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Sardine and Anchovy Recruitment Prediction — South Africa

by Suzanne J. Painting

The pelagic fishery, predominantly anchovy, in the southern Benguela upwelling region is of great commercial and socio-economic value. Annual landings average 400,000 mT and have a value near U.S. $70 million. The life-history of the anchovy, *Engraulis capensis*, is relatively well understood (Fig. 1). Adults spawn on the south coast throughout summer; and eggs and larvae are transported by a jet current up the west coast. Late larvae and/or juveniles are either transported or migrate into the nearshore nursery area.

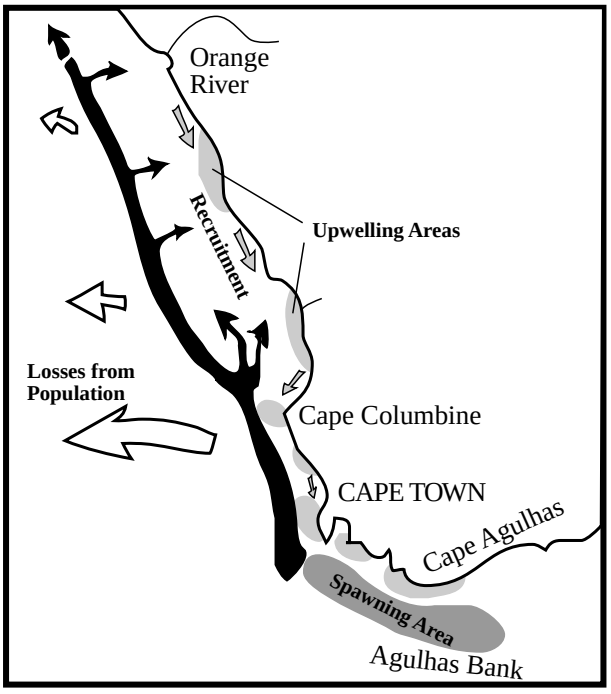

Figure 1. The life history of anchovy in the south west Cape; it includes a spawning region at a shelf-break front offshore of an upwelling center, a transport phase alongshore (black arrows), a recruitment and nursery region, a return migration (nearshore southward arrows) and a potential for offshore losses (large open arrows).

These nearshore regions are extremely productive because the prevailing southerly winds cause episodic upwelling of cool, nutrient-rich water throughout much of the year. The commercial fishery for anchovy is based on fish (recruits) which are 6-9 months old and have attained 9 cm. In spring the recruits begin their return migration to the Agulhas Bank on the south coast to spawn. Fishing quotas for the following season are provisionally determined on the basis of estimates of the total biomass of the spawner stock in November, but quotas are adjusted during the fishing season using acoustic surveys. Poor correlations between spawner biomass and recruitment the following year complicate management of these resources.

The Benguela Ecology Program (BEP) in South Africa recently initiated a new Sardine and Anchovy Recruitment Prediction (SARP) program involving scientists at the Sea Fisheries Research Institute (SFRI) and the University of Cape Town (UCT). Cruises are done every month during the summer spawning season of the anchovy to determine

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within-season variability in spawner stock size, fish condition, egg production rates and environmental factors (e.g., food concentration, water column stratification). Recruits captured six months later during a winter survey are aged to determine birth-date distributions, which are then related back to the variability observed during the spawning season. The overall objectives of the SARP program are:

- To identify the key biological and environmental factors regulating the recruitment of anchovy and sardine.
- To describe their variability and quantify their potential and realised impact on recruitment.
- To develop the ability to predict the spawning success of anchovy and sardine from year-to-year and so allow more rigorous management of these resources.

During its initial phases, the SARP program will focus only on spawner stocks found on the western Agulhas Bank (i.e., west of Cape Agulhas) although recent studies suggest that a large spawner biomass may concentrate on the eastern side of the Bank as well. Thirteen different projects are incorporated into the SARP program. The specific objectives of these projects include:

- To determine the spatial-temporal distribution and length-frequency distributions of adult anchovy and sardine on the western Agulhas Bank and west coast.
- To determine egg production rates and gonad states of anchovies and sardines.
- To collect biological data on anchovies, sardines and round herring.
- To estimate the availability of planktonic food in relation to hydrography and the food requirements of pelagic fish.
- To determine rates of invertebrate predation on pelagic fish eggs and larvae.
- To examine within-season variability in anchovy spawning in relation to environmental factors.
- To assess the nutritional condition of anchovy larvae in relation to environmental factors.

Details of Summer SARP Cruises

SARP cruises take place every month from September to March (austral summer) on the F.R.S. *Algoa*. The total number of days per cruise alternates between 6 and 8 days. The area covered on the shorter surveys is between Cape Agulhas and the Olifants River. On longer cruises the survey grid includes a two-day acoustic survey of pilchard stocks east of Cape Agulhas, and extends only as far north as Cape Columbine.

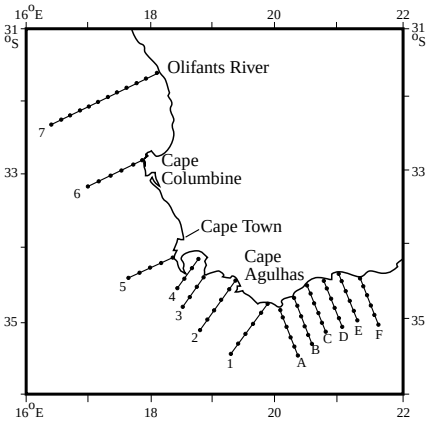

Figure 2. Transects occupied during SARP sampling off south west Cape. Lines 1-7 are done during 6-day cruises; lines 1-6 are done during 8-day cruises; lines A-F are acoustic transects done during 8-day cruises.

A standard grid with 7 sampling lines has been designed for the cruises (Figure 2). Transects (lines 1-7) start as close as possible to the coast and extend to the 200 m or 500 m depth contour, with stations spaced every 10 nautical miles (nm). Acoustic surveys for pelagic fish are conducted while underway, and midwater trawls are done on an *ad hoc* basis. An acoustic Doppler current profiler (ADCP) is also operated while underway in order to obtain current profiles. Pelagic fish eggs and larvae are collected from the upper 70 m at each station using a vertical Calvet net haul and an oblique Bongo tow. CTD's at each station provide water column hydrography and vertical profiles of fluorescence. Size-fractionated chlorophyll analysis is done on water from the surface and the subsurface fluorescence maximum. Five of the transects (Lines 1,2,5,6 and 7) are "Full Biological Lines" and are sampled more intensively to determine zooplankton biomass and copepod secondary production rates (from egg production and molting rate experiments).

Greater emphasis is placed on acoustic surveying during the 8 day cruises. A standard acoustic grid with 6 transects (A to F in Fig. 2) has been designed for the area between Cape Agulhas and Cape Barracouta in the east. These lines are 50 nm long, with stations at 10 nm intervals. At each of these stations an electronic bathythermograph (BT) is deployed to obtain a profile of water column temperature. There is no other sampling at these stations. After the two day acoustic survey of lines A to F, the ship does a standard survey of lines 1 to 6, as described above. During the 6 day cruises, lines 3, 4 and A to F are omitted, and line 7 is sampled.

SARP—South Africa, in its present format is planned to continue over the next two to five years. Future research plans may include greater emphasis on larval research, and the dynamic linkages between the eastern and western Agulhas Bank regions. *(Dr. Suzanne Painting is a research scientist with the Sea Fisheries Research Institute in Rogge Bay, South Africa)* ΔΔΔ

GLOBEC International Southern Ocean Planning

by Eileen Hofmann

The unique characteristics of the Antarctic marine food web make the Southern Ocean an ideal environment in which to test many of the GLOBEC core hypotheses that consider the effects of variability in the physical environment on population dynamics. Consequently, U.S. GLOBEC and GLOBEC International have identified the Southern Ocean as a potential site to conduct research on the response of the marine ecosystem to climate change. Given the nature of Antarctic research, any GLOBEC initiative in the Southern Ocean will be international in scope, making it natural that GLOBEC International should take the lead in the organization and planning of a Southern Ocean GLOBEC program.

From 15 to 17 June 1993, the first meeting of the International GLOBEC Southern Ocean Planning Group was held at the Center for Coastal Physical Oceanography of the Old Dominion University in Norfolk, VA. This meeting was convened under the auspices of the GLOBEC International program and was attended by 26 scientists who represented 9 nations and the Intergovernmental Oceanographic Commission (IOC). The goals of the meeting were to define key questions and the framework to be used as a basis for the development of an implementation plan for an international Southern Ocean GLOBEC program.

The first day of the meeting consisted of several overview presentations. The first of these reviewed recommendations from earlier GLOBEC efforts that were relevant to the goals of the Southern Ocean meeting, such as the U.S. GLOBEC Southern Ocean Workshop held in 1991 and the report of the GLOBEC Working Group on Population Dynamics and Physical Variability. Following this, presentations were given on physical processes as related to site selection, animal physiology and distribution as related to the Southern Ocean marine food web, fish and krill distributions, marine bird and mammal distributions, and technology capabilities, especially in regard to satellites. Following the overview presentations, the meeting participants divided into working groups which met on the second and third days. At the end of each day, a plenary session was convened for a discussion of the recommendations from the working groups. Each working group prepared a summary report of the group discussions.

The working groups were structured to focus on population dynamics and physical variability, historical data and data management, sampling and observation systems and modeling. The population dynamics and physical variability working group was subdivided into groups that focused on issues relating to zooplankton, top predators, and interactions between zooplankton and top predators. These working groups were tasked with developing key questions that could be used as a basis for an implementation plan for a Southern Ocean GLOBEC program.

Key questions for GLOBEC-related zooplankton research in the Southern Ocean focused on: overwintering strategies; seasonal and geographical distributions, especially in relation to the environment; factors affecting successful reproduction; physical factors affecting larval survival and recruitment; and the distribution of Southern Ocean zooplankton in relation to the distribution of biomass and reproduction. Key zooplankton species selected for a Southern Ocean GLOBEC program are: *Euphausia superba*, *Calanoides acutus*, and *Metridia gerlachei*. However, the scientific basis of a Southern Ocean program should be broad enough to accommodate research on other zooplankton species, as needed.

The top predator working group identified as key questions: effects of variability in the physical environment on predator populations; the role of sea-ice in affecting top predator populations; krill variability and its allocation among several top predator species; the effect of predator foraging activity on krill distribution; and the nature of the functional relationships between krill availability and performance and survival of its predators. The primary top predator key species for a Southern Ocean program were identified as Crabeater seals, Adelie penguins, Snow petrels, Antarctic petrels, fish, and squid.

The joint zooplankton-top predator working group put forward recommendations on how to structure research programs that include organisms from zooplankton to large mammals, which encompass a wide range of space and time scales. The historical data and data management working group and the modeling working group made specific recommendations that were designed to encourage the use of historical data bases and the development of models for the Southern Ocean prior to a field program, respectively. The sampling and observation working group focused on the need to better incorporate and use remote sensing techniques for studying zooplankton and top predator populations.

The report from the Southern Ocean Planning Meeting will be available from the GLOBEC International Planning Office in late fall 1993 as part of their report series. A second meeting of the Southern Ocean Planning Group is planned for April or May 1994. The objectives of this meeting will be to develop an implementation plan for a Southern Ocean GLOBEC program. The likely venue for this meeting will be Cambridge, England. *(Eileen Hofmann is a member of the GLOBEC.INT Southern Ocean Planning Group and chair of the U.S. GLOBEC Southern Ocean Committee)*

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International Symposium Examines Climate Change Effects on North Atlantic Cod Stocks

by Harold P. Batchelder

Several members of the community of U.S.GLOBEC scientists attended the ICES Symposium on Cod and Climate Change, in Reykjavik, Iceland, 23-27 August. We were welcomed to Reykjavik, Iceland by the President of Iceland, Vigdís Finnbogadóttir. She noted how it was appropriate that Iceland host the symposium on Cod and Climate Change since historically, cod (and fish, generally) have been extremely important to the people of Iceland. Farms were too unproductive to sustain a family and fish were an important food of the earliest Icelanders. The President quoted an old Icelandic saying, "*Lifid er saltfiskur*"—translated "*Life is Fish*". In days past, codfish were a form of currency, with one cow equal in value to several "well-fed" ewes or "240 fat and juicy fish". Further illustrating the importance of fish, and especially cod, to the Icelanders is the Insignia of Iceland (Icelandic Coat of Arms introduced in 1591) which depicts a split, dried cod with a crown. Following the President's welcoming address, we enjoyed three Icelandic Folk songs, a Finnish boat song, and an Irish Folk song performed by a choir of young Icelandic singers. All in all a very pleasant, and unexpected, way to open an international symposium. After the President of ICES, D. de G. Griffith, and the convenor of the symposium, Jakob Jakobsson made their opening remarks, the scientific sessions began. One advantage to the ICES symposium format is that there is only a single scientific session at one time—meaning that the participants are able to hear every presentation. For the Cod and Climate Change (hereafter CCC) symposium, the presentations were divided into eight scientific sessions.

Session 1. Historic Overview. [4 oral, 3 posters]—This session highlighted changes in cod stocks and cod fisheries using diverse data sources ranging from anecdotal reports from Icelandic Annals, population trends, taxation levels, more recent catch statistics, and bioarcheology (estimation of the size of codfish from bones found in archeological sites).

Session 2. Diagnosis of the causes of trends and fluctuations in cod stocks, with reference to environmental influences, anthropogenic influences (fishing, pollution), and interactions with other species (including marine mammals and birds). [12 oral, 3 posters]—During this session overviews were presented of changes in both fisheries and environmental factors for each distinct major cod stock. NW Atlantic (Georges Bank, Scotian Shelf, Gulf of St. Lawrence, Labrador and Newfoundland), Iceland-Greenland complex (Greenland and Iceland stocks), NE Arctic (Arcto-Norwegian stock) and marginal or enclosed sea (North Sea and Baltic) stocks were discussed.

Session 3. Physical (meteorological and oceanographic) processes and models of a) North Atlantic circulation and shelf systems and b) regions of importance of cod, with special emphasis on changes to be expected in the physical environment of cod. [5 oral, 4 posters]—Papers in this session directly addressed the focus of the symposium—how does (or has) climate affected the abundance and/or distribution of cod in the North Atlantic. Large-scale circulation changes, effects of the Great Salinity Anomaly, and shelf circulation are some of the "climate-related" processes that were demonstrated (or hypothesized) to affect the physical environment of cod.

Session 4. Models of bio-physical processes influencing the dynamics of cod populations. [7 oral, 3 poster]—Papers in this session ranged from effects of the environment on the smallest scales influencing swimming and feeding behavior of larval cod, and fertilization success of spawned eggs, to larger scale advection and transport and its effects on residence times of cod eggs and larvae in suitable habitat. Dr. Gregory Lough (National Marine Fisheries Service, Woods Hole) presented results from a modelling study of retention time of cod eggs and larvae on Georges Bank that he and his coworkers have done with U.S. GLOBEC funding.

Session 5. Biology of cod (eggs, larvae, juveniles, and adults), stock identity, migration, stock structure, recruitment processes, and population dynamics. [16 oral, 19 posters]—This, the largest, session included presentations on a broad range of issues related to stock structure (age and size at maturity, growth dynamics, temperature preferences, migration patterns) and recruitment—all with a view towards the effects of environmental conditions, and changes thereof, as a determinant of observed patterns. Most presentations were restricted to results from a single cod stock. Dr. Keith Brander (Lowestoft, UK) argued that the research findings accumulated for separate regional cod stocks are of considerable value in generating hypotheses when compared inter-regionally. Through such comparisons of patterns of occurrence, growth and survival in different areas, ideas may emerge that are not evident from single site results alone.

Session 6. The position of "king cod" in the various ecosystems and relevant management implications,

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(CCC Symposium—(Cont. from page 4)

e.g., prey and predators of eggs, larvae, juveniles and adult cod. [5 oral, 3 posters]—This session examined trophodynamic aspects of cod, including predation of cod on capelin and their own species (cannibalism) and predation upon cod by invertebrates, fish, mammals and birds.

Session 7. Experimental studies of the biological performance at various stages of the life history. Spawning, larval survival, maturation, and growth of cod from contrasting environments. [6 oral, 4 posters]—Papers in this session discussed egg production, effects of the environment on eggs and the behavior of cod larvae, and the influence of egg size on egg and larval survival.

Session 8. Studies on physiology and genetics, particularly those which indicate the response of cod under changing environmental conditions. [5 oral, 7 posters]—The linkage between identifiable genetic structure and physiology was a focus of the papers presented in this session, as were the role (and especially ontogenetic changes in the amount) of antifreeze proteins in cod survival and distribution (off Labrador) and new genetic techniques of identifying geographic and parentage variation.

Summary

The meeting was excellently organized and the presentations, and discussions, were very informative. There is a great deal known about cod stocks—both in fisheries and cod biology generally—and the presenters, with few exceptions, directly addressed the issue of cod stocks and cod biology and how they are affected by environmental (climate) change. One theme that came through clearly from the talks and ensuing discussions at the CCC symposium is that most North Atlantic cod stocks have been harvested at levels too high to be sustained. Consequently, many of the abundance (catch) fluctuations in cod stocks are due to fishery-related activities—implementation of new gears, fishing restrictions, or quotas.

The impact of climate or changing physical environment on the cod stocks of the North Atlantic may be small compared to the effect that fishing has had (to date) upon the stocks. Changing environmental conditions, coupled with high harvesting rates, may have accelerated declines in the abundance and structure of some cod stocks. Overall, however, it is unclear where and how we will see climate change in the North Atlantic. Will it be a basin-wide effect, or a local effect? If local, evidence suggests that each cod stock will respond differently. Examples of climate change effects on specific cod stocks were provided in a paper by Bob Dickson and Keith Brander. They document (1) changes in advection affecting the West Greenland stock—i.e., advection of larvae from Iceland that reach West Greenland and then grow up there, (2) effects of the Great Salinity Anomaly on Barents Sea cod stocks, (3) effects of windspeed changes on the Faroes Bank cod—acting through the effect of windspeeds on production, feeding and condition of larval cod, and (4) climate driven changes in the frequency of replacement of low oxygen water with high oxygen water in the Baltic—which changes the volume of the Baltic having conditions suitable for cod egg development and hatching, and larval development.

In days past, codfish were a form of currency, with one cow equal in value to...240 fat and juicy fish.

Nearly all speakers at ICES symposia arrive with several hundred copies of their (nearly) completed manuscript which are subsequently distributed at the meeting on the day of their presentations. The proceedings of this symposium will be published by ICES—but may take a year or more. In the meantime, a list of the titles, authors names and senior author's address are available from Omnet Bulletin Board GLOBEC.STATUS (Message Titled: ICES CCC Titles) for those who are interested in contacting the author directly for a copy (preprint) prior to publication. Alternatively, the list can be provided via internet by requesting it from Hal Batchelder at internet address hpbatchelder@ucdavis.edu. Please specify that you want the ICES CCC Titles and Abstracts.

A Congress Dinner of cod and lamb (two Icelandic staples) followed the closing of the scientific sessions. During these closing dinners at ICES symposia it is apparently traditional for the participants of each nation to stand together and sing one or more traditional songs of their homeland. Many of the nations had prepared for this and were accompanied by guitar (Norway) or had practiced (Canada even had a very fine soloist—Dr. Sally Goddard). The unprepared U.S. contingent (Dr. Mike Sissenwine and Dr. Brian Rothschild, probably aware of the tradition, having left the symposium already) were led by Dr. Fredric Serchuk (NMFS, Woods Hole) and Dr. Kenneth Brink (Woods Hole Oceanographic Institution)—and accompanied ably by Greg Lough (NMFS, Woods Hole), Jim Meehan (NOAA), Bill Peterson (U.S. GLOBEC Interagency Program Office) and Hal Batchelder (U.S. GLOBEC SSC Office)—in rousing renditions of "Home, Home on the Range" and "Take Me Out to The Ballgame". Thanks, Fred and Ken.

(Hal Batchelder is an administrative analyst with the U.S. GLOBEC Coordinating Office at UC Davis, and a biological oceanographer when time permits) ΔΔΔ

(Editors Note: Technology Forum is intended to stimulate thought and discussion on diverse oceanographic technology issues. We welcome contributions on technological issues relative to ocean science, but particularly to U.S. GLOBEC.)

Instrumentation For Biological/Physical Microstructure

by Tim Cowles and Russ Desiderio

Laboratory studies of zooplankton feeding mechanisms, selectivity, and swimming behavior over the past two decades have demonstrated the need to understand the conditions experienced by planktonic organisms in their natural habitat, on the time and space scales relevant to the organism. At the same time, advances in oceanic microstructure measurement technology by physical oceanographers have provided temperature, salinity, density, and turbulent kinetic energy shear data on centimeter vertical scales. These data have led to new insights into the intermittent nature of turbulent vertical mixing in the upper ocean. Given these data, what is the appropriate scale for evaluation of the organism's behavioral and physiological response to the mean and fluctuating components of the environment?

Our approach to answering this question has been to integrate new biooptical instrumentation with existing physical oceanographic instruments to obtain coincident biological/physical data over small spatial scales and short time scales. We now have two different instrument packages which can begin to address small-scale biological variability in the field, and its connection to physical microstructure.

Laser/Fiber Optic Microstructure Fluorometer

Our first development project was a free-falling, retrievable microstructure profiler that simultaneously measures fluorescence emission spectra of photosynthetic pigments, temperature, conductivity and horizontal velocity shear. (This system was developed in collaboration with Dr. Jim Moum, a physical oceanographer at Oregon State). A free-fall design was used to eliminate the effects of ship motion on microstructure data. A shipboard Argon laser provides 488 or 514 nm excitation energy through a 200 m optical fiber which is connected to a custom-designed, optical sensor in the nosecone of a well-tested microstructure profiler (Caldwell et al., 1985). The excitation light illuminates a flow-through sample volume (approximately 0.25 ml) in the optical sensor. The fluorescence emitted by the phyto-

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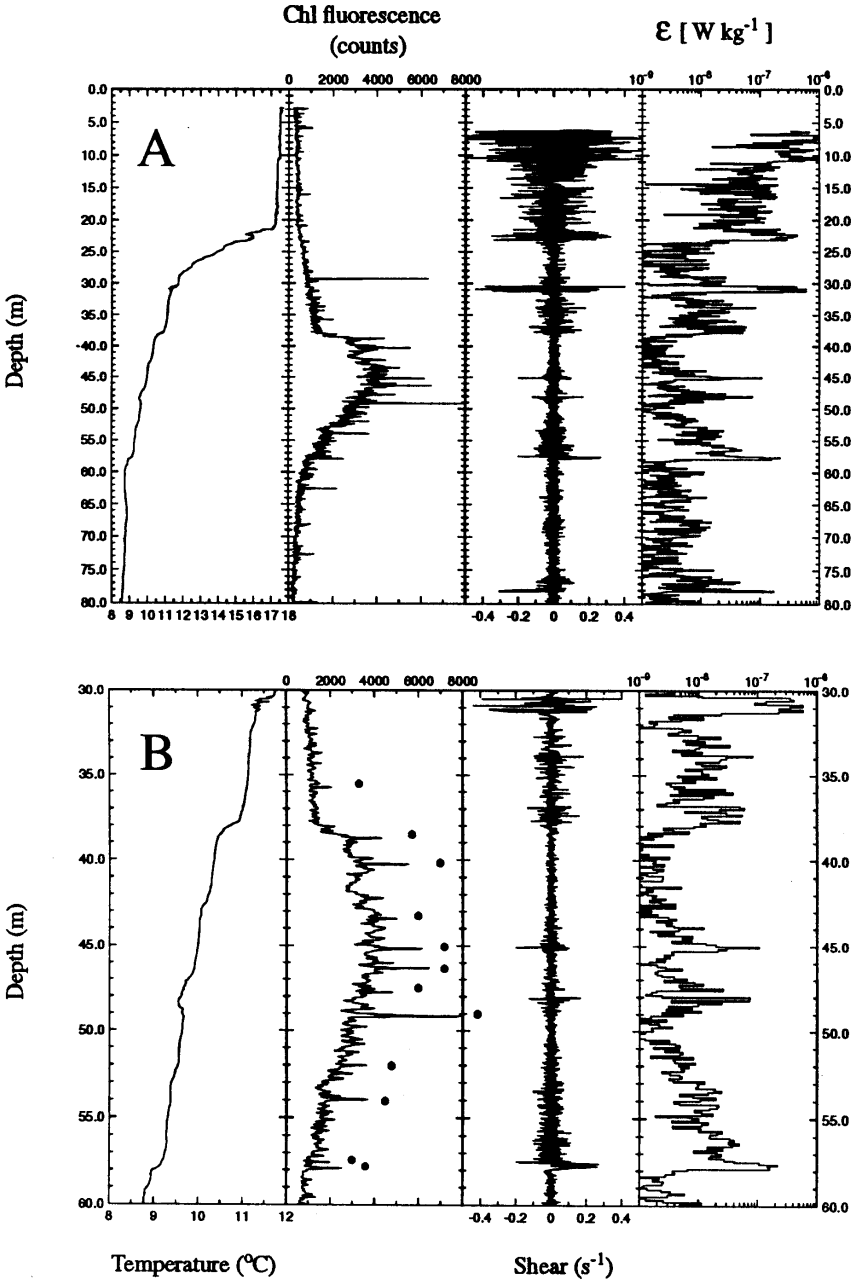

Figure 1. A) Vertical profile (0-80m) of temperature, chlorophyll fluorescence, horizontal velocity shear, and 10 cm estimates of turbulent kinetic energy dissipation during an interval of low wind stress (<3 m s^{-1}). B) An expanded view of the 30-60 m segment of this vertical profile, with thin layers identified with circles.

Microstructure—(Cont. from page 6)

plankton cells in the sample volume is collected by a second optical fiber attached to a shipboard multichannel diode array detector system. The detection system collects 30 fluorescence emission spectra (550nm-750nm) per second, yielding approximately 2 cm vertical resolution of the water column at the 0.50 m s^{-1} drop rate of the instrument package. Microstructure temperature, conductivity and horizontal velocity shear data are acquired simultaneously. Following data collection, fluorescence emission spectra from each 2 cm layer are individually smoothed with a 7 nm wide filter and corrected for baseline shifts and fiber fluorescence. The peak value for chlorophyll (Chl) emission is found between 680-688 nm while the emission maximum for phycoerythrin (PE) is found between 565-595 nm. We use the Raman scattering of water as an internal standard to correct for fluctuations in laser power output and attenuation due to flexing of the optical fiber. Detailed vertical profiles (2 cm vertical resolution) of pigment emission are obtained by integrating the Raman-scaled bands of wavelengths (PE: 565-595 nm and Chl: 680-688 nm) for each of the approximately 5000 emission spectra per 100 m profile (see Desiderio et al., 1993 for instrumentation details). The data for Chl and PE then are merged with the microstructure physical data to provide high-resolution depth profiles. Figure 1 shows a profile collected off the Oregon coast which contains numerous "thin layers", i.e., chlorophyll fluorescence features less than 0.5 m thick, between 30 and 60 meters. Most profiles have several thin layers within and below the thermocline, and successive profiles often reveal a few thin layers which persist for 40-60 mins. One thin layer persisted within a narrow isopycnal band for 6 hours. The fluorescence emission spectra collected with this system can detect differences in photosynthetic pigment composition between assemblages located at different depths within the euphotic zone (Cowles et al., 1993), thus providing *in situ* taxonomic information. These data on thin layers and composition of the autotrophic assemblage provide a starting point for the evaluation of the microhabitat of the individual planktonic organism.Although this profiling microstructure instrumentation has opened a new window on small-scale biological/physical interactions, this instrument is a prototype device. High spatial resolution spectroscopy is possible by using optical fibers for analog optical transmission of *in situ* fluorescence, but the use of optical fibers also limits deployment since manual retrieval (hand-over-hand) is required after every free-fall profile.

Laboratory studies ...demonstrated the need to understand the conditions experienced by planktonic organisms in their natural habitat, on the time and space scales relevant to the organism.

Multi-Excitation Spectral Fluorometer

In June and August 1993, we deployed a multi-excitation spectral fluorometer on SeaSoar during the ONR-sponsored Eastern Boundary Current project off Northern California. This instrument package uses a tungsten-halogen lamp and a rotating filter wheel to provide three colors of excitation light (violet, blue, green) to the sample volume; 30 fluorescence emission spectra (550nm-750nm) are collected per second by twenty pixels of a diode array detector. We thus obtain ten spectra per second from each excitation color. We can resolve phycoerythrin fluorescence emission as well as chlorophyll emission. The primary objective is to exploit the differences in chlorophyll emission intensity as a function of the three different excitation wavebands to extract information on the relative contribution of accessory pigments to the total chlorophyll fluorescence. The lamp, filter wheel assembly, optical path, sample volume, and monochrometer/detector are contained in a 5.8" diam X 22" long pressure case which just fits within the SeaSoar body. We had to implement a custom communications hardware/software package because our data rate exceeded the normal bandwidth of the SeaSoar cable. In the SeaSoar use of this instrument, we can obtain 20 cm vertical resolution of fluorescence emission spectra if the vertical velocity of the SeaSoar is about 1 ms^{-1}. Undulations of the SeaSoar through the upper 300m yields 1-2km horizontal resolution for the instruments on the vehicle.

In October 1993, in East Sound, WA, our multi-excitation spectral fluorometer was combined with a nine-wavelength absorption/beam attenuation meter and a CTD on a retrievable, free-fall package in a collaborative project with Ron Zaneveld (OSU), Percy Donaghay (URI), Casey Moore (WET Labs, Inc) and Mike Linse (Alpha Omega, Inc). This integrated package can resolve centimeter-scale spectral absorption, attenuation, and fluorescence in conjunction with temperature, salinity, and pressure. This type of integrated, *in situ* sensor package will complement the high-resolution microstructure profiling systems, and provides a slightly larger platform for other newly developed instruments which have not yet been miniaturized.

Future Developments and Important Technologies

Long-term gains in our understanding of small-scale bio/physical dynamics will require the incorporation of bio-optical, bio-acoustical, imaging,

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Microstructure—(Cont. from page 7)

and physical measurement systems into integrated towed, profiling, moored and remote vehicle packages. We expect to see the commercial development and miniaturization of solid-state lasers with blue excitation, along with small, msec response CCD detectors. It will be critical to incorporate this technology into instrumentation "suites" which include video and holographic observation systems, chemical detectors, and discrete sampling capabilities. Resolution of small-scale turbulent mixing, as well as the resolution of the small-scale velocity shear field will play an integral role in our understanding of bio/physical interactions, and we need to work closely with physical oceanographers to integrate these measurement systems into new instrument packages. Finally, it is important to stress that compelling scientific questions are the motivating forces for innovative instrumentation development. We have no lack of compelling questions in oceanography. *(Tim Cowles and Russ Desiderio are with the College of Oceanic and Atmospheric Sciences at Oregon State University. They thank NSF and ONR for supporting development of these instruments.)*

References

Caldwell, D.R., T.M. Dillon, and J.N. Moum. 1985. The rapid-sampling vertical profiler: an evaluation. J. Atmos. Ocean. Technol., 2, 615-625.

Cowles, T.J., R.A. Desiderio, and S. Neuer. 1993. *In situ* characterization of phytoplankton from vertical profiles of fluorescence emission spectra. Mar. Biol., 115, 217-222.

Desiderio, R.A., T.J. Cowles, J.N. Moum, and M. Myrick. 1993. Microstructure profiles of laser-induced chlorophyll fluorescence spectra: evaluation of backscatter and forward-scatter fiber-optic sensors. J. Atmos. Ocean. Technol., 10, 209-224. ΔΔΔ

In Situ Spectral Absorption Meter

by Ronald Zaneveld

An *in situ* spectral absorption and attenuation meter has been developed that measures the absorption coefficient at multiple wavelengths at a rate of several Hz. This instrument is based on the reflective tube absorption meter principle. A collimated beam of light is transmitted through a reflecting tube. Both the directly transmitted light and most of the scattered light are collected using a diffuser and photodiode at the end of the tube. Since most of the scattering in the ocean is near-forward only a small amount of light is lost. The instrument uses precisely the same principle as a spectrophotometer and is perhaps best thought of as an *in situ* spectrophotometer. Wavelengths are selected by means of a wheel containing interference filters in the light source housing. The device contains a beam splitter and a reference detector to correct for drift

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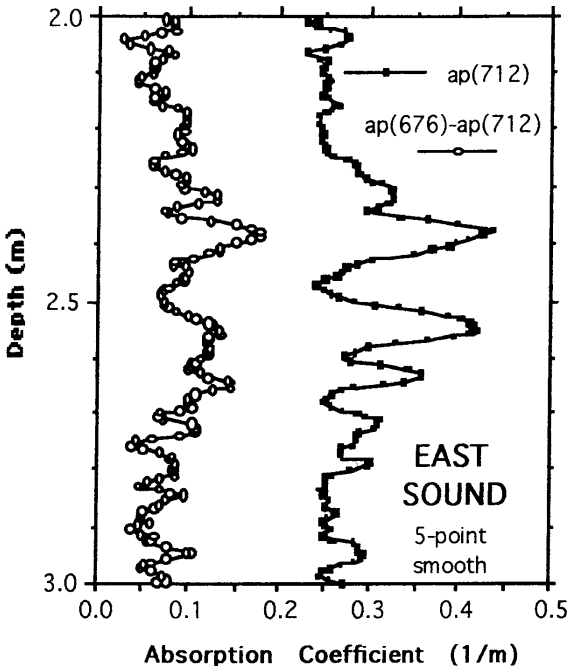

Figure 1. Fine detail of absorption measurements from 2 to 3 meters depth in East Sound.

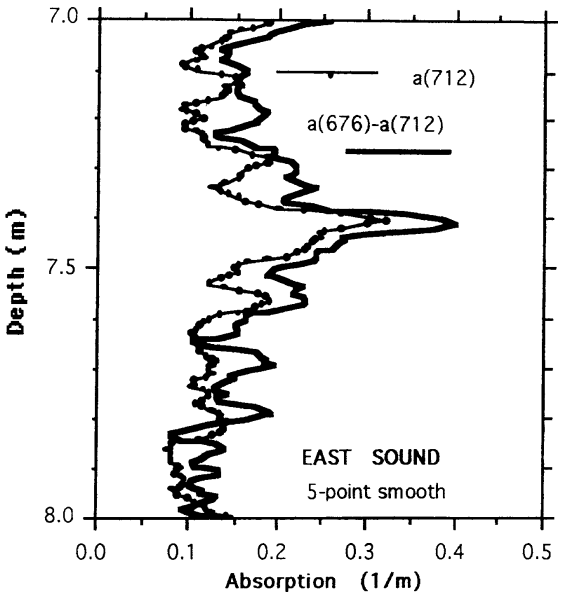

Figure 2. Fine detail of absorption measurements from 7 to 8 meters depth in East Sound.

Absorption—(Cont. from page 8)

in lamp output. The device uses nine wavelengths. Figures 1-3 show profiles and absorption spectra obtained in East Sound, Washington. The difference of the particulate absorption coefficients at 676 and 712 nm (ap(676)- ap(712)) is an indicator of chlorophyll concentration, whereas ap(712) is an indicator of scattering error and therefore estimates particulate concentration. Note from Figures 1 and 2 the fine-scale of some of the vertical structure, with some of the layers only ca. 10 cm thick. Since the device combines the measurement of spectral absorption with spectral attenuation, we can calculate the scattering coefficient from the difference of the attenuation and absorption coefficients. We can then obtain the scattering error for the absorption meter at any wavelength.

Current Status

WET Labs of Philomath, Oregon (503) 929-5650 now produces the 9-wavelength, absorption and attenuation meter (ac-9) commercially. They also produce a three-wavelength version (ac-3) and a device that measures the chlorophyll absorption at the red absorption peak. These devices sample at 12 Hz and consume 3 watts at 12 volts. They measure 46 cm x 10 cm (length by diameter) and weigh 2 kg in air. Signal output is either analog or RS-232 (serial), so that they can be readily interfaced to CTD's.

Future Development

WET Labs, together with Satlantic, has also received a NASA-SBIR grant to develop a combination spectral absorption, backscattering, attenuation and irradiance sensor. If the second phase is funded the combination device should be commercially available in about one year. Oregon State University, with a subcontract to WET Labs, has requested funding from the NSF to develop an *in situ* spectral fluorescence sensor. Development should take two years and make the instrument available in mid-1995. *(Ron Zaneveld is with the College of Oceanic and Atmospheric Sciences at Oregon State University)*

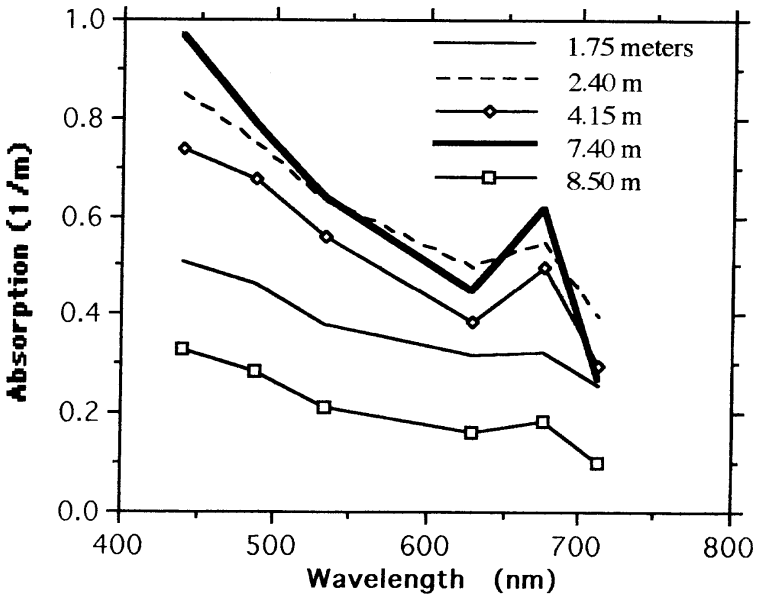

Figure 3. Spectra of raw absorption measurements from various depths in the East Sound profile.

References

Zaneveld, J. R. V., J. C. Kitchen, A. Bricaud and C. Moore. 1992. Analysis of *in situ* spectral absorption meter data. Ocean Optics XI. G. D. Gilbert, Ed., Proc. SPIE, 1750, 187-200.

Moore, C., J. R. V. Zaneveld and J. C. Kitchen. 1992. Preliminary results from an *in situ* spectral absorption meter. Ocean Optics XI, G. D. Gilbert, Ed., Proc. SPIE, 1750, 330-337.

ΔΔΔ

Integration of Video Imaging with Optical Plankton Counting: "Smart-Sampling"

by Peter B. Ortner

For the past decade biological oceanographers in Miami have been employing in-situ strobelight silhouette photography to sample fine-scale zooplankton distributions (Ortner et al., 1981). We were regularly tempted but invariably deferred substituting an electronic or video camera for a photographic camera. While the change would have permited real-time display and make possible extended deployments impossible with film based in-situ photography, the resolution of affordable CCD-based cameras was simply unsatisfactory. Even today, pixel density is orders of magnitude less in CCD video than film cameras. Moreover, absent some mechanical concentration video-based camera systems would take too many empty pictures given their high inherent sampling rates, low animal densities and the comparatively small sample volumes needed to sufficiently resolve small zooplankton. In most oceanic environments one percent or less of the individual images would contain targets of biological interest. The other frames would be empty.

Processing video images in real time has become feasible but still requires comparatively expensive technology in regard to both image acquisition and image processing. This

(Cont. on page 10)

Smart-Sampling—(Cont. from page 9)

type of processing would be inconsistent with our overall objective of facilitating technology transfer by constructing comparatively inexpensive samplers with largely off-the-shelf components. Using an approach we have termed "smart-sampling", however, we have now incorporated video imaging into our strobe silhouette-illuminated zooplankton sampling. Resolution at comparable fields of view are reduced (ca. 40 µm for the deck unit and 100 µm for the *in situ* unit) but still useful.

In collaboration with Drs. Checkley, Scripps Institution of Oceanography, and Herman, Bedford Institute of Oceanography, we have used the Optical Particle Counter (OPC) invented by Dr. Herman (Herman et al., 1988) to flag possible targets before they pass through the field of view of a video silhouette strobe system. Drs. Davis and Gallagher of the Woods Hole Oceanographic Institution (see GLOBEC NEWS No. 3 for a description of their Video Plankton Recorder-VPR), greatly assisted us in the initial selection of video components. In the smart-sampler, the OPC detects and sizes incoming particles. If they fall within a user-specified size range the individual video frame number is then recorded and a digital flag encoded on the video tape. Using an inexpensive framegrabber, a desktop microcomputer and commercial image-processing software, images of interest can be processed, their features extracted, compressed and stored at rates up to 0.5 Hz upon optical disks.

Integrating the instruments reduces the data flow often more than a hundredfold and simplifies data processing proportionally. The OPC (not the video camera) is the primary sampler. It counts and sizes every single particle encountered (up to 200 Hz), while the video images are used predominately for target identification (taxonomy) of the OPC size classes. Comparatively large amounts of data can be efficiently processed. Figure 2 depicts a transect of ca. 32 km that reaches an acute midshelf front. At the front the abundance of small copepods (the dominant particle type) plummets. Using the computer-encoded video tape and the synchronized OPC datafile we can regenerate another set of images for a size class not originally selected.

As in our in situ photographic silhouette system, strobe illumination is absolutely essential in eliminating blurred images because the organisms move rapidly through the field of view. Moreover it faciliates seeing near transparent objects like teleost eggs. Because we are actually imaging the shadow of objects comparatively near the light source rather than the light reflected from distant objects, we can use a low power strobe of our own design which has facilitate packaging the unit for in-situ application. Finally, since the video silhouettes are used primarily for target identification with the "smart-sampling" approach it is unnecessary for many purposes to image every particle - merely a random subsample. This allows us to strobe at the video frame

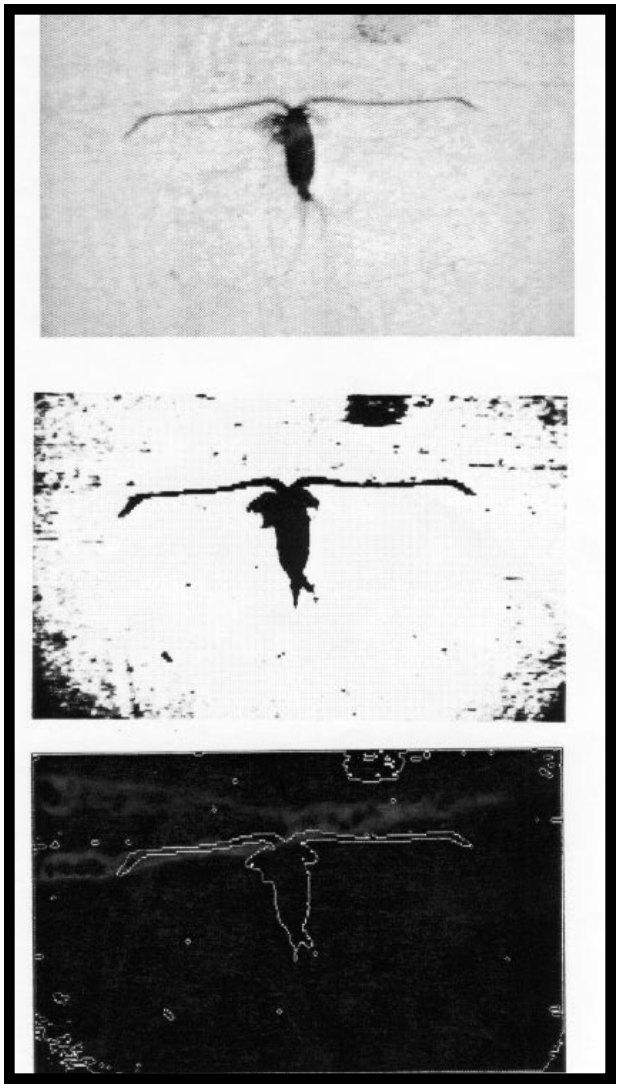

Figure 1. Top) Raw digitized image of copepod passing through smart-OPC; Middle) Reduced storage image after thresholding and binarization to maximize contrast; Bottom) Copepod outline "cartoon" after edge detection.

interval rate (30 Hz) rather than the field rate (60 Hz) so that the two fields representing a single exposure can be integrated which doubles the number of independent horizontal lines in the pixcell array.

A far better technical solution for a "smart-sampler" would be to use a "snapshot" CCD camera/strobe (akin to our original photographic system but substituting asynchronous for synchronous frame acquisition). Such a fully digital system would free us from the inherent constraints of video technology (the digital to analogue and back to digital conversions). We hope to test this alternative within the next year. Regardless of how plankton images are obtained, it is essential for the various workers in this field to collaborate in

(Cont. on page 11)

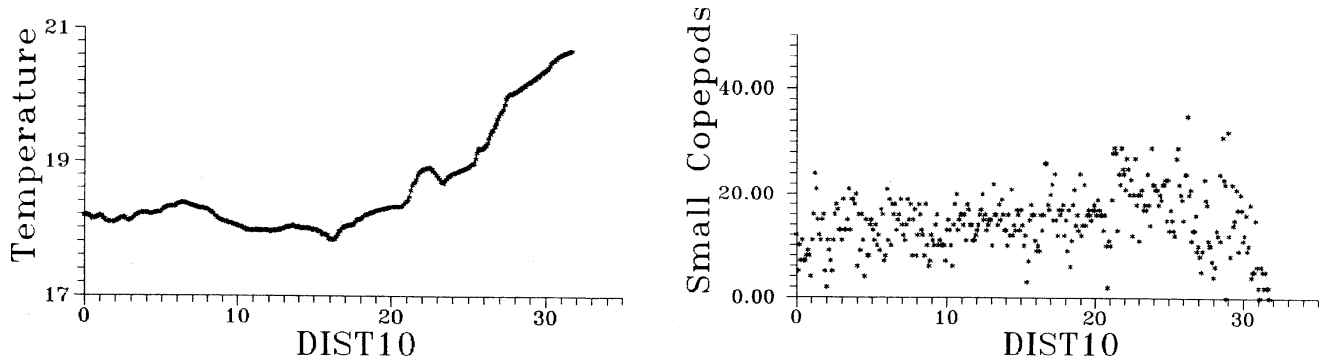

Figure 2. Left) Temperature (°C) along a transect running offshore of North Carolina. Distance along transect is in kilometers. Right) Abundance of small copepods (no. per minute of tow) along same transect offshore. Note that numbers first increase slightly, then decline as warmer water is encountered offshore.

Smart-Sampling—(Cont. from page 10)

establishing a standard protocol for efficient image analysis of plankton "cartoons" (see Figure 1). Purely statistical classification of randomly oriented objects has proven to be less than fully satisfactory. Various alternatives are currently being explored including the applicability of deformable template image analysis techniques.

References

Davis, C. and S. Gallager. 1993. The Video Plankton Recorder. U.S. GLOBEC NEWS, No. 3.

Herman, A.W. 1988. Simultaneous measurement of light attenuance with a new optical particle counter. Cont. Shelf Res., 8, 205-221.

Ortner, P. B., L. C. Hill, and H. E. Edgerton. 1981. *In-situ* silhouette photography of Gulf Stream zooplankton. Deep Sea Res., 28, 1569-1576. ΔΔΔ

Peter Ortner (left) and Dave Mountain, liaison between the U.S. GLOBEC SSC and the Northwest Atlantic/Georges Bank PI's, discuss strategy during a break at a recent SSC meeting in Woods Hole.

CALENDAR—(Cont. from page 16)

15-18 August: ICES Symposium on Zooplankton Production: Measurement and Role in Global Ecosystems and Biogeochemical Cycles, Plymouth, U.K. Contacts: R. P. Harris, Plymouth Marine Laboratory, or J. C. Gamble, Sir Alister Hardy Foundation for Ocean Science, Prospect Place, Plymouth PL1 3DH, UK (Omnet: PML.UK or J.GAMBLE.CPR; Phone: + 44 752 222772; FAX +44 752 670637). (Abstract deadline is January 15, 1994; also see next item in calendar)

19 August: GLOBEC International and ICES Cod and Climate Change Mini-symposium, Plymouth, U.K. Contact: B. Rothschild, CBL, University of Maryland, Solomons, MD; Phone: 410-326-7289; FAX: 410-326-6987; Omnet: B.ROTHSCHILD; Internet: broth@cbl.umd.edu) (see previous item in calendar)

10-14 October: International symposium on the assessment, yield, and long-term sustainability of large marine ecosystems of the Pacific. Qingdao, China. Contact: Q. Tang, Yellow Sea Fisheries Research Institute, 19 Laiyang Road, Qingdao 266003 P.R. China; FAX: 0086-532-270702; Phone: 0086-532-2869103)

24-28 October: Symposium on the Biology and Ecology of Northwest Atlantic Cod. (for further details see announcement on page 15 of this newsletter)

IAI Workshop on Comparative Studies of Oceanic, Coastal and Estuarine Processes in Temperate Zones

by Ruben Lara Lara

August 2-6, 1993, Montevideo, Uruguay was the setting for IAI's first workshop to advance the science agenda for the topic *Comparative Studies of Oceanic, Coastal and Estuarine Processes in Temperate Zones*. Over 80 scientists from the region, as well as representatives from international programs participated in a three day symposium on oceanic, coastal and estuarine processes in temperate zones, in which scientists from throughout the region shared their research studies and programs. The Institute held a two-day workshop during which scientific experts from across the Americas collaborated in producing an extensive report with recommendations on IAI's science agenda for this topic.

The workshop consisted of six working groups: Oceanic Processes; Coastal Processes; Estuarine, Coastal, Lagoons, Fjords, Rivers and Salt Marshes Processes; Data Management and Communications; IAI and International Programs; and Capacity and Needs for Education and Training. The following are conclusions from each working group on initial steps which need to be taken in the development of the research program:

Oceanic Processes. The temperate coasts of North and South America present a unique global research opportunity to compare two pairs of eastern and western boundary currents that share some important features but differ in others. Some of the key issues that should be addressed from this comparative perspective to further our understanding of the impacts of global change on oceanic processes are:

- Development of an oceanographic climatology on a seasonal basis for the south Pacific and Atlantic Oceans;
- Enhancement of continental shelf/slope survey efforts based on determined key spatial and temporal scales of variability;
- Implementation of a continuing sequence of process studies;
- Development and exploitation of retrospective records, i.e., use of high-resolution anaerobic marine sediments;
- Description and understanding of the interdecadal change in oceanic ecosystems;
- Development or adaptation of numerical models of atmospheric and oceanic circulation, and ecosystem response to be applied to Southern Hemisphere regions;
- Advancement of our understanding of plankton distributions and their interannual variability between the northern and southern temperate oceanic zones of the Americas.

Coastal Processes. This working group arrived at the following six general issues which must be addressed so that we may gain an improved understanding of the impacts of global change in the coastal zone:

- Determine the mean state of the atmospheric and oceanic climate;
- Describe the typical scales of variability of the atmospheric and oceanic climate;
- Understand the key responses of coastal ecosystems to the spatio-temporal scales of variability;
- Determine the processes which control the variability of the atmospheric and oceanic climate and their interaction;
- Define the interactions of these processes with socioeconomic systems and increasing human population;
- Incorporate the coastal zone processes into both stochastic and mechanistic predictive models.

Estuaries, Coastal Lagoons, Fjords, Rivers and Salt Marshes. These environments at the land-sea interface are the buffer zone between land and ocean. This interface therefore is the receptacle for most natural and anthropogenic materials reaching the ocean from land. The working group concluded that there are five key issues to address in these regions:

- Evaluate the release of human generated materials either directly or indirectly into semi-enclosed coastal ecosystems;
- Separate the effects of overharvesting or overcultivation from other anthropogenic and natural effects on these ecosystems;
- Study how river flow modifications impact the biotic communities and biogeochemical cycles;
- Understand the morphological, hydrological and hydrographic changes associated with sea level rise;
- Evaluate the alteration of shoreline and bottom topography during near-shore development activities.

One of the greatest challenges faced by the workshop participants was the integration of policy-relevant issues into the natural science perspective. As one of IAI's founding principals, the integration of natural and social sciences has to be advanced in order for the regional community to reach a comprehensive understanding of global change and its impact on society. This integration is an increasingly needed step if we are to work towards a sustainable future.

Training and Education. Several approaches to promoting multi-national and international training and education in IAI Member Nations were considered. Some possible approaches include: fostering cooperative multina-

(Cont. on page 13)

The Inter-American Institute for Global Change Research

by Ruben Lara Lara

The Inter-American Institute for Global Change Research (IAI) is a multinational initiative to establish a regional network of Research Centers dedicated to the monitoring and understanding of global change related phenomena and the impacts of such phenomena on the region's natural systems and human societies. The IAI was conceptualized in response to the growing perception within the scientific community in recent years of global change as a regional issue with global implications. Recognizing the enormous scope of global change issues, eleven countries of the American region signed the Agreement Establishing the Inter-American Institute for Global Change Research on May 13, 1992 in Montevideo, Uruguay; these Founding Parties have since been joined by five additional countries.

The Agreement Establishing the IAI has been ratified by four countries and will enter into force following the ratification of six signatories. Once fully operational, the IAI will be governed by the coordinated efforts of a Conference of the Parties, an Executive Council and an Institute Director. The Scientific Advisory Committee (SAC) will guide the development and implementation of the Institute's scientific agenda.

The primary objectives of the IAI are to conduct interdisciplinary research in global change related fields and to increase the overall scientific capacity of the region. These objectives will be accomplished through the creation of a network of Research Centers dedicated to the study of global change issues which have been identified as priority based on their relevance to the region and potential for contribution to global studies. Results generated from IAI research activities, including data, will be available within the region for analysis and integration in the policy-making processes. Furthermore, the IAI is firmly committed to augmenting existing opportunities for training and education within the scientific fields relevant to global change studies. It is anticipated that IAI Training and Education Programs will foster the enhancement and development of working relationships among the individuals, institutions and governments involved in IAI activities while providing valuable opportunities for technical and information exchanges.

The initial scientific research agenda of the IAI as specified in the Agreement Establishing the IAI, is the result of a multinational and interdisciplinary planning process and is intended to reflect those aspects of global change which have significant physical and socioeconomic impacts on the American Region. As global change is a dynamic issue, it is expected that the agenda will continue to evolve under the stewardship of the IAI's Scientific Advisory Committee.

Seven research topics have been identified as initial priorities of the IAI:

- Tropical Ecosystems and Biogeochemical Cycles
- The Impacts of Climate Change on Biodiversity
- El Niño-Southern Oscillation and Interannual Climate Variability
- Ocean/Atmosphere/Land Interactions in the Inter-tropical Americas
- Oceanic, Coastal and Estuarine Processes in Temperate Zones
- Temperate Terrestrial Ecosystems
- High Latitude Processes.

During this implementation period, the institutional aspects and the scientific agenda of the IAI are being developed by a multinational Implementation Committee (IAI/IC). The IAI/IC has adhered to the principles embedded in the Agreement throughout the Institute's development process, which include: scientific excellence; interdisciplinary collaboration; open exchange of data and information; and commitment to training and education.

The IC Executive Scientist is currently coordinating scientific and program development workshops for each of the seven research foci to be convened by scientific experts throughout the region. Individuals interested in obtaining further information about the IAI and its development activities should contact Dr. Ruben Lara Lara, IC Executive Scientist, by telephone at (301) 589-5747 or by FAX at (301) 589-5711.

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IAI Workshop—(Cont. from page 12)

tional and interdisciplinary research programs; promoting visits and short-term courses of scientists with recognized areas of expertise; convening regional meetings for natural and social scientists; updating undergraduate and graduate-level curricula; supporting exchange visits, pre- and post-doctoral training opportunities in member IAI countries and joint research projects; and developing modeling capabilities in the region.

Data and Information Management. Data and information management provides a critical bridge between national and international global change observations and scientific understanding. This knowledge is the keystone of effective policy decisions regarding environmental issues. During this workshop, scientists from throughout the region agreed on the need to use the data management infrastructure already available in other international programs to facilitate access to data throughout the entire regional scientific community.

IAI and Other International Programs. A broad range of international interactions among global, regional, and national programs addressing the IAI scientific objectives and the major cross-cutting issues such as data exchange and management, modeling, and capacity building are necessary for effective and efficient planning and implementation of such efforts. During the workshop, we reached the conclusion that the main objectives of these interactions should include efforts to facilitate and encourage coordination and cooperation among programs to more optimally use scientific resources, including personnel, facilities, and financial resources; and also to cooperate in identifying priorities and significant gaps that need to be filled to ensure complementarity among the programs.

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Sevastopol Workshop Report

by William T. Peterson

The Woods Hole Oceanographic Institution recently co-hosted a workshop together with the Marine Hydrophysical Institute (MHI) and the Institute of Biology of the Southern Seas (IBSS) of Sevastopol, Ukraine. The goals of the meeting, held in Sevastopol on 20-24 September 1993, were to share what each of us knew about the oceanography of the Arabian Sea, to explore ways and means of sharing data, and to identify counterparts with whom future research collaboration might take place, in the Arabian Sea, Black Sea, and elsewhere. Our hope was that such a workshop would aid greatly the planning of forthcoming JGOFS, ONR, WOCE and GLOBEC efforts in the Arabian Sea. The chief organizers of the workshop were Joel Goldman, Biology Department at WHOI, Hugh Livingston, Scientific Officer, U.S. JGOFS Planning Office at WHOI, Valery Eremeev, Director, MHI and Stanislaw Knonvalov, Director, IBSS. Funding was provided by the National Science Foundation (International Programs and Biological Oceanography), by WHOI, and by NOAA through the U.S. GLOBEC Interagency Program Coordination Office.

Those attending from the U.S. included Joel Goldman, Hugh Livingston, Karl Banse, Ken Brink, John Brock, Ken Buessler, Ed Buskey, Dave Caron, Lou Codispotti, Alessandra Conversi, Alan Devol, Tom Dickey, Hugh Ducklow, Ann Edwards, Margarita Conkright-Gregg, Syd Levitus, Charlie Miller, Mark Ohman, Don Olsen, Dave Stein, and myself. Most of the attendees from the Former Soviet Union were from MHI or IBSS, but Moscow State University and the Ukraine NIRO (a federal fisheries lab in Kerch, Crimea) were represented as well.

The goal of educating each other on what we knew collectively about the Arabian Sea was accomplished through oral and poster presentations. Issues relating to data exchange and future collaboration were discussed during three meetings of six working groups: ocean physics, remote sensing, chemistry, microplankton, zooplankton, and myctophid fishes/squids. One full day was devoted to touring the MHI and IBSS facilities and visiting scientists in their laboratories. Evening social activities assured lively discussions of Arabian Sea and other issues. While there, we stayed aboard a passenger ship, moored next to the Russian fleet.

We learned that at least twenty major research expeditions have visited the Arabian Sea since 1963. However none of the oceanographic data reside in a centralized archive; rather data are kept in various laboratories (at least five in number) both in Moscow and in the Crimea. In the case of plankton data, thousands of plankton samples have been collected and enumerated from the Arabian Sea but most of the data remain on the original laboratory counting sheets. We also learned that a staggeringly high biomass of squid lives in the Arabian Sea, which apparently turns over annually! These squid feed on the large myctophid stocks, doing so even in the oxygen minimum zone; the fate of the squid carbon pool is completely unknown. Not surprisingly, we learned of a large number of papers and monographs that have been published in Russian reviewing aspects of the oceanography of the Arabian Sea. Since few of them have been translated into English, these papers and their contents were unknown to all of us. Each of us returned with at least a dozen monographs which beg translation.

Meeting participants resolved that the first steps toward future collaborations should include three efforts: funding for translation of key papers and monographs, funding for visits of U.S. scientists to the Ukraine for the purpose of writing co-authored review papers based on retrospective analysis of existing data sets, and funding for Ukraine scientists to visit the U.S. and work on joint research ventures, including preparation of review articles. Facilitation of these options is being explored—an ad hoc interagency working group may be formalized soon so stay tuned. In the interim, interested parties should contact Bill Peterson, U.S. GLOBEC Interagency Program Coordination Office (301) 713-2367, W.PETERSON/Omnet. ΔΔΔ

Modelling Physical-Biological Coupling In The Ocean

by James E. Eckman

The first step in launching U.S. GLOBEC was to initiate a number of modelling studies. It was argued that modelling could help guide future field studies, and resolve certain key questions about what measurements need to be taken, at what resolution, and under what conditions. Six

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U.S. GLOBEC

GLOBAL OCEAN ECOSYSTEMS DYNAMICS

U.S. GLOBEC NEWS

U.S. GLOBEC NEWS is published by the U.S. GLOBEC Scientific Coordinating Office, Division of Environmental Studies, University of California, Davis, California 95616-8576, telephone (916) 752-2332, FAX (916) 752-3350. Correspondence may be directed to Hal Batchelder at the above address. Articles, contributions to the meeting calendar, and suggestions are welcomed. Contributions to the meeting calendar should contain dates, location, contact person and telephone number. To subscribe to U.S. GLOBEC NEWS, or to change your mailing address, please call Sharon Lynch at (916) 752-4163, or send a message to Omnet address T.POWELL or H.BATCHELDER or Internet address hpbatchelder@ucdavis.edu, or write to the address above.

U.S. GLOBEC NEWS Staff
Hal Batchelder
Tom Powell
Sharon Lynch

Symposium on the Biology and Ecology of Northwest Atlantic Cod

A symposium will be held October 24-28, 1994 in St. John's, Newfoundland, CANADA, to review recent research on Atlantic cod undertaken by the Northern Cod Science Program (NCSP), the Ocean Production Enhancement Network (OPEN), and Memorial University of Newfoundland (MUN). Researchers not affiliated with these programs are also encouraged to participate. The goals of the symposium will be to summarize current knowledge on cod biology and ecology with particular emphasis on the Northwest Atlantic, to discuss application of recent research results to current fisheries problems, and to provide recommendations for research directions. The symposium will include formal oral presentations, posters, and workshop discussions on relevant topics.

Persons conducting cod-related research are invited to submit titles for paper or poster presentations no later than December 1, 1993. Presentations are encouraged on biological (e.g., phenology, physiology, genetics, growth, survival), ecological (e.g., distribution, abundance, behavior, predator/prey interactions) and physical (e.g., transport, models) processes and on new research methods and technologies. Titles, authorship, affiliation, and paper/poster preference should be sent to:

Symposium on Biology and Ecology of Northwest Atlantic Cod
Department of Fisheries and Oceans, Science Branch
P.O. Box 5667
St. John's, Newfoundland A1C 5X1
Telephone: (709) 772-2051
FAX: (709) 772-6100

Abstracts of papers and posters will be requested in early 1994. Papers and posters will be eligible for publication in a supplement of the Canadian Journal of Fisheries and Aquatic Sciences subject to normal peer review process. ΔΔΔ

Modelling—(Cont. from page 14)

independent modelling projects were initiated as a result of an RFP in early 1990. Investigators supported for these modelling studies were encouraged to meet jointly on occasion to keep each other appraised of progress being made via formal presentations from each program. The most recent meeting was held in March, 1993 at the Southwest Fisheries Center of the National Marine Fisheries Service in La Jolla, California. Ten presentations were made at this meeting by U.S. GLOBEC researchers, and by other modellers carrying out related research programs. *Topical Studies in Oceanography*, an affiliated journal of *Deep Sea Research* devoted to publishing groups of related papers as special issues, agreed to publish papers resulting from the presentations delivered at the La Jolla meeting. These papers provide examples of the broader program of research being carried out by each research team as part of U.S. GLOBEC's initial modelling studies. The issue will be published in early 1994. ΔΔΔ

Arabian Sea Update

In May 1993, U.S. GLOBEC published Report No. 9, an *Implementation Plan and Workshop Report for U.S. GLOBEC Studies in the Arabian Sea*. The report offers two levels of implementation plan for U.S. GLOBEC studies in the Arabian Sea. The first was a modest scale program that could be undertaken in the Arabian Sea during the 1994-1996 frame in conjunction with other programs (JGOFS, ONR/ARI, and WOCE). The second implementation was an ambitious plan designed to answer some of the exciting questions presented by the pelagic ecology of the Arabian Sea; it was presented to provide a framework for a "full-scale" study of the dynamics of the physical regime, mesozooplankton stocks, and stocks of migratory myctophids in the event that at some future time the U.S. oceanographic and fisheries community might revisit the Arabian Sea.

The U.S. GLOBEC Scientific Steering Committee, Arabian Sea Implementation Committee, and Program Office strongly believe that the science issues (for both levels of implementation) detailed in U.S. GLOBEC Report No. 9 on the Arabian Sea represent excellent science. At this time, however, U.S. GLOBEC, because of lack of funds and an underfunded, concurrent program in the NW Atlantic, does NOT anticipate the release of a directed announcement of opportunity for U.S. GLOBEC funding of research in the Arabian Sea in the near-term (i.e., during 1994-1996).

We would point out that three major programs will have ship-resources in the Arabian Sea during the 1994-96 period (most of which are already fully committed). In addition, there are two cruises of a NOAA research vessel scheduled (one in spring [intermonsoon] and one in summer [monsoon] of 1995) for the Arabian Sea. These cruises will be focusing on the interactions of marine organisms with their environment in a GLOBEC sense. Plans are to sample near the JGOFS, ONR/ARI mooring site(s) as well as to traverse the upwelling region. There may be opportunities for participation on these research cruises. Contact for obtaining more information about these NOAA cruises to the Arabian Sea is Dr. Peter B. Ortner at 305-361-4384 (phone), 305-361-4582 (fax), or P.ORTNER (Omnet). Funding for participation on these cruises will have to be obtained from agencies in the usual manner for unsolicited proposals. ΔΔΔ

U.S. GLOBEC Calendar

1994

21-25 February: AGU/ASLO Ocean Sciences 1994 Meeting, San Diego, CA. Contact: E. Hofmann, Old Dominion University, Norfolk, VA. (Omnet: E.HOFMANN; Internet: hofmann@ccpo.odu.edu)

Special session on the effect of stratification on larval fish and zooplankton populations on Georges Bank. Contact: D. Mountain, NFSC/NMFS/NOAA, Woods Hole, MA; Omnet: D.MOUNTAIN; Internet: dmountai@whsun1.whoi.edu)

Special session on modelling physical-biological couplings in the ocean. Contact: J. Eckman, Skidaway Instit. Oceanogr., Savannah, GA; Omnet: J.ECKMAN; Internet: eckman@skio.peachnet.edu)

Special session on decadal-scale variability in the ocean, lakes and the atmosphere. Contact: W. Peterson, U.S. GLOBEC IPCO, NOAA/NMFS, Silver Spring, MD; Omnet: W.PETERSON; Internet: w.peterson@omnet.nasa.gov)

10-11 March: U.S. GLOBEC Scientific Steering Committee meeting, Boulder, CO. Contact: H. Batchelder, Division of Environmental Studies, University of California, Davis, CA. (Omnet: H.BATCHELDER; Internet: hpbatchelder@ucdavis.edu; Phone: 916-752-2332; FAX 916-752-3350).

April: ICES Laboratory workshop on growth and production of *Calanus*. Date and venue still to be finalized. Contact: H.-R. Skjoldal, Institute of Marine Research, P.O. Box 1870 Nordnes, 5024 Bergen, Norway; Omnet: H.Skjoldal)

4-7 April: 5th Global Warming International Conference, San Francisco, CA. Contact: GW International Center, One Heritage Plaza, P.O. Box 5275, Woodridge, IL 60517; Phone: 708-910-1551; FAX: 708-910-1561)

6-8 April: ICES workshop on Translatitudinal study of Calanus finmarchicus. Oslo, Norway. Contact: K. Tande, University of Tromso, Tromso, Norway; Internet: ktande@nfh.uit.no)

9-10 June: U.S. GLOBEC Scientific Steering Committee meeting, Corvallis, OR. Contact: H. Batchelder, Division of Environmental Studies, University of California, Davis, CA. (Omnet: H.BATCHELDER; Internet: hpbatchelder@ucdavis.edu; Phone: 916-752-2332; FAX 916-752-3350).

12-16 June: ASLO and PSA 1994 Joint Meeting, Miami, FL. Contact: A. Szmant, MFB, RSMAS, University of Miami, 4600 Rickenbacker Cswy, Miami, FL 33149; Phone: 305-361-4609; FAX: 305-361-4600; Omnet: A.SZMANT; Internet: aszmant@rsmas.miami.edu) Abstract deadline is January 15, 1994.

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