorial Pacific Process Study data, Jim Murray said that he plans to ask EqPac investigators to check their data on the web to see whether more should be added. A merged bottle data set has recently been posted, he said.

Sharon said that some sediment trap data are still missing from the Arabian Sea Expedition collection. John Morrison of North Carolina State University has processed and submitted some satellite data for the region. Sharon also plans to check with investigators for updates and any loose ends that need to be tied up.

Marlon Lewis raised the question of fusion of data from different sources, times and locations. He likes

to use data management routines from HOT and BATS because he can select information by parameter rather than by cruise. He hopes that data from the process studies can be made available in the same way. Chris Hammond expects to have new tools later this year that can be used to select data by parameter, Dave said.

Dick Barber pointed out that JGOFS data management is more successful than that of other programs or sites such as the national Ocean Data Center in part because of its guiding principles. It is essential to develop ideas about how data will be used a decade from now, he said.

31.5 U.S. JGOFS Planning Office

U.S. JGOFS executive scientist Ken Buesseler reviewed a number of planning office matters for the SSC. Both the planning office and the data management office (DMO) are supported by one NSF grant now with Ken and data manager Chris Hammond as co-principal investigators. Chris has taken a temporary leave of absence to serve as interim director of WHOI's central computing facility; she is expected to return to the DMO in August. Dave Schneider is taking care of DMO matters at present.

Ken reviewed the list of U.S. JGOFS workshops and meetings already planned or proposed and noted the relentless pressure to increase participation in these activities. Remaining funds are limited, and he needs guidance from the SSC on priorities.

Scott pointed out that SMP investigators do not go on cruises together and that both the topical workshops and the annual SMP meeting are essential to foster communication and to prevent the program from fracturing into its component parts. Although some SMP proposals had included funds for small workshops, most of the funds for this purpose were cut out of grants during the review process. Jim Yoder noted that NASA has means of sponsoring small workshops on topics of interest to to the agency's managers. Hugh Ducklow urged the SSC to help Scott by setting priorities so that SMP funds can be deployed as effectively as possible.

Tony Michaels pointed out that HOT and BATS have never had a real time-series workshop equivalent to the ones held for each of the process studies.

31.6 Science Presentation: Results from a Food-web Model

The afternoon session began with a presentation by Ed Laws of the University of Hawaii of some results from simulations with a pelagic food-web model. The goal of the project is to develop an understanding of the relationship between total production, export production and environmental variables in marine ecosystems.

Photosynthetic production in the model is partitioned between large phytoplankton and small phytoplankton cells. The model describes the relationship between water temperature and the export *f*-ratio under varying levels of total production. Results show that water temperature can account for

nearly 90% of the variability in *ef*-ratio instead. If the predicted relationship between export *f*-ratio and temperature holds up, it could provide a simple element to include in ocean models.

31.7 Time-series Programs: HOT

Luis Tupas presented the HOT report on behalf of Dave Karl, who was unable to attend. He reviewed the status of the time-series program, including the participants, their research projects and the accomplishments of 1998. These included a full set of cruises, all on RV Moana Wave, and redeployments of the HALE-ALOHA mooring, the moored sediment traps and the inverted Echo sounder. The availability of the mooring for instruments has attracted a number of collaborators, and publications using mooring data are starting to appear. HOT participants celebrated the first 10 years and 100th cruise of the program in December.

The upcoming retirement of RV Moana Wave in May is casting a pall on future planning for HOT, Luis said. Although the University of Hawaii has received approval for a SWATH vessel (AGOR 26) to replace the Wave, the new ship is not scheduled to enter service until January 2001. In the meantime, the only ship currently available is the university's RV Ka'Imikai

O' Kanaloa, mother ship for the PICES V submersible, which is not entirely suitable for HOT purposes.

HOT researchers have participated in meetings associated with two new time-series programs in the North Pacific over the last year. One is the Kyodo North Pacific time-series program (KNOT), and the other is the upcoming South East Asia Time-series Station (SEATS).

HOT data from 1988 through 1997 are available on the web at **http://hahana.soest.hawaii.edu**; the 1998 data will be available in June. The 1997 data report is available in hard copy, and the 1998 report is in progress. The plan is to have all HOT data from 1988 through 1998 in CD-ROM format soon. The HOT web site gets active use, much of it from students at schools and colleges, Luis said.

Science highlights in recent publications and presentations include nitrous oxide production, nitrogenase genes, marine Archaea, phosphorus biogeochemistry, DOM release from primary production, CO2 and inorganic carbon fluxes, and the carbon flux mediated by zooplankton. The papers in the upcoming Deep-Sea Research II volume on BATS and HOT are listed in the SSC briefing book.

Turning to HOT-DOGS, the HOT Data Organization and Graphing System, Luis pointed out that a basic version of this tool is available on the web and an advanced version is available in-house. The system can do time series of various parameters and make parameter vs. parameter plots. He showed some examples. A system now under development for linking and viewing data will include BATS data.

Luis ended his presentation with a review of the new news at HOT: increased understanding of temporal variability in ecosystem structure at varying time scales; developments in ecological stoichiometry; new information on biogeochemical cycles, including nitrogen fixation, phosphorus dynamics, N2O, DOM,

primary production and carbon and CO2 fluxes; new information on the diversity of Archaea, Bacteria, prochlorophytes, diazotrophs and diatoms; changes in population structure, and the development of both HOT-DOGS and HOT beer.

Dennis McGillicuddy asked about UNOLS plans for a ship for HOT and about the struggle to keep moorings at both the HOT and the BATS stations. Funding is a continuous problem for the latter, he said, arguing that support for moorings should come under facilities at NSF.

31.8 Time-Series Programs: BATS

Tony Knap began his BATS update by noting that the time-series program has taken over the task of making atmospheric temperature measurements on land from AEROCE, a program that has ended, as well as on cruises and on the BATS mooring. BATS has completed 126 core cruises in addition to 30 bloom cruises and 25 validation cruises. Online systems on the ship are adding to the data set. Tony showed a figure with four years' worth of atmospheric and sea surface pCO2 measurements.

Neutrally buoyant sediment traps are being tested at the BATS site now. This approach may offer a cheap and simple solution to the problem of obtaining particle flux measurements in the water column, Ken Buesseler noted.

The BATS web site also gets considerable use by students at colleges and schools. Bermuda Biological Station for Research is actively involved in a number of distance learning projects for students, and these include the use of the BATS data set.

In answer to a question about funding, Tony pointed out that the time-series programs received funding for three more years. That will end in spring 2001. He hopes that the programs will continue under some other umbrella, whether it is NSF's Long-Term Ecological Research (LTER) program or the Global Ocean Observing System (GOOS) or some other entity.

Craig Carlson spoke next on determining the response of surface and deep bacterioplankton communities to the DOM that accumulates at the BATS station. DOC builds up during the spring after the waters start to stratify and stabilizes during the summer. Craig hypothesized that an uncoupling between production and consumption allows the material to accumulate in the water column. The quality of the material also changes. He described a nutrient enrichment experiment on bacterial growth and DOC drawdown conducted at BBSR. The results show the importance of mixing and specialized microbial communities in the portion of the drawdown of DOC observed at depth in the Sargasso Sea. Different microbes use different materials for food.

After a discussion about the possibility of holding an upcoming SSC meeting at Bermuda, Tony Knap emphasized the need for a time-series workshop, possibly in conjunction with an SSC meeting. Dick Barber noted the infrastructure problem; the science is healthy, but ships and moorings are a constant headache. Hugh Ducklow suggested that it might be time to rock the boat a little on behalf of the time-

series programs.

31.9 AESOPS Summer Workshop

Bob Anderson opened the second day of the meeting with a request for advice on how to attract the best possible attendance from participants in the upcoming AESOPS workshop. Demand for participation in the workshop is high, and the organizers are considering requiring participants to stay a specified length of time or to pay for their own expenses. Asked for their experiences, Jim Murray and Sharon Smith acknowledged the problem of drop-off but said that the most important participants tended to stay until the end. Others suggested that priority be accorded those who were willing to stay for the whole workshop.

Length was discussed as well. Although some SSC members questioned the need for an eight-day workshop, Bob and others defended the need for more than four or five days. Jim McCarthy pointed out that synthesis does not just happen and that organizers need to apply pressure to get workshop participants to stay. The SSC accorded its approval to a plan to give priority to prospective participants who could stay for the whole workshop.

31.10 Science Presentation: Interannual Variability in a Biogeochemical Model of the North Atlantic

Mick Follows reported on a modeling effort to address questions about biogeochemical responses to physical ocean variability on broad spatial scales and interannual time scales and about connections to meteorological patterns and climatic regimes such as the North Atlantic Oscillation. He and his colleagues formulated a simple model of nutrients and chlorophyll concentrations with a focus on interannual variability. This simple model identifies oceanic regimes according to which of two convective mixing functions dominates the interannual variability in springtime chlorophyll: supplying nutrients to the surface or removing phytoplankton to the depths. Mick and his colleagues used their simple model to evaluate a more sophisticated ecosystem model embedded in a general circulation model of the North Atlantic and concluded that the relationships described by the simple model held true for the more complete one.

31.11 Future Directions for Ocean Biogeochemical Studies

Hugh Ducklow announced that Bob Anderson would preside over the discussion of future directions, and he urged those making presentations to leave room for discussion. Bob began with four points to keep in mind:

1. What important issues in ocean biogeochemistry need to be addressed?

2. Will programs now being planned address these issues?

3. If the answer is "no," can these programs be modified to address these issues? If so, how?

4. If the answer is again "no," we need to define the character of a program that would address these issues.

The U.S. Global Change Research Program (GCRP) has adopted a set of topical priorities for the next decade that include changes in the biology and biogeochemistry of ecosystems, changes in climate on both seasonal-to-interannual and decadal-to-century time scales, changes in atmospheric chemistry, paleoclimate and human dimensions of environmental change. A few very large programs, like CLIVAR, have been proposed so far.

Under the leadership of Bob Corell, the Geosciences Directorate of the NSF is conducting a long-range planning effort at present; an outline and completed chapters are posted on the web at **http://www.geo.nsf.gov/adgeo/geo2000**. This effort and the GCRP list of priorities show some common themes, including biogeochemistry, human dimensions, global hydrology, carbon cycle and interaction between biotic and physical components of global systems.

NSF Ocean Sciences Division has also established a decadal planning committee that is charged with coming up with seven or eight cross-cutting themes. This committee reports to Michael Purdy. Peter Brewer is a co-chair, along with Ted Moore of the University of Michigan. Hugh asked Sharon Smith, who is a committee member, to provide liaison between the NSF committee and the SSC.

Kendra Daly gave the NSF perspective on planning for future ocean research on behalf of Don Rice and Phil Taylor, who were unable to attend the SSC meeting. She mentioned a number of program and division planning groups and some upcoming changes in personnel. She also reviewed the status of U.S. JGOFS and funding projections for its last few years. Citing an email message that Don sent just before the meeting, she said that the chemistry program is looking for bold innovative proposals for planning workshops in the area of large-scale carbon cycle research.

Kendra noted that biological oceanography wants a more biologically and ecologically focused program and showed a preliminary list of themes. Ken Buesseler observed that a critical strength of U.S. JGOFS has been in pooling resources from both chemistry and biology and that he did not want to see two camps develop. Kendra agreed and pointed out that the decadal planning group was interdisciplinary.

Paul Falkowski raised again the question of preserving the U.S. JGOFS database in the future. Kendra said that NSF recognizes that there is an interagency problem here and asked for guidance from the committee. A number of participants criticized the way data are handled and stored at the NODC. Hugh expressed his intention to put the issue on the agenda for the next SSC meeting.

Paul moved that interested parties write a letter to Bob Corell to explain their concern over the long-term fate of the JGOFS, WOCE and other large databases. Noting that long-term archiving of data was an agency problem, he argued that an interagency task force was needed to deal with the problem. He also

expressed his distress with the fate of DOE data sets, which slowly disappear as years pass after their collection. Hugh asked Paul and others to draft a letter for his signature as chairman of the U.S. JGOFS SSC.

On behalf of Janet Campbell, who could not attend the meeting, Jim Yoder reported on the current state of planning at NASA as related to JGOFS and future biogeochemical programs. If oceanographers are able to make the case that ocean biogeochemical research is critical to our understanding of the global carbon cycle, NASA will stay involved, he said. The agency is committed to carbon cycle research.

Jim urged the SSC to anticipate and encourage the continued involvement of NASA with the SMP. Janet sees new opportunities for funding in FY 2000, he said. He recommended that the NSF representatives talk with her about a joint announcement for 2000, noting that it was easy for NASA to participate in a joint announcement like one two years ago for the SMP. Proposals that focus on modeling and satellite data are the easiest for NASA to fund, he added.

It may be time for JGOFS folks to make another presentation to NASA, Jim continued. The agency is taking steps toward implementing a carbon and climate program, and biogeochemistry is a major element under "biology and biogeochemistry of ecosystems." Jim also noted an increase in stability and accessibility at NASA headquarters. The head of the Earth Science Enterprise, the new name for Mission to Planet Earth, is Ghasem Asrar, who is favorably inclined toward JGOFS sort of research. Janet Campbell will be with NASA until September 1999; the status of her replacement was not yet resolved.

Rik Wanninkhof reported on behalf of Lisa Dilling on NOAA activities. NOAA and DOE have issued a joint call for proposals for the synthesis of results from the JGOFS CO2 survey, including data from the NOAA Ocean-Atmosphere Carbon Exchange Study (OACES) and from the DOE-supported Survey of Carbon Dioxide in the Oceans, conducted on WOCE Hydrographic Program cruises. Rik listed the investigators who received funding, some of whom also have NSF SMP grants. The investigators supported by DOE and NOAA will be invited to SMP workshops but will pay their own way.

Rik outlined NOAA plans for future carbon research and noted the agency's interest in interagency collaboration on assessing carbon fluxes between the ocean and atmosphere. He reviewed results from CO2 meetings over the last year and mentioned some upcoming ones.

Rik also noted some recent developments in air-sea gas flux research. Taro Takahashi has added to his database and changed his estimate of the flux of CO2 from -1.4 gigatonnes a year to -2.2 gigatonnes a year. He also discussed new views of the relationship between wind speed and gas exchange.

Bob Anderson observed that all the agencies seem to be at some stage of supporting the carbon and climate change program and urged SSC members to think about whether this program covers the biogeochemistry themes that they consider important. He then asked Jim Murray to discuss two recent planning activities, the National Research Council's Major Ocean Programs (MOP) evaluation and the

Future of Ocean Biogeochemical Research (FOBR) assessment carried out by an ad-hoc committee of scientists.

Jim reviewed the history and goals of each of these projects as well as their accomplishments and conclusions. The FOBR effort attracted attention to biogeochemistry issues and got people thinking about future programs. NSF has expressed willingness to fund workshops for bold ideas. The MOP committee assessed the history of large-scale programs and their effect on science, education and facilities, drawing a number of conclusions about the structure and management of such programs. The tension between keeping core programs strong and supporting major ocean programs will remain a fact of life for the ocean sciences, Jim said. The MOP committee recommended creating a new interdisciplinary unit within the NSF Ocean Sciences division.

Jim said that the process of establishing a new large-scale program is clear: formulate the scientific question(s), organize an initial committee, make a presentation to the National Research Council and seek support for a workshop, produce a plan. The critical problem is having clearly stated scientific goals.

SSC members discussed alternative pathways to the establishment of a new large-scale program. An important question is how to show community support. Open planning meetings, presentations at national meetings and availability of information on the web are among the answers.

Dick Barber and Paul Falkowski discussed the problems that interdisciplinary projects have in getting favorable reviews and funding. Such proposals fall through the cracks, Dick said, despite the monumental efforts of Don Rice to try to close these cracks. The problem is especially serious for biogeochemistry as an emerging and interdisciplinary field of research. Paul urged the establishment of an appeals process for proposals rejected because reviewers were not familiar with all aspects of the proposal.

Scott Doney spoke next on the National Ocean Partnership Program (NOPP) ocean data assimilation and modeling initiative. Mike Purdy got this effort started in response to concerns that the present state of ocean modeling and data assimilation are unsatisfactory. The original impetus came from JGOFS and WOCE, which have huge data sets. But all sorts of ocean research groups that do numerical modeling have been involved, Scott said.

FY 1999 funds of roughly $5 million are being allocated to planning and to the establishment of multidisciplinary scientific teams ("nodes"). The plan is for four nodes: coastal, climate, biogeochemistry, biology. Some 69 proposals came in for the February 1999 deadline; a second call for proposals is expected for FY 2000. The central computing facility ("hub") will be defined in the future. ONR and NASA are joining NSF in supporting this initiative. A scientific steering committee will be formed once the proposals are awarded, Scott said. Jim Yoder noted the interest of Adm. James Watkins, head of the Consortium on Ocean Research and Education, in pushing this program. Scott said that the original level of resource commitment seemed to be around $10 to $20 million.

Tony Knap made a presentation on the progress of the Global Ocean Observing System (GOOS). GOOS planners envision a unified global network of information provided from a number of ocean monitoring programs, which are organized into four modules: climate, coastal, living marine resources, and ocean health. Tony is chairman of the ocean health module. Data collection and integration rather than research are the aims of the observing system.

In the area of ocean health, a number of pilot projects are now monitoring pollution in various ocean regions, and countries are getting funds from the World Bank to carry out programs, Tony said. The U. S. GOOS is well behind and needs to step along faster if it is going to catch up with other nations, he added. Rik noted that miscommunication between different levels within the program has contributed to this problem.

Jim McCarthy pointed out that GOOS is designed to produce products for a number of customers, not just scientists. Governments need ocean data to meet treaty and convention obligations, for example. The future of GOOS will depend on who wants what products, he said.

Jim Yoder spoke next on the activities of the multidisciplinary Carbon and Climate Working Group, chaired by Jorge Sarmiento and Steve Wofsy. Both Jim Yoder and Jim McCarthy are members as well. This group has produced the Carbon Cycle Science Plan (CCSP), portions of which are included in the SSC briefing book. The plan recommends near-term emphasis on establishing accurate estimates of the Northern Hemisphere terrestrial carbon sink, the ocean carbon sink, including its spatial distribution and interannual variability, and the effect of change in land use in the tropics and the Northern Hemisphere in the global carbon budget.

Jim pointed out that the major program elements and activities recommended under the ocean carbon sink goal include reference to global surveys, long-term stations, process studies and remote sensing, just as JGOFS planning documents did. He urged SSC members to read the whole plan and send comments to the web site. Tony Michaels urged members to comment on the allocation of resources at the end of the report. The numbers in the report, which add up to roughly $108 million, include funds for a lot of existing programs, including current expenditures for JGOFS, Jim said. The total rises to $189M when the NASA space budget is included.

Jim McCarthy noted that all the working group members, including the terrestrial and atmospheric scientists, agreed that ocean CO2 measurements were essential to them. Hugh Ducklow said that the objectives of reviewing the plan were to provide input as well as to look out for the goals of ocean biogeochemical research.

One of the interesting questions to emerge from the working group's deliberations was whether terrestrial and marine ecologists operate with very different concepts of equilibrium and disturbance in ecosystems. The question is whether marine ecosystems and their effects on biogeochemical cycles are at equilibrium and thus different from terrestrial ecosystems, which are generally regarded as disturbed by human activities. Jim Yoder listed a number of ocean studies that suggest that marine ecosystems and

biogeochemical cycles are subject to perturbations of various sorts on various time scales.

Bob Anderson commented that people need to think about whether what they want to do can be fitted into these bullets and plans and whether the scale is right. If not, the plans should be modified.

Dick Barber made the next presentation, which was on a proposed international project titled the Surface Ocean-Lower Atmosphere Study (SOLAS). Co-chairmen of the SOLAS planning group are Bob Duce and Peter Liss. The proposed study contains four components: atmospheric chemistry and physics, marine biogeochemistry, climate, and marine physical processes. It will address key interactions among these components and the ways in which they affect and are affected by past and future climate and environmental changes.

An open science conference will be held next February, at which Dick and a number of other JGOFS participants will be giving papers. Some of the questions to be addressed are changes in marine sulfur emissions, iron and nitrogen changes, changes in biogeochemistry that are likely to affect ocean uptake of CO2, the effects of changes in climate-driven physical forcing, the accuracy and precision of existing techniques, and changes in the spectra and intensity of radiation and their effects on gas flux.

SOLAS planners hope to take advantage of natural experimental opportunities and to conduct experimental manipulations, Dick said. The proposed study should build on both JGOFS and IGAC and work closely with these programs during their synthesis phases. Its planners hope that SOLAS will be accepted as an IGBP core project; a science plan will be required before IGBP will consider it. No U.S. SOLAS committee has been formed yet. The planning group is international, and its focus is on developing a science plan and getting IGBP approval.

Considerable discussion ensued about the integration of SOLAS around a central theme or themes, whether it was a coherent program with a set of essential parts, none of which could be omitted without changing the whole. While agreeing that SOLAS was not an integrated program in the same way that JGOFS was, Dick argued that SOLAS studies would provide information that would prove essential to the synthesis of JGOFS results.

Paul cited experiences suggesting that scientists who work with atmospheric aerosols are not, for the most part, interested in ocean processes. Hugh said U.S. JGOFS recognized that the proposed SOLAS program offered several valuable follow-on studies but that it did not address many issues of direct relevance to JGOFS concerns for future carbon cycle priorities. The difficulty of crossing the ocean/ atmosphere boundary in NSF funding was noted, mentioning again that Don was unusual in his interest in interdisciplinary efforts.

Bob asked the group whether it thought it should try for input into SOLAS on behalf of ocean biogeochemists or whether it should put all its eggs in the CCSP basket. Dick said that Bob Duce would welcome input. Jim McCarthy argued that it was comparing apples and oranges to compare SOLAS and the CCSP approaches, but he agreed that the SSC should see if it could map its questions onto these

structures.

After lunch, Bob Anderson began a discussion of interannual variability with the argument that he had made at the end of the previous SSC meeting. Two research priorities in ocean biogeochemistry, interannual variability and the response of the ocean to global warming, are intimately linked and can be pursued simultaneously. They follow logically from JGOFS and build upon it. Bob proposed a strategy of incorporating knowledge of ecosystem structure and relevant parameters gained during JGOFS into models of the response of biogeochemical systems and carbon fluxes to changes in atmospheric organization to predict response to global warming.

Supporting his approach, Bob linked long-term records of climate changes with records of El Niño cycles and cited Will Berelson's data on the relationships between sea-surface temperature and carbon fluxes in the equatorial Pacific. He also showed a number of figures of seasonal and spatial patterns in fluxes and processes in the Southern Ocean. He described the propagation of changes in a variety of parameters eastward around Antarctica and raised the question of links between this "circumpolar wave" and ENSO cycles in the tropics. He also stressed that air/sea/ice/biogeochemistry linkages are sensitive to interannual variability, and this variability, in turn, may be influenced by changes in the tropics.

Speaking for Dave Karl as well as himself, Tony Michaels discussed interannual variability at the two subtropical time-series sites. Instead of concentrating on the unidirectional impact of climate on biology, Tony and Dave propose a focus on feedbacks between climate and ocean biogeochemistry. Both carbon sequestration and DMS are relevant topics; the former includes nitrogen fixation, the effects of iron on new production, time scales for remineralization, and changes in the stoichiometry of elements.

Tony showed data from HOT and discussed the evidence for pulsed input of nutrients, alternation between nitrogen and phosphorus limitation of primary productivity, and selection for and against nitrogen fixers like *Trichodesmium*. Evidence is emerging for links between changes in these factors and ENSO cycles, he said.

Tony also presented nitrogen fixation data from the BATS site and discussed the questions BATS investigators are raising about stoichiometric relationships in the Sargasso Sea and their link to atmospheric dust in that region. He concluded his presentation by noting that feedback cycles between climate and ocean biogeochemistry are a fertile ground for a link with CLIVAR.

Ken Johnson, the final speaker of the afternoon, described the deliberate manipulation experiments that have been carried out in an effort to understand the role of iron from wind-borne dust in the regulation of ocean productivity and the link between this relationship and climate. Ken listed the iron release experiments carried out so far in HNLC regions of the equatorial Pacific and the Southern Ocean as well as bottle experiments in a variety of regions, oligotrophic and HNLC. Iron affects primary productivity directly as a micronutrient and indirectly by stimulating nitrogen fixation and by regulating iron binding ligand concentrations.

Ken described a European Union Environment and Climate Research Programme called Carbon Dioxide Uptake by the Southern Ocean (CARUSO), which plans an iron release experiment in the Southern Ocean in February 2001. He also mentioned planning for IRONEX III, which included a workshop held in December 1998. A proposal submitted to NSF for a third IRONEX project, this one to be carried out in the Southern Ocean, was turned down in 1998 with recommendations for resubmission after synthesis of JGOFS and other data was farther along.

Bob recapitulated the foci of the three presentations: interannual variability, feedbacks and kinetics. The "zero-order question," he said, is whether we try to adjust programs that are on the table now or to get a new large program rolling. Hugh said he was not sure that the questions discussed during the day-long session are all covered by programs that are underway.

George Jackson emphasized the need for coastal ocean studies, which often fall through the cracks. Paul Falkowski argued that an evolution of JGOFS should treat the ocean as a whole, open and coastal. Bob noted the focus of the CCSP plan on anthropogenic carbon and argued for the need to understand the natural carbon cycle. Paul Quay agreed and observed that the document is focused on anthropogenic perturbation, particularly terrestrial.

After a discussion about whether the CCSP program would serve JGOFS interests adequately, Jim McCarthy suggested that the chairman identify a small group to write a few pages describing central science questions and research approaches the SSC would want to have discussed at a planning workshop. SSC members agreed to the formation of a small group charged with putting together a statement and a proposal for a workshop to go to Don Rice as soon as possible. Jim Murray suggested including a few people from outside the SSC as well as a few SSC members.

Other points arose in the discussion of themes that such a workshop might consider. Paul Falkowski noted the importance of the paleoceanographic framework for understanding changes in climate and ocean. Mark Abbott emphasized the importance of looking at the controls on the structure and functioning of ecosystems in trying to understand the effect of variation on species composition. Eileen Hofmann and Dennis McGillicuddy pointed out that natural perturbations occur all the time and ramify throughout trophic levels; deliberate manipulations are not always necessary to get at effects of disturbance on community structure and functioning. If one is designing a carbon program, Eileen added, one should put in linkages across parts of systems.

Paul Quay observed that JGOFS has made a unique contribution by focusing on both chemical fluxes and biological processes. He does not see that link in the CCSP terrestrial hypotheses.

Will Berelson pointed out that JGOFS has brought geologists, biologists and chemists together and stressed the importance of listening to experts outside the JGOFS framework. Hugh ascribed the success of JGOFS to starting with a simple program and letting it grow. It brought in all kinds of people. We are looking for contexts now, he said. Tony Knap urged the group to couch their interests in terms of social questions to promote the value of ocean biogeochemical research.

31.12 Science Presentation: Modeling Seasonal and Interannual Biogeochemical and N2-fixation Cycles at BATS

The third day of the meeting began with a presentation by Raleigh Hood on modeling biogeochemical and nitrogen-fixation cycles at the BATS station. He and his colleagues are using a one-dimensional biogeochemical model and data from the BATS site to tackle the question of how much nitrogen fixation occurs in the North Atlantic. Geochemical estimates and direct observations differ by an order of magnitude. With this model they have explored two solutions to the question. In the first, they set the rate of N2 fixation high enough to produce the observed summertime drawdown of dissolved inorganic carbon (DIC); in the second, they set the rate to produce observed sediment-trap fluxes.

Both solutions indicate that there is significant interannual variability in N2-fixation rates at BATS, Raleigh said, but he considers the model solution that reproduces the drawdown of DIC to be more consistent with the BATS data set than the one that reproduces trap fluxes. He offered what he called an outrageous suggestion that flux patterns of the last decade may be driven by variation in the rate of N2 fixation, which is in turn driven by climate.

31.13 Synthesis and Modeling Project

Scott Doney began his review of the Synthesis and Modeling Project (SMP) with an update on currently funded projects. Counting NSF awards in FY 1998 and 1999, NASA awards in FY 1998 and NOAA and DOE awards in FY 1999, there are a grand total of 41 projects and 91 principal investigators and co-investigators. Some are funded on more than one project. Scott listed the newly funded PI's and projects but cautioned that the NOAA and DOE ones were not yet official.

Scott then showed how the projects divide up. Five groups are carrying out global-scale modeling; seven groups are doing modeling for regions where JGOFS has conducted field studies; 15 groups are carrying out basin and global synthesis, and four are working on the ocean margins. Of the groups carrying out process study and cross-cutting time-series projects, Scott listed seven that are working on euphotic zone production and export, three that are working on functional groups and one that is working on processes in the sediments. No one is working on transport and remineralization in the water column below the euphotic zone, he noted.

Most basin and global synthesis groups are not extrapolating processes but rather fields, Scott said, expressing concern about extrapolations from smaller to larger scales. Discussion ensued about communications between those working at regional scales and those working on a global scale and the inclusion of ecosystem components in global-scale models. Eileen pointed out that regional models are all different and cannot just be plugged into global models, although global models can pick up parameterizations from regional models.

Working group structure has evolved considerably, Scott said. The current list comprises global-scale biogeochemistry/OCMIP, large-scale data sets, regional test beds, satellite biogeochemistry, continental

margins, N2 fixation and functional groups, and food webs. Scott divided up the data resources available to the working groups into global survey of CO2 and climatological data, general JGOFS and non-JGOFS, satellite data, JGOFS process-study data, and time-series; he linked each to the relevant working groups.

Turning to future directions, Scott listed recommendations for the FY 2000 announcement of opportunity of issues that were important but not as yet well covered in the SMP:

· Calcium carbonate and silicate production and redistribution

· Biogeochemical effects of trace-metal cycling

· Mid- to deep-water processes, including dynamics, particle fluxes and remineralization

· Spatial and temporal extrapolation from local to basin and glocal scales

· Synthesis and modeling of AESOPS, Arabian Sea, U.S. and international time-series data

Bob Anderson has suggested a focus on large-scale synthesis of coastal margins data and interactions with the open ocean, Scott said. Putting resources into the first three items above means possibly not putting resources into the synthesis of data from JGOFS process studies (last item).

Looking at the topics covered, Hugh said that he did not see any explicit synthesis of primary production across JGOFS, which should be a high priority. Jim McCarthy noted the importance of comparing production and export flux estimates. Tony Michaels suggested that the spatial and temporal extrapolations item include some explanation of what is wanted.

Although some of the SMP projects are using North Atlantic data, no one is using data from the North Atlantic Bloom Experiment (NABE) specifically. Scott asked whether NABE should be put on the list of issues or areas that are not well covered. All agreed that it should be added to the items under the synthesis and modeling bullet. A reference to ocean margins will be added as well.

After a break, Scott presented the current list of upcoming working group and other SMP meetings. Paul Falkowski headed a workshop on functional diversity of phytoplankton in January. Chris Sabine may head up a workshop on large-scale data sets during 1999. The summer all-investigator meeting will be held in July in Keystone, Colorado. Doug Capone is scheduled to lead a workshop on N2 fixation in September. Fei Chai and Jim Murray are going to organize an equatorial Pacific regional testbed meeting sometime in the fall. Scott and Hugh are organizing a special session on the SMP at the Ocean Sciences meeting next January. Other meetings will take place in 2000, including a joint WOCE/JGOFS tracer flux meeting, which Doug Wallace is involved in organizing.

A discussion ensued on the importance of cross-cutting themes versus a regional focus in synthesis

efforts. An important legacy of JGOFS will be a framework for testing models across data sets, Scott said.

Scott then showed the plan for the next summer SMP meeting. Given the concern about the cost of meetings and time for investigators to work together in small groups, Hugh said, why not cut down on general talks at the summer meeting? Scott argued for the value of presentations on common problems and crosscutting topics.

Executive scientist Ken Buesseler discussed the funds available for SMP workshops and meetings. Some $60,000 is currently unallocated for meetings in 1999. Everyone agreed that Doug Capone should go ahead with the N2 fixation meeting, which is expected to cost about $15,000. Scott asked if there were a proposal for a time-series meeting on the table. Hugh said that it had been long recommended.

Joanie Kleypas spoke next on SMP data management matters. The goals are to provide public access to SMP results and to give investigators access to key data sets for SMP research. Large-scale synthesized data available include biogeochemical distributions and fluxes, carbon system parameters and biological fluxes. Modeled data include descriptions of available model results, OGCM/OCMIP data extractions along WHP cruise tracks, and regional and process model results. Joanie coordinates her efforts with the U.S. JGOFS data management office and creates links to other data servers, such as CDIAC. She is responsible for creating and maintaining the SMP web site and facilitating interactions among its users. She encouraged anyone with questions to get in touch with her.

Scott reminded everyone that synthesized data is the point of SMP management efforts. The aim is not to generate data sets but rather to facilitate sharing of them. The U.S. JGOFS SMP model data policy has been published in the newsletter and is posted on the web site. NOAA/DOE grantees have to submit their data to CDIAC as well as to the U.S. JGOFS data management office.

Hugh noted that Don Rice and other agency representatives want to see a conspicuous listing via the U. S. JGOFS home page of what we think the gaps and uncertainties are in the synthesis effort. It should be very clear and available, he said.

31.14 SMP Working Group Update: Functional Groups

In view of the time, SSC members voted to ask Joanie if she would be kind enough to give her "science minute" presentation on carbonate saturation in tropic waters and coral reef calcification at the next meeting instead of this one. Paul Falkowski made a very short presentation on functional groups and the results of the recent workshop. He described functional groups of phytoplankton in terms of the biogeochemical processes they mediate and talked about selection, diversity and niches of these groups. An important question to ask is what the processes are that select for organisms over time, he said.

31.15 Other Business

With regard to the next SSC meeting, Hugh suggested holding it at BBSR at the end of August. An alternative would be to go to the University of Hawaii in the fall and BBSR in the spring.

He also reminded SSC members that Don Rice wanted a brief report on the discussion of future directions in ocean biogeochemistry. Hugh will draft this report and circulate it promptly. A small committee will be formed, as discussed above, to draft a statement of scientific questions and to make a proposal for a workshop. As agreed, Hugh said, it will include some members from the SSC and some from the outside.