**Oct. 25-27, 1995**

# U.S. JGOFS Scientific Steering Committee meeting

**Woods Hole Oceanographic Institution, Woods Hole, MA**

**Attendees**

**SSC members**
**R. Anderson, R. Barber, P. Brewer (emeritus), O. Brown(chairman), T. Dickey, S. Doney, H. Ducklow, R. Feely, W. Gardner, M. Lewis, D. McGillicuddy, J. Murray, B. Prezelin, P. Quay, J. Sarmiento, S. Smith, W. Smith, T. Takahashi, B. Ward**
**Time-series programs**
**D. Hebel, D. Karl, A. Knap, A. Michaels**
**U.S. JGOFS Planning Office**
**M. Bowles, K. Elder, C. Hammond, H. Livingston, M. Zawoysky**
**Federal agency representatives**
**NSF: E. Carpenter, M. Purdy, M. Reeve, D. Rice, P. Taylor**
**NOAA: J. Todd**
**NASA: R. Frouin**
**NODC: G. Heimerdinger**
**Guests: N. Andersen, C. Goyet**

## 26.1 Introduction

Chairman Otis Brown welcomed members, guests and federal agency representatives to a meeting of the U.S. JGOFS Scientific Steering Committee (SSC), held at Woods Hole Oceanographic Institution Oct. 25, 26 and 27. He touched briefly on the accomplishments of the program and noted the beginning of the efforts at synthesis that will be necessary to extrapolate from the findings of field and modeling studies to regional and basin-scale contexts and to create budgets on these scales.

## 26.2 Committee Structure and Rotation

The chairman then introduced the topic of committee rotation and restructuring and invited executive scientist Hugh Livingston to describe the process of developing the recommendations that were presented to the committee. Early in the summer Hugh had circulated a list of continuing and retiring members of the steering committee, the executive committee and the "exec-plus" committee and collected comments and suggestions from current and former members of the SSC as well as participants in U.S. JGOFS projects. The executive committee reviewed the responses and put together recommendations for clarifying the roles of the various committees, some changes in their structure and a set of candidates from which to choose new members of the executive and steering committees.

Otis reviewed the philosophy of the U.S. JGOFS oversight structure. The executive committee handles the day-to-day issues that arise, seeking help as needed from the heads of the various research programs. These heads and the exec members make up the exec-plus, an ad-hoc group of those responsible for carrying out various parts of the overall U.S. JGOFS program. The steering committee, on the other hand, is responsible for long-range policy formulation, program overview and community outreach. The problem, Otis pointed out, is that the "heroes and heroines" who coordinate the various field programs are currently being asked to participate in SSC deliberations on long-term policy issues and program balance at the same time that they are expected to serve as advocates for particular projects.

The executive committee is proposing that the exec-plus be formalized as a group of eight to 10 people, comprising the members of the executive committee plus the coordinators of each research component of the overall U.S. JGOFS program.

This committee will continue to focus on the practical details of carrying out the various U.S. JGOFS studies. Members who are project coordinators will not also be voting members of the SSC, although they will participate in an ex-officio capacity. As a consequence, the SSC per se will become a somewhat smaller body.

Otis followed his presentation with a request for comments. Dave Karl expressed concern that moving the coordinators to the exec-plus simply moved them up the decision-making tree. Otis distinguished between making policy and implementing it and noted that the oversight structure was not a hierarchical one. Other members expressed approval of the effort to separate responsibility for policymaking from responsibility for implementing it, although many observed that it was hard to achieve this separation in practice. The consensus of the group was that the new plan should be tried for a year and reviewed at that point.

The chairman then asked the members of the SSC to discuss the roster of candidates proposed for new terms and to choose four from the eight listed. Candidates were selected for the diversity of their disciplinary interests and their ability to contribute to program synthesis; all had agreed to serve if elected. Also discussed were the candidates proposed for the executive committee. Peter Brewer raised the question of keeping the current chairman on the exec, stressing the importance of continuity.

A number of points arose in the discussion of the process of identifying and proposing candidates. Jorge Sarmiento noted that Hugh Livingston had worked long and hard to elicit views and recommendations from SSC members. Others suggested a second round of comments once a set of names had been identified or carrying out the whole process at the SSC meeting. A number of members expressed concerns that the process be and appear to be open to input from the committee and the relevant scientific community.

Discussion focused on the selection of new candidates for chair and for the executive committee. Several members noted that the number of candidates qualified to serve as chair were few, that corporate memory was critically important and that they were satisfied with the recommendation of the executive committee. With regard to the executive committee as a whole, however, the sense of the group was that the nominations should be opened up to include more candidates.

Otis called for a vote on whether to separate the vote for chair from the vote for members of the executive committee. A majority said yes to this proposal. He then asked for a vote on the nomination of Hugh Ducklow to serve as the next chairman. The vote for Ducklow was unanimous. Otis then read the results of voting on new members of the SSC. The winning candidates were Mark Abbott, David Archer, Mike Landry and David Siegel .

Discussion of the nominations for the exec followed these votes. The recommended candidates were Cindy Lee of the State University of New York at Stony Brook and Steve Emerson of the University of Washington, both former members of the SSC. Otis explained the concern of the exec for disciplinary breadth, geographical distribution and diversity of gender and expressed his hope that any new nominations would take these issues into account. Continuing members will be Ducklow and Jim McCarthy, both biologists. Dick Barber pointed out that the exec needed adequate representation of physics and chemistry perspectives.

In answer to a question about the pool of candidates for membership in the exec, Jorge read the original list. In answer to another question, Otis said that Jorge was leaving the exec and joining the exec-plus, since he had agreed to serve as the coordinator of the synthesis and modeling working group. Peter recommended once again that Otis stay on the exec as past president for two years.

In order to facilitate discussion of the composition of the executive committee, Otis asked if he might leave the room. Peter led the ensuing discussion, reminding the group of the huge amount of work involved in leading the program. Tony Knap concurred, stressing the importance of continuity on boards and committees. In answer to a question about emeritus status versus regular membership in the committee, Peter characterized the former as an advisory role removed from participation in the day-to-day work.

In response to suggestions that persons on the exec-plus be considered for the exec, Scott Doney reiterated the distinction between responsibility for implementation and responsibility for policymaking. Bob Anderson stressed the need for exec members with long corporate memories. Jorge mentioned the need for members with broad perspectives. Paul Quay emphasized the value of new people and new perspectives.

Barbara Prezelin and Peter encouraged the group to think in terms of adding the position of past president to the number of exec members rather than taking up an available slot. When Otis returned, Peter articulated a consensus for keeping the past president as an active exec member rather than emeritus, keeping the current position of vice chair as well, and thus increasing by one the number of persons on the committee.

After further discussion of the role of the exec, Otis proposed a nominating ballot for candidates for the two unfilled positions. Ballots with the names of two recommended candidates and spaces for write-ins were distributed.

Subsequently, Otis passed out ballots with six names of candidates for the two vacant positions on the executive committee. Two were Lee and Emerson, the nominees originally recommended by the exec, and the other four were current SSC members nominated by their peers. Dave Karl, Jorge Sarmiento and Sharon Smith agreed to be considered, and Paul Quay declined.

Later,Otis announced the results of the vote for two new members of the executive committee. Elected were Cindy Lee and Steve Emerson.

**26.3 Time-Series Programs**

Tony Knap began the presentation on the Bermuda Atlantic Time-series Study (BATS) with a brief update on activities and personnel. He reported that two meetings of the time-series oversight committee were planned, one in Bermuda in March and one in Hawaii in May. Representatives from each program will attend both. He noted that the JGOFS protocols manual, put together by BATS staff members, was snapped up rapidly after its publication and was now out of print. He also reviewed other observing programs working in and around Bermuda and described some of the activities of the Atlantic Global Change Institute's Risk Prediction Initiative.

Dave Karl reviewed the Hawaii Ocean Time-series (HOT) program and its ancillary programs. Ship problems have eased in the last year because R/V Moana Wave, stationed in Honolulu, has been much more available for HOT cruises than she used to be. Dave noted the seasonal distribution of cruises and stressed the importance of catching seasonal changes in various biogeochemical signals. Nine cruises are scheduled for 1995 plus a sediment trap cruise, and 10 are scheduled for 1996 plus three to the proposed "Hale ALOHA" mooring and two transects.

New items for 1995-96 include the biogeochemical mooring noted above, which is comparable to the mooring at the BATS site near Bermuda. Dave described a variety of other projects, including a cross-site comparison between Station ALOHA and an antarctic site and a science symposium timed to coincide with the 75th HOT cruise.

A special volume on time-series studies is coming out shortly in Deep-Sea Research; Dave and Tony Michaels are co-editors. And HOT data report no. 6 (1994) is now available on paper and electronically. Finally, Dave gave his "HOT science second," a preview of his lunch-time presentation of HOT results.

Tony Michaels presented a brief review of recent BATS results, including some comparisons with HOT findings. Both HOT and BATS researchers are discovering that the fixation of atmospheric nitrogen is important to production and element cycling, despite some fundamental differences in characteristics of the two time-series sites. DIC is drawn down in the summer at the BATS site, Tony said, but only about one-third of the carbon that disappears is accounted for by the measured vertical fluxes. He concluded that either some of the measurements are incorrect or there are unmeasured horizontal processes occurring, or both.

Tom Dickey described the recently established Bermuda test-bed mooring program. With funding from several agencies and private sources, scientists from several institutions are developing and testing instruments for deployment on moorings. They are also providing ground truth for satellite measurements and developing algorithms. The buoy that is currently deployed has current meters, radiometers, optical sensors, vector sensors, water samplers and a nitrate analyzer. Data are sent by telemetry as well as down-loaded by shipboard investigators. The nitrate analyzer and temperature sensors gratified everyone by showing a nitrate spike and a drop in surface and water-column temperatures after Hurricane Felix passed through last summer. The survival of the mooring and all its instruments was even more gratifying.

Otis reminded those assembled that the U.S. JGOFS time-series oversight committee needs one more member. Jim McCarthy is chairman, and Scott Doney and Jim Bishop are members.

Dave Karl spoke during the lunch break on some long-term results from the HOT study. The first topic was the role of bacteria in the North Pacific gyre. Dave described the bacteria present at the HOT site and compared them to those present at the antarctic study site. He then took up the question of phosphorus dynamics at Station ALOHA, focusing on the role of phosphorus in nitrogen fixation.

Surface phosphorus has been dropping slightly over the last five years at the HOT site. Comparing various characteristics of the ecosystem during ENSO and non-ENSO conditions, Dave pointed out that Trichodesmium, which fixes nitrogen, is common during ENSO conditions and not during "normal" conditions. The physical characteristics of the system during ENSO conditions, such as calmer waters and less mixing, favor the growth of Trichodesmium. Nitrogen increases relative to phosphorus, and the system becomes phosphorus limited rather than nitrogen limited. Dick Barber noted that nitrogen fixation also requires high light levels and relatively large amounts of iron, suggesting that the Pinatubo eruption could not be discounted as a factor.

**26.4 Carbon Dioxide Survey**

Taro Takahashi, Dick Feely and Catherine Goyet reported on aspects of the survey of CO2 in the ocean. Taro handed out figures that showed the number of samples analyzed per year, WHP cruise legs and CO2 survey participants from 1990 to the present and projected until 1998, and an oceanographic data inventory from CDIAC showing cruise dates, data contributors, variables in data sets, status of data, and date of publication. He noted that differences in dissolved inorganic carbon values between those produced by C.D. Keeling's lab at Scripps and those produced on board ships were within 2 micromoles, and thus within the goal the CO2 survey science team had set itself. Shipboard coulometers are calibrated with certified reference materials prepared in Andrew Dickson's lab at Scripps and standard pipettes are used.

Taro brought the SSC up to date on the crisis at DOE, which is proposing to terminate support for the CO2 survey and other ocean programs at the end of 1995. Resolution of this crisis has not yet been achieved, he said, and the current funding cycle ends in November. Funds for participation in the last WHP Indian Ocean cruise in January are not available right now, leaving the CO2 team for that cruise in a difficult position. He noted the loss of morale and the impact on the pace of data processing that have accompanied the funding uncertainties.

Dick Feely presented a map that includes NOAA survey cruises as well as the WHP ones. The coverage in the Pacific, Indian and southern Atlantic oceans is extensive. Dick observed that the DOE crisis has had a serious effect on the NOAA CO2 program as well.

Catherine Goyet, recently returned from a WHP cruise along 10 N in the Indian Ocean, showed figures with CO2 from U.S. JGOFS cruises in the Arabian Sea. Data from March show that pCO2 in the air and water are in equilibrium; data from July, on the other hand, show a big difference. During the summer, the Arabian Sea releases CO2 into the atmosphere.

Jorge showed a figure and noted that the increased accuracy of CO2 measurements makes it increasingly likely that researchers will be able to detect the anthropogenic CO2 transient in the ocean. He considers the accomplishments of the CO2 survey to be impressive, he said.

Otis summarized the course of events since DOE announced its decision to shut down its ocean programs, reminding the group of the CO2 survey team's impact statement in August. He pointed to efforts within U.S. JGOFS and within various federal agencies and committees to articulate the consequences of shutting down the CO2 survey and to look at alternatives. The Global Change Research Program wants to resolve this crisis as part of its charge to coordinate interagency programs, he said.

Otis went on to point out that this program was a technical success but that there was an inevitable lag in publishing the results. It is also a low-cost program at roughly $2.5 million a year for collecting, reporting and managing the data and some modeling work. He reiterated that the question to be resolved was who was going to take responsibility for supporting the rest of the survey and management of the data it is generating.

**26.5 SeaWiFS**

Robert Frouin of NASA passed out a message from Gene Feldman and expressed the deep disappointment of one and all with Orbital Systems over the 2.5-year delay in the launch of the SeaWiFS ocean color sensor. Two rockets have failed, and a third could bring down the company, he said, noting that the only alternatives are waiting for EOS or relying on foreign satellite missions. The earliest point at which the satellite and instrument could be ready for launching is February 1996. Launch is possible in March.

Robert went on to discuss aspects of NASA's Ocean Biogeochemistry Program. This program will be cut by 20% in FY 1996, eliminating ocean fieldwork aircraft support. A new announcement of opportunity for ocean research in 1996 will include implementation of the SIMBIOS program, the aim of which is to make ocean color data sets from different countries comparable. Sharon Smith raised the question of aircraft support for future U.S. JGOFS studies, such as the Southern Ocean Process Study, noting the value of aircraft coverage during the summer monsoon in the Arabian Sea. Robert said that a proposal should be sent to NASA to make the case.

**26.6 Sediment Trap Meeting at Villefranche**

Wilf Gardner presented a brief synopsis of his report on sediment trap technology and sampling in surface waters, reviewing the history of the debate over surface sediment traps and the discussion at Villefranche last May during the JGOFS Scientific Symposium. The vertical flux of carbon comes in three forms: settling of particles, vertical migration and mixing and advective export. Sources of error in trap measurements are swimmers, solubilization of carbon within the trap (lysing of plankton and release of DOC), and various hydrodynamic effects. The bottom line is that the level of picking swimmers out is not the problem, at least at Bermuda, Wilf said. Height to width ratio of traps is critical, and the way the brine is added is as well. Surface-moored sediment traps have more inherent difficulties than deep moored traps.

Calibration of traps .... Jim Murray and Wilf both stated that thorium is currently the best tool available for calibration of sediment traps. Ideally, thorium measurements could give confidence that traps were not over- or under-collecting the flux of settling particles.

Recommendations of the report include designing and conducting a three-dimensional trap/234Th calibration experiment in a high-productivity, low-energy regime, minimizing the flow past traps and measuring velocity, deploying traps with 5 psu excess brine only in the bottom, measuring flux at a single depth per array, decoupling traps from surface wave motion, removing all swimmers from samples, developing neutrally buoyant traps, putting JGOFS protocols on the WWW, reporting methods and errors fully in all publications.

Jorge asked whether there were any unambiguous absolute method for calibrating traps and why a tracer was necessary. Wilf answered that thorium was low in swimmers and not solubilized. He regarded hydrodynamics as the main problem. Jim Murray pointed out that there are good new data sets on export in the equatorial Pacific in which thorium was used to calibrate several different kinds of traps. Tony Knap suggested that trap data should not be accepted unless they had thorium data with

them.

**26.7 Global Ocean Observing System**

Neil Andersen gave a brief report on the Global Ocean Observing System (GOOS) that built upon the report from Mel Briscoe that was included in the briefing books for the meeting. GOOS has resources, however small, he said, and offers an umbrella for monitoring programs that can increase our ability to predict oceanic and atmospheric events and changes. Unlike JGOFS, Neil noted, the international program is developing faster and more coherently than the national program in the U.S. The health of the oceans is one of five GOOS modules and is Neil's responsibility. The most important issues for this module will be things that affect human health and are easily measured.

Otis pointed out that GOOS will be the operational way to do routine ocean measurements in the future and that JGOFS measurements should be included. The three relevant GOOS modules are health, climate modeling and marine resources, he said. Peter asked whether the health of the oceans module will focus on coastal matters, and Neil agreed that most activity would be coastal.

**26.8 North Atlantic Study**

Scott Doney reported on planning to date for a basin-scale study in the North Atlantic and its potential as a contribution to synthesis of JGOFS results. He began by reviewing a number of European plans for North Atlantic studies as well as the status of WOCE plans for work in the region. A study of the sort under discussion would be different from previous JGOFS process studies and could serve as a prototype for post-JGOFS studies, he noted. It would focus on seasonal and basin scales. It would make use of novel techniques, including drifters and underway sampling of both CO2 and nutrients. And it would have process, time-series and survey components, tying process studies and the time-series sites to a larger basin-scale study of the carbon cycle.

Scott pointed to the on-going debate over the contribution of the North Atlantic to the global carbon cycle. Models, tracers and hydrographic data indicate that the North Atlantic is a site of deep water formation and that it is characterized by large-scale decadal variability. Very little is understood about how that affects the CO2 system, Scott said. An important goal of the proposed study is to constrain two components of the North Atlantic system, pCO2 for one and the meridional fluxes of DIC and DOC for the other.

The planning meeting agreed upon at the last SSC meeting was postponed for several reasons: uncertainties about the fate of the DOE-supported CO2 survey, the status of WHP sections in the North Atlantic, and the failure of the European JGOFS programs to obtain MAST funding. The plan was to hold a workshop in March 1996, but subsequent to the meeting this was canceled.

Scott went on to point out that it would not be possible to mount any sort of U.S. JGOFS field program in the North Atlantic before early 1999 because of the commitment of resources to the Southern Ocean Process Study through 1998. Thus it will be hard to coordinate a study with the Europeans, providing they are successful in finding support in the near future. The MAGE program, a component of IGAC, has plans for marine aerosol and gas exchange studies around the NABE site in the North Atlantic in 1997-98. French, Norwegian and Canadian programs are planning some biogeochemical studies at the same time as the MAGE effort. He reviewed WOCE plans briefly as well. It is not clear how many WHP sections will be completed of the six planned for the North Atlantic.

Dennis McGillicuddy spoke briefly about the review of the U.S. JGOFS NABE archive that he and John Marra are carrying out. He was impressed with what the data management office has accomplished, noting how much less cumbersome data retrieval has become and how straightforward the process is. Hugh Ducklow added that the NABE data set is now complete and available via the U.S. JGOFS Home Page.

Jim Murray noted that confusion remains among EqPac investigators as to whether they should submit all data to the data

management office or just core data. He is now requiring that all investigators submit their data before their papers are accepted for inclusion in the Deep-Sea Research special issues on the EqPac study.

Wilf Gardner asked about the fate of U.S. JGOFS data after the program is over. George Heimerdinger said that the National Oceanographic Data Center (NODC) will put the data on CD-ROM.

Jorge Sarmiento returned to the question of hypotheses to be tested in the proposed North Atlantic study. Scott referred again to the proposed attempt to constrain the seasonal cycle and spatial distribution of pCO2 and a plan to test a hypothesis that there is a major DOC flux out of the North Atlantic. A discussion of sampling difficulties ensued. Scott emphasized the need for a strong modeling component in the proposed study.

**26.9 Funding Projections**

Don Rice of OCE presented a comprehensive review of NSF funding projections for U.S. JGOFS for the next three fiscal years (Appendix 1). His figures, which refer to OCE resources only, assume level funding for U.S. JGOFS for FY 96 through FY98. Overcommitments of $781,000 for FY 95 and $758,000 for FY 96 will be carried over into future years. His projections showed uncommitted totals of $3,650,000 for FY 97 and $8,450,000 for FY 1998.

The Southern Ocean Process Study will be supported by OPP alone during FY 96, by both OPP and OCE during FY 97 and by OCE alone during FY 98. Don's projections showed a total of $6 million per year for each of these years. The OCE funds as yet uncommitted for FY 97 will go almost entirely to the Southern Ocean study, as will most of the uncommitted funds for FY 98.

Mike Reeve pointed out that the OCE projections were optimistic and that funds could decrease. The Arabian Sea study is costing OCE about $6 million a year; proposals for the study totaled $54 million. Proposals for the Southern Ocean study total about $52 million. Bob Anderson noted that the final cruise in the Southern Ocean will take place halfway through FY 98 and that sample analysis will run into the next year. The study will also require funds in FY 99 for analysis and synthesis. Walker Smith expressed concern about support for finishing up the longer projects; some of the Southern Ocean proposals are for four years.

Dave Karl observed that the OCE projections do not list any funds for the time-series programs for FY 98. Don indicated that the question mark in the time-series line does not mean that the time-series programs will end with FY 97 but rather that OCE does not yet know what the amount for the following year will be.

Hugh Ducklow referred the group to the projection of resources needed that is included in the recently completed U.S. JGOFS implementation plan. That projection shows the time-series programs continuing until 2002. He reminded everyone that the projections in the plan are intended to show what would be needed to achieve the scientific goals of the program and to provide guidance to the funding agencies.

**26.10 Equatorial Pacific Process Study**

Jim Murray began his report on EqPac activities with a review of various publications that are planned. *Deep-Sea Research* will publish two or three volumes of EqPac papers. The first, with 42 papers, is already out. The second is in press. A possible third volume will include synthesis papers and reports from the NATO workshop on the carbon cycle in the equatorial Pacific, held in Noumea last June. This third volume, which will have a large international component, may be published in some other journal instead. An ad hoc session will be held for EqPac presentations at the Ocean Sciences meeting in February.

Jim mentioned efforts to agree on standard units for publications. EqPac investigators have agreed that all chemists and biologists will present their data in moles of carbon rather than other units. After discussion, Jim admitted that it is necessary to use mass rather than moles in some cases. A discussion of accuracy standards for measuring productivity followed. Dick Barber pointed out that JGOFS studies were using two different approaches, measuring to a defined light level or to a specific

depth. He prefers the latter, which is the approach taken at the time-series sites.

The NATO ARW was organized by Jim, Yves Dandonneau of LODYC, Paris, and Robert LeBorgne of ORSTOM, Noumea. It attracted good international participation and serious comparison of results. There were 24 talks and 50 posters total, leaving plenty of free time for discussions.

RV *Thomas G. Thompson* will revisit the Pacific next year for another cruise, and French scientists are planning a cruise as well. These are not JGOFS cruises but have similar goals. Jim noted that they offer a chance to see "normal" conditions in the equatorial Pacific after four years of El Nino conditions. The warm pool has moved west again, and water temperatures are normal or cool.

Discussion ensued about whether a permanent switch has taken place in equatorial Pacific conditions. The NATO workshop recommended putting instruments on the existing TOGA/TAO moorings to improve sampling coverage. Jim observed that we have sufficient information on processes to know how an oligotrophic tropical system works. What is needed is information on change in conditions over time.

Dick Feely mentioned NOAA plans for an OACES mooring deployment next fall along 170 W or both 150 W and 170 W. NASA will be supporting bio-optical sampling, he said.

Jorge asked what it would take to close the carbon budget in the equatorial Pacific. Will it be possible to extrapolate to larger scales with satellite observations? Jim noted the need to address the problem of scales of variability. Moorings are useful, he said, and a satellite would be great if it ever came to pass. Interannual variation, as opposed to seasonal, is critical in the equatorial Pacific. Discussion ensued on new and export production and it was pointed out that it is incorrect to equate nitrate uptake with export in production in this region, that "new" and "export" are not the same thing here.

Jim went on to show estimates on the ratio of new to export production for the EqPac study region. In 1987, Chavez and Barber estimated 0.85 Gt C/y from f-ratio times primary production and 1.90 Gt C/y from upwelling times nitrate. The total EqPac estimate is 0.75 Gt C/y, which is 56% particulate and 44% dissolved carbon.

Synthesis groups are continuing to work together. Hugh Ducklow noted that several EqPac papers were mentioned in the recently published *Our Changing Planet*. Jim also observed the benefits of cooperation between the NSF-supported EqPac study and the NOAA programs as well as the value of the TOGA/TAO moorings. The EqPac review concluded with an interesting discussion on the "line in the sea" observed during the fall EqPac process study cruise in 1992.

**26.11 Arabian Sea Expedition**

Sharon Smith reported on the status of the Arabian Sea Expedition, which will end in January after a total of 17 cruises. Five process study cruises have been completed with two more to come. Recovery of the moorings has just been completed. Four of the five moorings weathered the year in the Arabian Sea successfully, and one was lost. A NASA P3B aircraft flew a series of missions over the study area in June and July. The Arabian Sea study has had the benefit of the regional modeling work of Jay McCreary, John Kindle and Mark Luther, and the output of Luther's model has been available to shipboard investigators during the various cruises. Although SeaWiFS never materialized, Arabian Sea investigators had shipboard access to AVHRR data for the region.

Seasons are critical in the Arabian Sea, unlike the equatorial Pacific, Sharon noted, as she reviewed the components of the overall project. The seasonal monsoons are driven by the location of low and high pressure areas, which affect the formation and direction of the Findlater Jet. The mooring site was chosen for its position under the axis of the jet.

Sharon compared data from Bob Weller's air-sea interaction mooring for the months of the summer monsoon with averages taken from the Hastenrath and Land atlas to show that the 1995 southwest monsoon had close to average winds. The maximum winds were higher than usual in June, although the average was close to the mean. The June/July SeaSoar cruise,

which stayed relatively close to the central moorings and thus right under the Findlater Jet, encountered worse weather than either of the two process cruises that followed it. The southwest winds died on Sept. 9, pretty much right on schedule.

AVHRR images showed upwelling beginning in June along the Omani coast. When the southwest winds died, the upwelling decreased rapidly. The cruises did not find any open ocean upwelling, leaving investigators wondering about the causes of the bloom they observed. Sharon suggested that mixing and restratifying rather than upwelling probably produced the bloom. Marlon Lewis pointed out that the NASA aircraft saw a great deal of fine red dust all the way up to the flight level at 500 feet. Sharon said that dust input was one of the original hypotheses about productivity in the Arabian Sea. In answer to a question from Ed Carpenter about the presence of *Trichodesmium*, Dick Barber said that these fixers did not tolerate the strong mixing of the summer monsoon; *Phaeocystis* dominated in the open ocean in these conditions.

Open ocean productivity was highest during the northeast (winter) monsoon; coastal productivity was highest during the summer monsoon. The monsoon periods had similar overall levels of productivity, both much higher than the levels observed during the intermonsoon periods. Results of various measurements varied considerably from station to station.

On the international front, the JGOFS Indian program has a section out to the U.S. station 11 at the southern end of the easterly line. Indo/German traps are still in place. Scientists on R/V *Thompson* have carried out intercomparisons with RRS *Discovery* and R/V *Meteor* as well as with R/V *Knorr*, which was doing WHP section I7. NOAA ship *Malcolm Baldrige* is in the Indian Ocean as well and is carrying out the WHP I8 section.

Sharon reported that 58 abstracts have been submitted so far for the poster session at the Ocean Sciences meeting in February. She also noted that a symposium planned for November 1997 in The Netherlands will probably be held in Miami instead, since the Dutch government did not fund the meeting proposal.

The first Arabian Sea hydrographic data have been submitted to the data management office already. Lou Codispoti provides quality control for core hydrographic data before it goes to the DMO. Scientists are responsible for getting their own data in. The first U.S. data meeting will probably be held in August.

**26.12 Southern Ocean Process Study**

The Southern Ocean Process Study does not yet have an acronym or logo. SOPS is out, Bob Anderson announced as he began his presentation on the upcoming study. Earlier this year, an announcement of opportunity was issued for modeling studies in support of both GLOBEC and JGOFS field studies. Sixteen proposals were submitted; NSF hopes to fund five or six. Awards should be announced shortly.

An announcement of opportunity for process studies went out in June. NSF received 110 proposals (75 separate projects), which are now going out for mail reviews. A single panel will be held in December, not separate ones for OPP and OCE. Total support requested is about $54 million.

The goals of the study are set out in science and implementation plans and in the announcement of opportunity. Bob and Walker have assembled a priorities committee with broad experience to help guide the evaluation of proposals. This committee is getting input from Sharon Smith as to what did and did not work with the Arabian Sea study. The committee will rate themes for the Southern Ocean study, develop scenarios for shipboard work, set priorities to help guide the panel and try to develop a realistic budget. Among the aims is to identify all the elements necessary for a complete study. The committee is using the Arabian Sea priority matrix as a guide, since NSF managers said that they found this approach very helpful.

Bob presented the current timetable for the study. The whole process is being accelerated because the first cruise (intercalibration and testing) is scheduled to go to sea in September 1996, a little less than 12 months after the proposal deadline. NSF hopes to complete the funding decisions in January and February with start dates for the first awards in March and April. Cruise planning meetings will be held next spring to get the right people on the right ships. OPP waived the shipboard information packages (SIPS) for Southern Ocean process study proposals, but these will be requested after funding

decisions are made. The email address for all those interested in participating in the study is southocean@dataone.whoi.edu.

The study will make use of two ships and cover two seasons. Cruises will all begin and end in New Zealand. The first will go primarily to the continental shelf in the Ross Sea area, second to the Polar Front Zone. R/V *Nathaniel B. Palmer* is committed primarily to U.S. JGOFS from September 1996 to April 1997, and the planners are trying to get R/V *Thompson* for the second season. Walker asked for SSC endorsement of the request for R/V *Thompson*, emphasizing its value in previous U.S. JGOFS studies.

Dick Feely described plans for NOAA cruises in the same region. One will leave Hobart, Tasmania, in January and go along a line to 67 S, 170 W. Another cruise will go in and out of New Zealand, and a third will go to the coast of Chile. The focus of these cruises will be on CO2 and carbon transport; the aim is to achieve a scale of resolution like that of the WHP sections. Investigators will also collect the usual suite of hydrographic and chemical data.

Bob reminded SSC members that the location for the U.S. JGOFS cruises was determined years ago when various national programs decided where they wanted to work. No one else is working in the southern Pacific Ocean on a JGOFS scale, he said.

Following the highly successful Arabian Sea Expedition model, Bob said, the basic suite of measurements will be handled by a unified team assembled from different institutions. These measurements will be supported as part of the overall management of the Southern Ocean Study. Lou Codispoti will coordinate the nutrients measurements, and John Morrison will coordinate the hydrographic measurements. The team assembled for the Arabian Sea effort will be maintained, with the addition of personnel experienced in the Southern Ocean and used to working with Antarctic Support Associates (ASA). Dick Barber lauded Arabian Sea core measurement team members for their competence and speed. The guidance from Lou and John was excellent, he said, and the support was the best he ever encountered.

The Southern Ocean planners are looking at the logistics and merits of asking NASA for P3B remote-sensing coverage. Like the Arabian Sea, the Southern Ocean has few summer days without cloud cover. The plane would be insurance for periods when satellite instruments could not see the region. The request would be for low-altitude flights over the polar front. Robert Frouin asked how data collected by the aircraft would advance the purposes of the study. Bob pointed out that aircraft instruments could get a snapshot of frontal dynamics, enhancing information on the physical forcing of biogeochemical processes for the shipboard investigators. The cost would be about $600,000.

Bob next addressed the question of logistics. ASA, which is based in Boulder, will handle all logistics of the field program, including travel and shipping of equipment. ASA handles the logistics for all field programs in the Antarctic that OPP supports; its personnel are well acquainted with matters such as regulations associated with the Antarctic Treaty. Bob, Walker and Barbara Prezelin stressed the importance of having a single point of contact at ASA, one person who is responsible for taking care of U.S. JGOFS interests.

In answer to a question about moorings, Bob said that they would be deployed and recovered during cruises and that trappers now have considerable experience with traps in polar regions. Taro Takahashi brought up a concern about underway pCO2 systems. Because the water intake clogs under certain ice conditions, better ice protection is needed for the underwater lines.

The JGOFS symposium held in Brest in August was a good opportunity to exchange information and to hear about the findings of other national programs with projects in the Southern Ocean. British, German and South African programs have Deep-Sea Research special volumes published or on the way. The meeting included a good discussion of the role of iron in the Southern Ocean ecosystem.

The JGOFS Southern Ocean Planning Group held a meeting after the symposium. It wants a synthesis of CO2 data for the region but is finding it hard to get data together from all the participating countries. Meeting participants emphasized the need for an international database available to all. Hugh Ducklow agreed that this was the number one problem for the international program. Dick Feely observed that the CO2 panel had given the task of collecting CO2 data sets to Alain Poisson of LODYC,

Paris. Taro is putting four U.S. data sets together and making them available. He feels that about 80% of the data on surface pCO2 will be available soon.

**26.13 Synthesis and Modeling**

Jorge Sarmiento opened discussion of data synthesis and modeling activities with a brief review of the discussion of these topics at Scottsdale in June 1994 and subsequent developments. He put up the resource summary created for the U.S. JGOFS Mid-Program Strategic Plan (Appendix 2) and noted that a significant increase in funds for modeling and synthesis is recommended for FY 1998 and after. The six-part implementation strategy described in the plan links modeling and synthesis efforts to the task of meeting the basic goals of the program and to U.S. JGOFS field studies. Syntheses and models must grow out of the field programs, Jorge said.

Turning to synthesis and modeling activites, Jorge noted a number of issues to be addressed and tools to be developed. The former include closing the carbon budget at Bermuda, calibration of sediment traps, the problem of Redfield and non-Redfield element ratios, and the effect of ENSO variability on the global CO2 budget. New ideas include the development of new mooring technology, such as pCO2 sensors, and the use of DOC and DIC measurements to constrain POC cycles.

Committee members discussed the role of synthesis in field studies and vice versa. Among the points that emerged was that synthesis occurs within field studies, as investigators share their data and address questions that cross disciplinary boundaries, as well as outside them. Modelers draw upon field results to construct and test their creations; increasingly, they also help guide field research with their projections.

Another point, introduced by Barbara Prezelin, was the importance of cross-site comparisons as well as vertical integration in the synthesis of field data. Hugh Ducklow observed that the carryover of investigators from one U.S. JGOFS field study to the next encouraged cross-site comparison. Dick Barber noted that synthesis of results was taking place within field studies, but that topics should be identified and an announcement of opportunity issued to encourage synthesis across domains.

Members also discussed the need to commit a larger share of the U.S. JGOFS pot to modeling activities in order to meet the goals of the program. Otis suggested that the level of resources devoted to field studies should drop within a few years to about 50%. All agreed that launching another large-scale U.S. JGOFS field program after the Southern Ocean one would make it impossible to support data synthesis and model development properly. Barbara asked why planning should proceed for a North Atlantic field study if U.S. JGOFS can't afford it. A number of participants pointed out the attractions of the North Atlantic for a limited study to test questions emerging from integration of earlier results.

Otis pointed out that NABE was a step forward, demonstrating to skeptics that scientists from different disciplines could work together. The program is close to making another step forward, coupling modeling and field studies in order to make basin-scale predictions. The next thing needed is the conceptual integration, where you can use models to predict the state of the system, he said.

Bob Anderson recommended strongly setting aside a whole day at the next SSC meeting to identify the synthesis issues and discuss priorities and strategies within the overall budget envelope. Several participants mentioned the obligation of the program to synthesize its results properly.

Scott Doney spoke briefly on the workshop on one-dimensional biogeochemical models sponsored by the JGOFS Task Team on Global Synthesis to be held 11/27 to 12/6. Its aim is the comparison of upper-ocean biogeochemical models using data collected at various time series sites and during programs such as EUMELI and NABE. Modelers from nine countries will carry out various exercises before the workshop using common physical parameters and diagnostics. They hope to develop a consensus model with agreed-upon parameters and to discuss a model "tool kit" for those who need to think about linking data collection and modeling.

Duck noted that the workshop was an official JGOFS synthesis activity, and Barbara asked for a synopsis to explain the

workshop's conclusions to field researchers. Taro Takahashi objected to the lack of field workers among those going to the workshop, arguing that the topic was one non-modelers could cope with. Jorge observed that modelers and field workers were working together closely at the BATS site, and Dennis McGillicuddy pointed out that the workshop was narrowly focused on the technicalities of building and comparing models.

Returning to the topic of planning for synthesis in U.S. JGOFS, Otis asked SSC members whether there was a consensus for putting together a synthesis working group. This group would be charged with developing a set of priorities and a strategy. Duck noted that part of the charge would be to figure out whether US JGOFS is ready to do a synthetically focused study such as constructing a basin-scale budget. The composition of the group would be arranged via e-mail between SSC meetings.

Dennis observed that he had recently attended a meeting of the GLOBEC numerical modeling group and pointed out some of the modeling problems GLOBEC and JGOFS share. These include physical/biological interactions, spatial and temporal variability, emphasis on productivity, and a need to describe upper ocean ecosystems and model population dynamics.

**26. 14 Program Synthesis and Near Term Implementation**

Discussion of program synthesis and near-term implementation continued on the final day of the U.S. JGOFS SSC meeting. Hugh Ducklow opened the session with a brief review of the state of the program and the planning office budget. Beginning with the field studies, he noted that EqPac was in the stage of active program synthesis, that Arabian Sea was nearing the end of the field work phase and beginning to plan workshops, and that Southern Ocean was just getting rolling. Observing that synthesis was not just something that would start in two or three years, he asked Hugh Livingston to discuss support for synthesis activities in the planning office budget.

Hugh said that the current budget had been submitted as a five- year plan and was later modified to three years. The planning office received interim funding for six months and then received an increment for another six months. It is Hugh's understanding that NSF has committed itself in principle to the three-year budget and to the support for synthesis activities that it contains. The FY 1995 figures include $20,000 for synthesis, which is being used to support small working-group meetings. The FY 1996 figures include $40,000 for EqPac synthesis activities, $20,000 for SeaWiFS data analysis and $133,000 for a synthesis and modeling workshop, to be held in the summer of 1996 and intended to be the first of several annual events. The third-year figures (FY 1997) include $40,000 for Arabian Sea synthesis activities (as well as funds for another modeling and synthesis workshop and SeaWifs workshop). Hugh noted that the planning office budget contains close to $400,000 in funds for synthesis activities over the next three years.

Hugh Ducklow listed three more topics for the morning's discussion: *

the proposed synthesis and modeling workshop,

the pros and cons of planning one final field program in the North Atlantic,

the future of the U.S. JGOFS time-series programs.

Barbara Prezelin began the discussion with a question about the nature of the workshop. Duck observed that the only conditions defined so far are that the topic must be something to do with synthesis in U.S. JGOFS and that the budget for the workshop is about $100,000. Jorge Sarmiento explained that he visualized the meeting as a chance to get a good cross section of modelers and field researchers together to talk about what has been accomplished and where the major issues lie. He views it as an opportunity to put together an overview rather than as a follow-on to the Toulouse modeling meeting.

Otis Brown suggested that the workshop have the "science camp" style of the Scottsdale EqPac workshop and that it be at least a week long. Dick Barber explained the organization of the Scottsdale workshop and noted that this approach to EqPac synthesis had worked well.

Following discussion with Dick Feely about using the opportunity to compare global CO2 survey results and modeling efforts, Jorge reiterated the importance of looking at issues broadly rather than focusing upon what is particularly relevant to a synthetically oriented study in the North Atlantic. Duck noted that he was hearing an interest in focusing on overviews, important issues and bringing modelers and field workers together, but not a charge to produce a plan for a particular study. In answer to a question from Marlon Lewis about the objectives of the meeting, Dick Barber said that the meeting should be conceptual and scholarly rather than programmatic. Jim Murray urged a tight focus rather than an overwhelming agenda.

Dave Karl asked what had happened to the idea of holding a series of workshops in recognition of the first 10 years of U.S. JGOFS. Otis pointed out that the proposed annual synthesis workshops could address the topics considered in the context of a 10th anniversary meeting. Jorge asked about number of participants. Jim again suggested focusing upon several specific topics, such as the relative importance of physical versus biological factors in controlling carbon flux or the controls on primary production. Jorge noted a disconnect in the program between the global and the local view and said that the workshop should concentrate on addressing this problem.

SSC members agreed that the workshop should be sequestered, camp-style, a week to 10 days long, and held in a nice place. Participants should number no more than 50.

Duck went on to note several more points. Jorge is now the exec plus member responsible for synthesis and thus de facto head of the task team that is being formed to work on this topic. This team should have about six members, half modelers and half field researchers. Duck urged interested SSC members to volunteer. One of the first tasks of the group will be to plan and carry out next summer's workshop. Another task that could fall to this working group, Duck said, is consideration of successor programs to come after JGOFS.

Turning to the subject of a North Atlantic field program, Duck reminded everyone that the current plan was to have Scott Doney organize a North Atlantic workshop. Barbara Prezelin and Paul Quay raised questions about having such a workshop before the synthesis meeting this summer and about discussing a new field program at all, given the projected constraints on the U.S. JGOFS budget in upcoming years. Duck noted that the study under discussion would not under any circumstances be a full-scale field study and that it would have to fit under the $2 million limit per year discussed earlier. Otis reminded SSC members about the "mini process study" concept developed a number of years ago and expressed his agreement with earlier comments about the importance of continuing to do field work as syntheses emerged. He and Paul agreed that all the SSC could say right now was that new field efforts costing more than $2 million a year would be beyond the scope of the program.

Bob Anderson pointed out that the nature of the CO2 sink in the northern hemisphere was a topic of much discussion in the literature. He argued that it was timely to take what JGOFS has learned and decide whether or not it is feasible to undertake a synthetic basin-scale study in the North Atlantic with both modeling and field components. Noting that he has been a contributor to the debate about terrestrial versus oceanic sinks, Jorge said that a resolution of this question would be a real advance. Barbara suggested that the topic be considered at the synthesis workshop, but Duck reiterated the concern over forcing the workshop to focus on programmatic rather than scholarly issues. Phil Taylor applauded the discussion and observed that a North Atlantic study could be conducted either within JGOFS or outside of it, like the iron experiment.

Duck asked committee members how confident they were that JGOFS hypotheses could be tested without further field work. Marlon argued that it would be disappointing to finish the program with a number of untested hypotheses; Paul observed that such a study could be done outside of JGOFS. Duck also reminded everyone of their commitment to the international program, which regards the North Atlantic as a priority. He also expressed his hope that EOS would be in operation by 1999, observing that it would be good to keep open the option of a field study in that time frame.

Dick Barber reiterated the importance of looking at the North Atlantic in a conceptual way, noting that EqPac results pointed to the North Atlantic. The global biogeochemical cycles are most influenced by the big unbalanced systems, not balanced ecosystems like the equatorial Pacific, he said. Otis pointed out that a field study means new observations, not necessarily big ships and many investigators. All parties agreed to table the question of whether or not to proceed with planning for a field study in the North Atlantic for the time being.

Discussion of the future of the U.S. JGOFS time-series studies focused on the question of whether they should continue as research-oriented programs or switch into an operational mode, perhaps under the umbrella of the Global Ocean Observing System (GOOS). One question was when. GOOS is not likely to be ready to take over existing programs during the next two years, Tony Knap said.

Tony and Dave Karl pointed out that if the time-series studies are to continue in their present form with support from NSF for the next couple of years, a decision must be made soon. Dave reviewed the history of the time-series programs and emphasized the progress made in installing buoys with continuous monitoring systems. He said that he thinks it best if BATS and HOT remain NSF-supported research programs for now, and he suggested that a possible home might be NSF's Long-Term Ecological Research (LTER) program.

The LTER program has 18 sites at present. NSF provides $685,000 per year per site plus logistical support. Barbara seconded the idea of exploring an LTER connection, mentioning also the smaller and newer Land-Margins Ecosystems Research (LMER) program.

Stating that he was impressed with the time-series work in JGOFS, Jorge urged the committee to consider what JGOFS gains from having longer time-series studies. Dave and Tony pointed to the usefulness of uncovering trends and cycles in temperatures, gas fluxes and other variables over decades and longer time periods. Dick Barber cited a paper that shows how conclusions change with assessment of longer and longer records and urged that the argument to continue HOT and BATS be based on the actual accomplishments of the first 10 years. Time-series directors need to propose a project design that can be perpetuated, focusing on what can be done in perpetuity, he said.

Otis noted that the real cost of doing time-series as we do now is roughly $2.5 to $3 million a year, a level of investment that was undertaken for research purposes, not long- term monitoring. We can't make that investment forever, he said.

Duck asked when Tony and Dave need a recommendation from the time-series oversight committee. They said that they need a decision on direction in the spring in order to prepare proposals by next summer.

Tony argued that the time-series studies need to reduce their dependence on shipboard measurements and to depend more upon moored instruments and drifters. Tony and Dave accepted the charge to make their programs as cost effective as possible.

Bob Anderson noted that time-series studies have contributed substantially to our understanding of nitrogen and phosphorus cycles, among other things. Although the programs will have to shift to another mode of operation sooner or later, he said, they should continue to receive support for a period of transition. Neither GOOS nor the LTER program is a realistic option right now. Bob argued that two year's transition was not long enough and suggested perhaps another five-year cycle of support.

Dick Feely stressed the importance of offering guidance to GOOS as it developed and agreed to serve as liaison between the two programs. Relationships between the two programs will be an agenda item at the next meeting.

Dick Barber expressed the view that the conceptual fit between JGOFS and the LTER program was better than the fit between GOOS and JGOFS and that the LTER program would be a better long-term home for HOT and BATS. Jorge and Taro pointed out that there are major regimes that the TS studies do not address.

Duck proposed expanding the charge to the time-series oversight committee to explore this matter further. He summarized the views expressed by the SSC as follows: the time-series studies should continue after JGOFS; their research focus should continue, but they can't continue under the JGOFS umbrella past a certain point.

Mike Reeve expressed the view that the studies were likely to continue as OCE-supported projects and that they were likely to

continue until the end of JGOFS, as long as the proposals were as good as they have been. Beyond that is not sure, he said.

Otis suggested the need for a critical evaluation of what has been done at each time-series site, regardless of whether JGOFS wants to continue the studies. Dave noted that the oversight committee was an entirely new group and suggested that either Tom Dickey or Steve Emerson continue as a member. Duck said that he would get in touch with Jim McCarthy, the new chairman of the committee, and encourage communication with Dave and Tony.

**26.15 Annual U.S. JGOFS Report**

Finally, the committee discussed briefly the merits of producing some sort of report, annual or otherwise, that would provide a quick and comprehensive review of U.S. JGOFS in non-technical language. Dick Barber argued that an overview article in a journal is a better investment of resources than a report. Otis agreed and suggested that the summer synthesis workshops would provide a good context in which to produce overview articles. Mike Reeve noted that lots of people do not want to bother with looking at home pages and suggested that a glossy brochure would be useful. Several people cited the IGBP publication *Reducing Uncertainties* as a particularly good example of a well-written overview. Those remaining agreed that periodic reports of roughly 16 to 20 pages with good graphics would be a good thing. Philip Williamson, organizer of the IGBP report and several JGOFS publications, will be consulted.

**26.16 Other Business**

A few bits of business took up the last minutes of the meeting. The next meeting of the steering committee will be held next summer in conjunction with the synthesis and modeling workshop and, possibly, the first Arabian Sea data workshop.

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Appendix 2

**US JGOFS**

**Resource Summary (in $K)**

| | FY 96 | FY 97 | FY 98 | FY 99 | FY 00 | FY 01 | FY 02 |
|---|---|---|---|---|---|---|---|
| So. Ocean P.S. | 4500 | 9700 | 8500 | 4000 | 500 | | |
| Arabian Sea P.S. | 5121 | 1464 | | | | | |
| Global Survey | 1500 | 1500 | 1500 | 1500 | | | |
| Time-Series | | | | | | | |
| HOTS/BATS | 1543 | 1728 | 1750 | 1760 | 1770 | 1790 | 1800 |
| Moorings | 1100 | 300 | ? | ? | ? | ? | ? |
| Auto. Instr. | 700 | 250 | ? | ? | ? | ? | ? |
| Modeling and Synthesis | 760 | 760 | 760 | 2000 | 3500 | 4000 | 4500 5000 |
| Data Management | 250 | 260 | 270 | 280 | 290 | 300 | 400 |
| Planning/Implemt. and Synthesis | 774 | 1005 | 1064 | 1128 | 1341 | 1360 | 1380 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Totals | 16248 | 16967 | 15084 | 12168 | 7901 | 7950 | 8490 |

Appendix 1

**U.S. JGOFS BUDGET PROJECTIONS**

***LEVEL FUNDING SCENARIO -- October, 1995***

***Thousands of Dollars***

| | **FY 1995** | **FY 1996** | **FY 1997** | **FY 1998** |
|---|---|---|---|---|
| Science Dollars (Real) | 10,000 | 10,000 | 10,000 | 10,000 |
| Committed/Obligated | 10,781 | 10,758 | 6,350 | 1,550 |
| Available | **-781** | **-758** | 3,650 | 8,580 |
| | | **MAJOR ELEMENTS** | | |
| EqPAC | | | | |
| HOTS & BATS | 766 | 2,431 | 1,450 | ? |
| ASPS (Science) | 6,657 | 5,400 | 2,000 | 0 |
| Standards | 195 | 200 | 200 | 200 |
| Modeling & Synthesis | 275 | 600 | 600 | ? |
| Data Mgmt. | 219 | 246 | 242 | 250 |
| P&I Office | 1,783 | 1,000 | 1,000 | 1,000 |
| Miscellaneous | 148 | 100 | 100 | 100 |
| FY Carryover | 738 | 781 | 758 | 0 |
| OCE SCIENCE TOTAL | 10,781 | 10,758 | 6,350 | 1,550 |
| | | **SOUTHERN OCEAN PROCESS STUDY** | | |
| Estimated Cost: Science | | 6000 | 6000 | 6000 |
| OPP Funding | | 6000 | 3000 | |
| OCE FUNDING | | | 3000 | 6000 |

*Figures assume level U.S. JGOFS funding for FY 96 through 98.*