Annual Report: SCOR Working Group 118

New Technologies for the Detection of Marine Life

Background:

The goals of this Working Group are to identify and foster the development of incipient technologies that will contribute to the detection of marine life over scales of plankton to marine mammals. A strong motivation and focus for this activity is the Census of Marine Life. During the past year WG 118 members have been active both through participation in targeted meetings, where there was direct intersection of interests, and in a group meeting. The decision to participate in targeted meetings was based both on the need to advertise WG 118 activities and also to gain new insights from other groups that would contribute to WG 118's goals. The group meeting, held in Mar del Plata 27 October 2001, which is documented in the attached report "SCOR WG 118 – Mar Del Plata", provided an opportunity for leaders of CoML Pilot Projects to discuss specific technical problems they were confronting, to which the Working Group could contribute. The Working Group plans to meet in Lima, Peru October 28-30, 2002.

WG 118 Meeting in Mar del Plata:

A meeting was held on 27 October at the Gran Iruna Hotel in Mar Del Plata, with timing designed to take advantage of the adjacent IABSE/IABO/IAPSO meetings. Our Working Group had a lively session attended by 23 individuals, nearly all of whom participated in the discussions. The purpose was to encourage the Pilot Project Leaders to identify their technical issues and for the Working Group and others to engage in "brainstorming" sessions in order to begin the process of identifying potentially useful technologies worthy of development. A full report has been submitted to the SCOR Secretariat and sponsor and is available upon request, but the following draws attention to some of the key issues that occupied our attention.

Chemosynthetic ecosystems in the Arctic and North Atlantic Ocean (ChESS). It has already been shown that hydrothermal vents have distinctive chemical signatures that can be used to locate them. This remains a challenging task by traditional shipboard/ROV methods. Could AUVs with chemical sensors be programmed to fly up the concentration gradients and search out the vents, taking photos and video as they go? This comes very close to technology that is now being developed and will form part of an active discussion at the Lima meeting.

Diversitas Western Pacific and Asia (DIWPA). DIWPA needs data loggers for SCUBA divers, habitat mapping technology, a GIS system to link to the Ocean Biogeographical Information System (OBIS), and a machine to assist in the enormous task of preserving information and classifying millions of individual animals and thousands of species. Many possible solutions were put forward and it was agreed that these would be further discussed at the Lima meeting. *Gulf of Maine Project*. This project, and others like it, desperately need well-calibrated fisheries echo-sounders providing a quantitative signal with good dynamic range. Good acoustic surveys and quantitative biological measurements are crucial, with target classification the third component that would contribute to the CoML goal of biomass by taxon. Combined optical and

acoustical techniques seem especially suitable. There was much discussion of ships of opportunity and the need for a reliable 'black-box' that would acquire the needed data. Innovative techniques were required to identify species, with neural networks posited as the kind of automated technology that might help, especially when combined with broad band acoustic and other measurements.

Interacciones entre Stocks Pelagicos, Pesquarias Y Ambiente (ISPPA). This proposed project requires measurements that cover a large area in a short period. Proposed solutions involve the use of the commercial fishing fleet equipped with automated acoustics with automated data processing, multibeam sonar and airborne LIDAR.

Pacific Ocean Salmon Tracking (POST). This is a tagging project and the need is to devise improved tags and improved means of recovering information from the moored detectors. Suggestions include acoustic modems and enhanced power supplies using oil-immersed lead batteries, among other concepts.

Patterns and Processes of Ecosystems in the Northern Mid-Atlantic (MAR-ECO). This ambitious project seeks many new technologies. Deep-sea landers were discussed; the potential use of the NEPTUNE cabled system approach, and the range gated underwater LIDAR developed at MBARI appear to offer particular promise.

Tagging of Pacific Pelagics (TOPP). Another tagging project, but this time with marine mammals, which are generally larger than fish, regularly come to the surface, and therefore offer many more possibilities for information acquisition and downloading. One of the more fascinating possibilities discussed is the potential for simultaneous measurement of other pertinent aspects of the ocean environment in addition to depth and position. For example, in addition to physiological data, the tags can record physical observations, low light level video, acoustic measurements, etc. The possibilities seem very broad.

Participation in targeted meetings of interest to WG 118:

In addition to the Working Group meeting at Mar del Plata, Working Group 118 members participated in various other meetings with intersecting interests. These included the **Partnership on Observations of the Global Oceans (POGO)** (Elgar Desa), the **Oceans** meeting (Emmanuel Boss), **SCOR WG 115** (Van Holiday), **ICES Symposium on Acoustics in Fisheries and Aquatic Ecology** (Van Holiday, Godo). A report on POGO is attached and a report on WG 115 may be had on request from Van Holiday.

Planned WG 118 Meeting, El Pueblo, Lima:

The next meeting of WG 118 will be held at the El Pueblo Hotel in Lima, Peru. The purpose will be

(a) To review activities and meetings of the past year, with emphasis on identifying technologies especially pertinent to CoML needs.

(b) To apprize the Working Group of pertinent technical aspects of projects planned in South America, in particular to meet the Peruvian scientists and learn of their interests.

(c) To be briefed of technical areas not previously considered by the WG 118, specifically methods in genetics, zooplankton acoustics, marine mammal research and phytoplankton.

(d) To discuss and initiate reporting of WG 118's activities and conclusions, with consideration of the final product, potential publication of a special journal issue, technical report to SCOR and/or a Web-based (living) report. The last of these is currently favored and discussion is proposed about ways of integrating this into the proposed CoML outreach and Web-based activities. Discussion will consolidate topics and outlines and the proposed timeline.

(e) To discuss the entrainment of additional groups, individuals and activities into the SCOR WG 118 effort and to identify new technologies not yet considered by the working group.

An agenda is attached.

Future Plans:

A primary goal will be to develop a living Web-based document summarizing evolving technologies pertinent to Census of Marine Life and related interests. Active participation in the proposed CoML outreach and education plans is proposed and will be discussed in Lima. Activities in the coming year will involve a meeting of a subgroup of WG 118 to implement the results and devise strategies to ensure it remains current, with input from the wider technological community. The current budget is sufficient for the Lima meeting followed by a meeting of the subgroup later in 2003 (details to be decided in Lima).

David Farmer
Van Holiday 5.viii.2002

AGENDA (preliminary)

SCOR WG 118
El Pueblo Hotel, Lima, Peru, 28-30 October 2002

27 October	1900	Informal reception at El Pueblo	
28 October	8:30-1200	Opening Comments	Farmer/Holiday
		Welcome	
		Local arrangements	Guttierez
		Objectives and agenda	Farmer
		IMARPE activities and interests	Adml. Arevelo
		Discussion: S American interests in WG 118	Guttierez
		WG 118's role in CoML	Ausubel
	13:30-1700	*Meeting reports & related activities (WG 118 members)*	
		Mar del Plata	Farmer/Arnold
		OCEANS	Boss
		WG 115	Holiday
		PICES	Gorsky
		ICES	Holiday/Godo
		Fisheries Acoustics (Japan)	Furusawa alternate
		Briefs on Technical Areas not covered elsewhere:	
		Genetics	Gaffney
		Marine Mammals	Mellinger
29 October	0830-1200	*Briefs on Technical Areas not covered elsewhere:*	
		Zooplankton acoustics	Holiday
		Lofoten monitoring	Godo
		Phytoplankton	Rines
		Technical needs in developing countries	Guttierez
		Reporting and outreach plans:	
		Discussion of appropriate reporting approach –	
		Special issue of journal	
		Technical report to SCOR	
		Web-based (living) document	
		Discussions led by:	Farmer/Holiday

	1330-1700	Continue discussion of reporting approach Summarize and outline agreed topics Contributions by each WG member	
30 October	0830-1200	Overview of technologies discussed Most urgent CoML needs Discussion, assignment of writing tasks	Farmer/Holiday
	1330-1700	Final discussion of writing assignments Entrainment of additional groups, individuals etc Action items. Summary and Closing Remarks	Farmer/Holiday

SCOR WG 118: NOTES OF MEETING AT GRAN HOTEL IRUNA, MAR DEL PLATA, ARGENTINA, 27 OCTOBER 2001

1. Purpose of meeting and update

David Farmer, the WG Chairman, welcomed attendees and explained the origins of the working group and the involvement of the Sloan Foundation. He outlined progress made during, and since, the WG's first meeting in Dunsmuir Lodge in November 2000 and drew attention to the group's Web site (http://pulson.seos.uvic.ca/links.html). He explained that the WG's main objective is to identify the major technical challenges confronting observers of marine life. To do this the group is seeking an active dialogue with scientists responsible for cutting edge research projects, including initially the leaders of the six Census of Marine Life (CoML) Pilot Projects.

2. Identification

Attendees then introduced themselves and explained their interests. Names, affiliations and e-mail addresses are listed in the Annex A.

3. Update on CoML

Jesse Ausubel gave a brief history of CoML and the Sloan Foundation's purpose in funding the WG, which was to identify key technical problems facing marine biologists, publicise these and encourage funding bodies and manufacturers to develop solutions.

4. Chemosynthetic ecosystems in the Arctic and North Atlantic Ocean (ChESS)

In the absence of the ChESS project leader, Fred Grassle summarised the technical challenges facing this project, which are to locate deep hydrothermal vents and sample high-temperature effluents and surrounding benthos. The fauna around deep vents, which includes microbes, tubeworms and specialised shrimps, is adapted to high temperature and pressure. It is very different from the fauna surrounding seeps on the continental margins, which support different communities, and are thought to offer considerable industrial potential in the form of new pharmaceuticals and specialised enzymes, for example. New vents had recently been discovered in the mid-Atlantic using chemical sensors and this technology will be used in conjunction with an autonomous vehicle, such as AUTOSUB, which will also need to carry still and video cameras. REMUS, whose development was partially funded by the U.S. Navy, is a possible vehicle; it has deep-water capability and could make overlapping transects and produce mosaics. Cindy Van Dover could provide further technical information.

David Farmer commented that imaging, mapping and underwater vehicles would also be discussed under other projects. The WG will contact Cindy Van Dover for information about REMUS.

5. Diversitas International of the Western Pacific Area (DIWPA) (Yoshihisa Shirayama)
The scientific aim of this project is to describe the latitudinal variation in coastal biodiversity in the western Pacific from the Bering Sea, via the Philippines, to Australia and New Zealand. Planning was at an advanced stage and a sampling protocol—which includes lakes and forests, as well as the marine environment—was to be published at the end of 2001. A major sampling effort was planned during 2002, which has been designated as International Biodiversity Observation Year (IBOY).

Identification and counting of meiobenthos presents a major technical challenge and it is necessary to find an accurate, inexpensive way of locating the positions of samples taken by SCUBA divers in the 0-10 m depth band. Advice is needed about (a) the selection of data loggers (during dives and over longer [= 1-year] periods); (b) the use of AUVs for habitat mapping and optical identification of epibenthos; and (c) a basic GIS system to link with the OBIS system for purposes of data analysis. There are also major issues associated with the taxonomy and long-term preservation of type specimens of soft-bodied species, such as nematodes, of which there can be 1-10 million individuals or 10,000 species (50-60 dominant) per square metre of sediment. Holograms, or 3-D images constructed by other techniques, offer one possible solution to the taxonomic problem. Because the literature is generally poor and there are only a few taxonomists with relevant knowledge, the project will have to rely heavily on parataxonomists, who will require computer-aided, self-learning identification systems. It would also be highly desirable to automate the process of sediment sorting, which is a slow, skilled and expensive job. The requirement is for a machine that can separate and sort organisms, identify and classify them to a higher taxonomic group and store them by taxon. Laser detection of red-stained protein might be one way of sorting organic material from sediment and trials of this technique were apparently underway in Germany.

There were several ideas for locating the position of a SCUBA diver. Olav Rune Godø suggested fixing acoustic pingers, possibly on surface floats, at known GPS positions. The diver could be fitted with an acoustic receiver and could operate a press-button recorder at appropriate intervals. Ian Perry suggested an underwater acoustic range and bearing finder to be used in conjunction with a GPS unit at the surface. Fred Grassle said that REMUS used two transponders set at known GPS positions to obtain simple, accurate acoustic locations. Dan Costa recollected a commercially available system (Desert Star?) for tracking a diver fitted with an acoustic beacon, which he thought had been available in Monterey about six years ago. A simple, cheap alternative would be to use a pop-up buoy with a GPS receiver, which the diver could deploy when he/she wanted to fix his/her position. David Welch suggested an even simpler solution in which the diver towed a cheap ($200), waterproof GPS receiver on a small float and merely recorded the time at which he/she wanted to determine his/her position.

Ron O'Dor drew attention to the technical problems of making long-term salinity measurements with unattended logging devices, especially in shallow tropical waters. David Farmer suggested measuring sound speed and temperature, instead of conductivity.

Gaby Gorsky suggested that stereoscopy might offer a simpler, cheaper and more affective approach than holography. Available neural network systems might also be applicable. He had experience of using stained histological sections to reconstruct 3-D images for preserving type

specimens and offered direct help to the project.

Fred Grassle commented that it is critical to reduce sample processing costs, especially as this was a poorly funded area of research. David Farmer suggested the use of local imaging with electronic transmission of images to a specialist taxonomic centre in, for example, Japan. Fred Grassle drew attention to the existing link between the British Museum of Natural History and Thailand for the identification of polychaetes.

Ken Foote asked if there is any value of obtaining data for which identification was only extended to order and genus. If there is, he suggested it might be possible to use a high-resolution system of silhouette photography in conjunction with a coarse, automated identification system; it would then be possible to select regions of interest for more detailed study later. Whilst it was agreed that there could be value in this approach, Gaby Gorsky and Fred Grassle pointed out that (a) it does not allow sorting or manipulation (rotation and orientation) of organisms for the initial identification; and (b) having identified the genus of an organism, it is usually quite easy (and thus more cost-effective) to identify the species at the same time. Ian Perry questioned whether it is necessary to sort and identify material from all samples, or whether it is possible to use sub-samples. Ron O'Dor drew attention to the large volume (50 cm^3) holographic system developed by Richard Lampert at Southampton Oceanography Centre (SOC) in the UK. This instrument, which is towed by a research ship, generates a huge amount of data but uses video to examine the holograms. Tommy Dickey drew attention to optical instruments (e.g., COBOD) for SCUBA divers and the latest edition (October 2001) of *Oceanography*, which was devoted to optical imaging, and asked if there was any system for exchanging information about identification methods. In reply, Fred Grassle commented that there is no forum for discussion, but one is needed.

Commenting on the time scales on which solutions are required, Olav Rune Godø pointed out that, although a means of accurately recording the position of SCUBA divers is an urgent requirement, the technology is already available and the problem could be solved quickly. The taxonomy for large organisms is also well established and a preliminary description of latitudinal distribution is therefore feasible by 2004. Comparable work with meiobenthos would not, however, be practical until the necessary taxonomic tools become available in 2004-2005. Jesse Ausubel asked for a list of time-lines by which technical solutions were required to make a significant difference to the outcome of the project. Fred Grassle said that field sorting of meiobenthos would be a significant breakthrough, particularly if accompanied by simple (3-D) algorithms for identification and *in situ* imaging using a sampler towed through the sediment. Gaby Gorsky commented that because the project entailed two tasks—census of common species and identification of rare ones—there would be several different time-lines.

David Farmer concluded the discussion by asking Yoshihisa Shirayama to send him his overhead slides, identifying the most important technical issues. The WG would then be able to sharpen the questions and put the weight of the oceanographic community behind the search for solutions. It should also be possible to identify companies willing to collaborate in the mass production of inexpensive technology, such as the recently developed toy microscope with an electronic imaging device, which is available for a few hundred dollars. Fred Grassle commented that *Skin Diver* magazine is a good source of simple, cheap equipment for

underwater scientific operations.

6. Census of Marine Life in the Gulf of Maine (Ken Foote)

Staying on the theme of mass production, Ken Foote made a strong plea for the provision of a calibrated output signal on mass-produced fisheries echo sounders, in place of the existing video signal. Artisanal fisheries in developing countries offer the potential for wide-scale synoptic surveys that cannot be achieved with research vessels, provided that standard sounders have a calibrated output. Water column mapping using sonar with a midwater signal was another area in which research could benefit from mass-produced instruments. Mass-produced ADCPs, too, offer the potential of four scientific sounders looking simultaneously in different directions. A quantitative signal with a good dynamic range is, however, an essential prerequisite.

Turning to the specific problems of the Gulf of Maine census, Ken Foote provided a list of species for which it would be appropriate to use acoustic surveys and identified four challenges in the development and application of this technology. The first and second challenges are to make good acoustic measurements and quantitative biological measurements. The third challenge entails target classification, for which better acoustic bandwidths are required. The WG could help by supporting the case and stimulating manufacturers to provide solutions. The fourth challenge involves integrating optical and acoustic technology and using acoustics to extend the range of observation of optical instruments. Echo sounders or multi-beam sonars, for example, could be used in conjunction with video to provide both long- and short-range observations.

A major component of the Gulf of Maine project is a census of intertidal and sub-tidal benthos. Distribution and abundance will be surveyed from 0 to 20 m in specified areas, using transects and standard protocols. Soft sediments will be sampled using cores, or an inexpensive sediment profile-imaging camera. Epifauna will be recorded with a digital still camera prior to physical sampling and the bottom will be surveyed in 10-m wide swathes, using an ROV or AUV (e.g., REMUS) with the ability to navigate precisely in shallow water. Bathymetry and backscatter data will be obtained with interferometric sidescan sonar. Oceanographic data will be obtained from nearshore GOMOOS moorings and data acquisition will be designed to complement parallel offshore benthic studies. The results of the pilot inshore and offshore studies will be fully integrated.

Data will be analysed as follows:

(a) description and quantification (rapid summary and specific identification) of sampled epifauna for each station and each habitat type, taking account of the different life stages of the various organisms, for which there are often large differences in essential habitat;
(b) description of grain size distribution in the top 25 cm of the sediment;
(c) quantification of bathymetry and backscatter along the transects;
(d) construction of aerial photomosaics;
(e) quantitative relation of abundance and spatial distribution to specific characteristics (depth, grain size, etc.) of the habitat;
(f) production of an atlas of results, using GMBIS (Gulf of Maine Bio-geographic Information System).

In response to questions from David Welch, Fred Grassle and Dan Costa about the key research questions to be addressed by the project, Jesse Ausubel stressed that one of the key issues for the CoML programme is the distribution of biomass by taxon and habitat. This question, which had been highlighted by Van Holliday at the inception of the CoML programme, has not been addressed at all in some environments. Subsequent discussion concerned sampling from ships of opportunity, species identification by acoustic means and how to merge complex data into an ecosystem database.

Ships of opportunity offer great opportunities in both developed and developing countries, if various problems can be overcome. François Gerlotto pointed out that developing countries can afford neither expensive equipment nor expert observers. Sorting and cleaning up data is therefore a major issue, especially as ships of opportunity afford the only way of carrying out large-scale synoptic surveys in such countries. Experience in Japan (Yoshihisa Shirayama) and Canada (David Welch) has demonstrated, however, the widespread need for simple, reliable, automated "black box" instruments, which can be used readily by fishermen and other mariners, and easily serviced and calibrated by scientists after each voyage. Fishing vessels, which could also provide "ground-truthing," could provide ideal platforms in the Gulf of Maine and also in the Humboldt Current (Mariano Gutierrez - see ISPPA below). Julie Hall pointed out that yachts could provide a useful alternative in some areas and Jesse Ausubel said that CoML had been approached by a group of ocean-going yacht owners, who were interested in marine conservation. The members of this association (Seakeepers) wanted to make observations at sea, but had no idea what to do; specific proposals were therefore needed if their interest and enthusiasm were to be harnessed usefully.

It was agreed that the question of equipping ships of opportunity was an important one to resolve, given the potentially large benefits in many parts of the world, especially developing countries. An ensuing discussion of ways and means of equipping fishing vessels concluded that, because fishermen replace their instruments frequently (David Welch), and in Chile would even pay for scientific equipment (Mariano Gutierrez), it would appropriate to plan to install calibrated echo sounders. This would probably be more cost-effective than attempting to fit "black boxes" in conjunction with existing sounders, although this might initially appear to be a cheaper alternative because it avoided dry-docking costs (Adrian Madirolas). Experience with the PICES programme in Canada (David Welch) indicated that, where other instrumentation was concerned, it was essential not only to provide an unobtrusive "sea chest," but also to convince fishermen of its ease of use.

Olav Rune Godø asked how the complex acoustic data obtained by the Gulf of Maine project were to be merged into an ecosystem database. He also drew attention to the problem of species identification and the need to determine the probability of correctly identifying the composition of the targets giving rise to an individual echo sounder record. Neural networks might offer one approach to this problem, a solution that would have worldwide application; a link to OBIS might be useful. In reply, Ken Foote said that, given that species identification is the long-term goal, he was in discussion with interested manufacturers and trying to encourage the development of multi-frequency, broad-band acoustic devices to be used in conjunction with neutral networks, as appropriate. Dan Costa pointed out that location *per se* might be a simple, effective way of differentiating between acoustic targets that would otherwise be

indistinguishable by their echoes. Summarising the discussion, David Farmer said that, whilst recognising that there were formidable problems (e.g., swimbladder form and function), the WG concluded that acoustic assessment and identification are key areas for scientific advancement and that increasing the bandwidth of instruments is a key technical issue. François Gerlotto drew the WG's attention to the ICES Symposium "Acoustics in Fisheries and Aquatic Ecology (Montpellier, France, June 2002), at which bandwidth and multi-frequency would figure prominently.

7. Interacciones entre Stocks Pelagicos, Pesquerias y Ambiente (ISPPA) (François Gerlotto)

ISPPA is an international project that involves France, Peru and Chile and will last from 2001 to 2008; it is hoped that it will be of interest to CoML. The objective is to explain how the very large fluctuations in fish catches off the coast of South America are linked to climatic variation and to understand how the multi-species ecology of the Humboldt Current responds to the huge environmental variations associated with ENSO. The approach is to study the behaviour of both individuals and schools and to relate these to stock behaviour and stock characteristics. There are significant technical challenges in making direct observations and also in surveying whole populations, which span a vast region subject to rapid environmental fluctuations, and also extend into inaccessible areas.

The solutions to these problems are to use (a) EUREKA to achieve effectively instantaneous survey coverage over a very large area; (b) LIDAR to survey the inaccessible areas; and (c) multi-beam sonar to evaluate biases by studying fish behaviour, quantifying fish avoidance and reconstructing school dimensions in 3-D.

EUREKA entails a two-day survey by a large fleet of commercial fishing boats, which is equivalent to a 1.5-month survey by a research vessel. The data are not quantitative, however, and there are major acoustic problems associated with calibration and noise. The technical challenge is to find a low-cost, standard scientific echo sounder with simple, automated calibration and also automated data processing, including GPS, SST and other quantities.

Airborne LIDAR allows large areas to be surveyed quickly at low cost. The instrument is non-intrusive and produces data very similar to those from acoustic instruments. The technical challenges are to match the LIDAR survey to the EUREKA survey and to cross calibrate the two sets of survey results.

Multi-beam sonar (e.g., Reson Seabat 6012), which can quantify and correct for fish avoidance, would allow the dimensions, density and internal structure of fish schools to be reconstructed in three dimensions. Its shortcomings are short range (~100 m), high frequency and restricted (90º) coverage, plus background noise (side lobes), a high volume of data, prototype software and a restricted survey speed. Technical improvements are needed to overcome these limitations.

In discussion, François Gerlotto and David Farmer agreed that calibration is absolutely vital to the success of the project. Otherwise, it was agreed that the project is an exciting one, given that—as Olav Rune Godø pointed out—the inability to make "snap-shot" surveys is a key constraint in attempting to understand ecosystem dynamics. The help of the international

community is needed to stimulate the necessary technical developments and encourage the participation of other regional laboratories.

8. Pacific Ocean Salmon Tracking (POST) (David Welch)

This project aims to investigate the migrations of Pacific salmon, using archival tags in the open ocean and acoustic tags on the narrow continental shelf from California to Alaska. Smolts will be tagged internally with surgically implanted acoustic tags, a well-tested technology. The plan is to install ~25 lines of acoustic receivers across the shelf at strategic points, and also to instrument all west-coast rivers from Sacramento northward. A total of 600-700 receivers is envisaged. The technical requirement is for autonomous units with lithium batteries providing a 3-5 year life. Each unit will comprise a low-power memory board with serial ports, a hydrophone and acoustic receiver for detecting acoustic tags, a modem for acoustic telemetry and an acoustic transponder for relocation, as well as sensors to measure temperature, salinity, depth, wave height and current speed (low-power ADCP?). A tilt sensor could be useful for initial deployment. The instruments will be encapsulated in resin inside a low-profile cast iron or concrete mount that would not readily be trawled up. A research vessel will recover data every few months. Acoustic receivers are readily available at low cost, but information is needed on acoustic modems.

A number of points were made in discussion. David Farmer suggested that it would be more efficient to use transponding acoustic tags instead of continuously transmitting "pingers," although Dan Costa thought that it might be difficult to motivate the manufacturer to develop these. Geoff Arnold pointed out that transponding acoustic tags have been in use for fish tracking in Europe since 1970 and that electronic circuits for high-frequency tags (76-300 kHz) have been published by both CEFAS and the University of Aberdeen in the UK (Annex B). Cynthia Decker asked if the use of transmitting arrays could create difficulties with public relations and Ken Foote emphasised that it would be necessary to demonstrate that there would be no interference with marine mammals. David Welch pointed out that, with the system he had proposed, acoustic transmission would be limited to data recovery when a research vessel is alongside the acoustic unit. At all other times, when unattended, the acoustic unit would only be listening. Low-power tag transmissions are not regarded as significant sources of noise for marine mammals. In relation to data retrieval, David Farmer commented that many acoustic modems are available and that experts at WHOI are well placed to advise. Fred Grassle commented that ROVs have been successfully used to recover seabed instruments during oil rig surveys and might offer a cheaper, more effective, solution than an acoustic modem. Another alternative would be to use a communication pod that comes to the surface on command. Other technical issues include the use of oil-immersed lead-acid batteries (with a pressure-venting membrane), which could provide ballast as well as a lot of power; risks of siltation (avoidable by choice of substrate) and bio-fouling (low at 40 m depth); acoustic releases to recover ADCPs; and speed-of-sound measurements to determine salinity over long periods.

9. Patterns and Processes of Ecosystems in the Northern Mid-Atlantic (Mar-Eco) (Odd Aksel Bergstad)

Mar-Eco is an emerging international ecosystem study that had recently received a planning grant as a CoML Pilot Project. It aims to conduct the first large-scale coherent study along the mid-Atlantic ridge, which is a poorly described environment. The objectives are to estimate

regional-scale biomass, map species composition and distribution, identify trophic interrelationships and food webs, and investigate the life history strategies of selected species. The survey will cover the 1500 km from Iceland to the Azores, a poorly mapped area with depths of 500-3500 m, characterised by rugged terrain, seamounts, steep slopes, hard substrates and variable currents. The project will focus on fish, cephalopods, crustaceans and gelatinous plankton and nekton, and will encompass bentho-pelagic and epibenthic macrofauna, as well as pelagic organisms. There will be a general pelagic survey plus detailed surveys. Fishing vessels might be used, although research vessel time was funded for 2002 (preliminary work) and 2004, by which time the new Norwegian RV "G.O. SARS" will be available to participate in the planned multi-ship operation. Acoustic surveys will form a central part of the project, using hull-mounted transducers and multi-beam and multi-frequency instruments. AUVs might also be used and consideration was being given to investigating seasonality, using floats, moorings and ships of opportunity. A planning workshop involving biologists and technicians was scheduled for January 2002. The analytical phase, including submission of data to OBIS, will span the period 2004-2008.

In discussion, Gaby Gorsky commented that he had recently returned from a cruise in the area, which had been devoted to physical oceanography. In response to Julie Hall, who commented that scientists in the Netherlands had experience with deep-sea landers and associated technology, Olav Bergstad said he was already in contact with Monty Priede, who had developed the AUDOS deep-sea lander at the University of Aberdeen in the UK. Mention was made of the proposed NEPTUNE cabled instrument system that is projected for studying the Juan de Fuca Ridge. In response to a number of questions from Ken Foote and Olav Godø, Odd Bergstad commented that they intended to use HUGIN, an ROV with a plug-and-play facility and a depth capability of 2000 m, although AUVs would be more useful in irregular topography. Most standard acoustic instruments could be plugged in on Norwegian research vessels and three echo sounders could be used simultaneously at different frequencies, although not at the same time as the sonars. Acoustics and optics are both needed to sample jellyfish and cephalopods effectively. Multiple opening and closing nets will also be used and trawling will be possible to 3000 m using very large pelagic trawls towed at 5 knots. It is intended to use standard trawl instrumentation, although this is only rated to 1200 m and, as David Farmer pointed out, there is an important technical challenge to be overcome in extending the equipment's capability to 3000 m. Observing and capturing jellyfish and cephalopods also present major problems. A number of solutions were suggested, including imaging techniques and ROVs, which offer some catching ability (Gaby Gorsky). A range-gated laser scanner developed at MBARI (Ron O'Dor), offer an exciting way to combine acoustics and optics and compare data at the same range. David Farmer commented that it would be challenging to deploy this instrument underwater, but offered to explore possibilities. On the basis of observing elephant seals at great depths in New Zealand, Dan Costa suggested installing a video camera on large pelagic trawls to investigate deep-water fauna. Julie Hall drew attention to experience of trawling on seamounts off New Zealand. Olav Rune Godø commented that the project will include a research vessel cruise in late 2002 to test deep-water technology.

10. Tagging of Pacific Pelagics (TOPP) (Dan Costa)

The aim of this program is to generate a detailed understanding of how marine animals from several trophic levels use distinct oceanic regions in the North Pacific Ocean. These include the

continental shelf system stretching from Baja California to the Aleutians, the pelagic realm of the sub-arctic and the sub-tropical transition zones and Central and Alaska Gyres, and complex current systems, including the California Current and the Alaska Coastal Current. The project, which will identify migration routes and critical habitats and link behaviour and distribution to oceanographic processes, will employ advanced electronic tags, whose use has already changed our perception of the distribution of some key species. Elephant seals, for example, which had been regarded as essentially coastal animals in 1990, are now known to range over the entire North Pacific Ocean and to show striking differences in distribution between the two sexes.

A workshop in Monterey in November 2001, which was funded by the Sloan and Packard Foundations, identified a list of 15-20 species for potential investigation. These species, which include cephalopods, sharks, teleost fish, birds and marine mammals, are thought to make extensive movements, can be readily tagged and would catch the imagination when trying to educate the public about the nature and complexity of the ocean (outreach is a key component of the project). It will not, however, be possible to work with all the identified species and the project will concentrate initially on several foundation species, which include the northern elephant seal, bluefin tuna, and one or more species of turtle, squid and albatross. Detailed planning for the project is now underway with additional funding from the Sloan and Packard Foundations.

The project will use available electronic tags, or new tags that could be field tested in 2002; the target species were partly selected based on their ability to carry these tags without difficulty. Archival tags, which can be implanted or attached externally, and pop-up tags, which are towed by the fish until release, both incorporate light sensors that are sufficiently sensitive to detect dawn and dusk at depths of 200-300 m in relatively clear water. From these measurements, it is possible to determine geographical location (latitude rather less accurately than longitude) with sufficient precision for the proposed aims. There were technical problems with the first generation of archival tags for use on large pelagic species, but these were relatively minor and have now reportedly been solved by their manufacturers. In one case, the light stalk had proved to be too fragile, leading to ingress of water; in the other, the pressure sensor had not been robust enough to withstand the pressures to which the fish subjected them. Field tests of the replacement tags are now needed. Pop-up tags that could transmit data via the Argos satellite system are now quite well proven and both manufacturers had recently made a number of improvements to solve the problems of premature release and fish mortality. The rate of data transmission via Argos is low, but no alternative is available in the short term. Standard GPS tags for use with marine mammals have high power consumption, but it is hoped to use a new tag currently under development in the UK, which will record a rapid "snapshot" of the GPS satellites each time the animal surfaces, but will not process the data.

A key technical issue will be to merge the data obtained from electronic tags on individual animals with oceanographic data (physical and biological) obtained from *in situ* instruments, or by satellite. Models will be needed to predict the depth distribution of physical quantities from surface measurements (e.g., SST from SeaWiFS data), although this problem could be solved by using diving animals to record depth profiles, a technique already used with sea birds and marine mammals. Elephant seals, for example, can be tagged with a simple GPS receiver to provide geographical location and an archival tag to record temperature, depth and other factors; data

obtained in this way have been entered in the World Ocean Database. Problems are envisaged, however, as a consequence of having to collect information on a variety of spatial or temporal scales. It is known, for example, from the "winds to whales" project that whales appeared in Monterey Bay following wind-driven upwelling, the onset of primary production and the consequent large increase in the local numbers of krill. This is a general phenomenon and the behaviour of crab-eater seals in the Antarctic, for example, follows a similar pattern. Krill surveys are time consuming, however, and whilst it is easy to describe the behaviour of individual seals, it is difficult to obtain an integrated picture of the local densities of the prey to which the seals are responding. LIDAR might offer a solution in some circumstances.

Discussion focused on a number of issues, including rates of satellite data transmission, tag attachment, rewards for the recovery of archival tags (currently $1000 for Atlantic bluefin tuna), low-frequency acoustic location, prey visualisation, passive listening devices and the effects of floating objects on tuna behaviour and migration. Ed Urban asked about the feasibility of easing the limitations on data transmission by increasing the bandwidth of the Argos system. In reply, David Farmer listed the alternative satellite systems and explained that Orbcomm, which is used to track vehicles and other items, has a transmitter that is generally too large for use with animals. The system is suitable, however, for retrieving oceanographic data and Geoff Arnold reported that CEFAS is routinely using Orbcomm to recover data from buoys on the European continental shelf. Iridium, which has a smaller transmitter and should be practical for animal telemetry, is not yet fully in operation, following financial difficulties in recent years. David Farmer made several suggestions, including long-range, low-frequency acoustic location using fixed RAFOS transmitters (range 1000 km) and miniaturised receivers; low light level cameras fitted to diving marine mammals to record prey and feeding events; and passive identification of sound-producing fish. The last technique has great scope, as evidenced by the University of Rhode Island's archive of fish sounds, which had recently been digitised. Fred Grassle suggested that MBARI's Neptune test site would provide a good location at which to test passive detection and also drew attention to a map of ocean fronts. This could provide a good guide to the location of floating objects that, as François Gerlotto pointed out, are known to attract tuna and possibly alter their migration routes. Behaviour also changes when individual tuna aggregate to form schools, and for this reason Dan Costa suggested that a proximity detector would be a useful sensor to add to electronic tags designed for use with schooling pelagic species. Ron O'Dor suggested that it might be possible to measure school cohesion using Vemco VR2 receivers and compatible acoustic tags.

11. Invitations from PICES

Ian Perry extended two invitations to the WG from the North Pacific Marine Science Organisation (PICES). The first was that WG118 should consider participating in PICES XI, which would be held in Qingdao, Peoples Republic of China in 2002 (18-26 October). The theme of the meeting will be "Technological Advances in Marine Scientific Research" and there will be a 1-day Science Board Symposium on the subject. WG 118 was invited either (a) to meet in conjunction with PICES XI; (b) nominate and fund selected speakers to attend the symposium; or (c) co-organise an electronic poster session on data processing.

The second invitation related to a 2-3 day workshop on "Voluntary Observing Systems," which had been proposed under the PICES/GLOBEC Climate Change and Carrying Capacity Program.

The meeting, was to be organised by the PICES Monitor Task Team, was to be held in Corvallis (Oregon) or Seattle (Washington) in February 2002. The objectives were to identify the type of monitoring observations that were required, discuss a "sea chest" of standard instruments that could be routinely installed on appropriate ships of opportunity, and identify sources of long-term funding. WG 118 was invited to participate in the meeting and, if possible, provide financial support. The scientific objectives of the monitoring proposed under the CCCC program were to investigate ecological change and identify a suitable quantitative measure. David Farmer thanked Ian Perry for both invitations and said he would respond in due course.

12. Concluding comments

David Farmer concluded the meeting by excusing the Rapporteur from presenting a verbal report. A record of the meeting would instead be circulated as soon as possible and he urged all attendees to comment freely on the record and also on the issues confronting the WG. The focus of the meeting had been on the presentations of the leaders of the CoML Pilot Projects, but the WG's conclusions would be updated as the various proposals evolved during the planning phase and other inputs became available. There was already, however, an overriding need to appraise manufacturers of CoML's needs and the potential to develop marketable equipment.

Geoff Arnold
Lowestoft
19 November 2001

Annex A: List of Attendees

The meeting was attended by:

Odd Aksel Bergstad	IMR, Bergen, Norway	oddaksel@imr.no
Geoff Arnold	CEFAS Lowestoft, UK	g.p.arnold@cefas.co.uk
Jesse Ausubel	Sloan Foundation, New York	ausubel@sloan.org
Alex Bychkov	PICES	bychkov@pices.int
Grace Chang	Univ. California, Santa Barbara	grace.chang@opl.ucsb.edu
Daniel Costa	Univ. California, Santa Cruz	costa@biology.ucsc.edu
Cynthia Decker	CORE, Washington, DC	cdecker@coreocean.org
Tommy Dickey	Univ. California, Santa Barbara	tommy.dickey@opl.ucsb.edu
David Farmer	Univ. Rhode Island	dfarmer@gso.uri.edu
Ken Foote	WHOI, Woods Holes, USA	kfoote@whoi.edu
François Gerlotto	IFOP Chile (IRD, France)	fgerlotto@ifop.cl
Gabriel Gorsky	CNRS, France	gorsky@obs-vlfr.fr
Fred Grassle	IMCS, Rutgers Univ.	grassle@imcs.rutgers.edu
Mariano Gutierrez	Peruvian Marine Institute	mgutierrez@imarpe.gob.pe
Julie Hall	NIWA, Hamilton, N Zealand	j.hall@niwa.cri.nz
Adrian Madirolas	INIDEP, Mar del Plata	adrian@inidep.edu.ar
Ron O'Dor	CORE, Washington, DC	rodor@coreocean.org
Ian Perry	DFO, Nanaimo, Canada	perry@pac.dfo-mpo.gc.ca

Olav Rune Godø	IMR, Bergen, Norway	olavrune@imr.no
Yoshihisa Shirayama	Seto MBL, Kyoto Univ.	yshira@bigfoot.com
Ed Urban	SCOR Secretariat	scor@jhu.edu
Horst Weikert	Univ. Hamburg	weikert@uni-hamburg.de
David Welch	DFO, Nanaimo, Canada	welchd@pac.dfo-mpo.gc.ca

Annex B: Transponding Acoustic Tags

Circuit designs for transponding acoustic tags are available in:

Mitson, R.B. & Storeton West, T.J. (1971). A transponding acoustic fish tag. Radio Electron. Eng., 41, 483-489.

Bagley, P.M. (1992). A code-activated transponder for the individual identification and tracking of deep-sea fish. Pages111-119 in Priede, I.G., and Swift, S.M. (eds.), Wildlife Telemetry, Ellis Horwood, New York.

Bagley, P.M., Bradley, S., Collins, M.A., Priede, I.G. & Gray, P. (2000). Miniature acoustic code activated transponder for tracking fish at abyssal depths using delayed activation to overcome reverberation. Pages 13-19 in Moore, A., and Russell, I., Advances in Fish Telemetry, Proceedings of the Third Conference on Fish Telemetry in Europe, Norwich, England, 20-25 June 1999, CEFAS Lowestoft.

Annex C: Web sites

CoML: http://www.coml.org
SCOR WG 118: http://pulson.uvic.seos
MAR-ECO: http://www.efan.no/midatlcensus/

Report on the IOC (UNESCO) - Census of Marine Life Workshop on Marine Biodiversity in Southeast Asia

Venue: Phuket Marine Biological Centre, Thailand
Date: 10-12 October 2001
Participant: Elgar Desa (National Institute of Oceanography, Goa, India)

Introduction

The basic objective of the Workshop organized by IOC (UNESCO) and CoML was to introduce and expand CoML activities to Southeast Asia. I attended the workshop as a member of SCOR Working Group 118 and made a presentation on Advanced (or Emerging) Technologies for Species Identification. A group discussion was then organized with participant scientists from Southeast Asia. These two activities will be discussed in this report.

Summary of presentation on Advanced/Emerging Technologies for Species Identification

My presentation began with an introduction of WG 118 and its objectives to identify emerging technologies for observing marine life and to inform the international community of what is happening in these areas of research.

The main features of the presentation dwelt upon:

1) Overview of what is involved in the science of biodiversity
    - Exploration and Collection
    - Identification
    - Monitoring
    - An experimental approach – mesocosms
    - Public Education

2) Emerging Technologies
    - Airborne Optical Lidar
    - Optical Plankton Recorder
    - Optical Imaging of micro plankton
    - Broadband plankton sonar
    - Holographic Camera
    - Small AUVs as platforms for monitoring purposes
    - The use of satellites (ocean color & SST) for assessing biodiversity from space
    - A block diagram summarizing biodiversity approaches for developing countries in Asia – a case example being India

Summary of discussion with Southeast Asian participants on New Technologies Working Group

The New Technologies Group consisted of Ned Cyr, Elgar Desa and participant scientists from the Philippines, Thailand, Malaysia, Indonesia, Vietnam, Cambodia, and Singapore. The discussion centered around the questions

(a) **To what extent are advanced sampling/identification technologies known and being used in Southeast Asia?**
(b) **What are the major needs for new technology in Southeast Asia**?

In response to (a), we find that most researchers are familiar with and do use the following in their work:

- Video cameras and microscopes for shallow-water surveys
- DNA probes (in the Philippines)
- Electronic keys for taxonomy
- Data buoys for environmental parameters
- ROVs (used only once by Malaysian researchers then abandoned due to "cable' problems)
- Geographic Information Systems (GIS)
- Information Technology
- Satellite Ocean Color
- Acoustics (but only as a tool in fisheries programs)

The reaction to the Use of Advanced Technologies presentation was ambiguous. Some felt that there is no pressing need as of now, as their traditional technologies—based on still photography, net collection from boats, microscopes and scuba diving in shallow water—are adequate for most biodiversity surveys. Others felt that the use of advanced technologies would be welcome but would require **training**, and in any case, such technologies would be too costly for them to procure under their programs. Ocean color is being used in Thailand and other countries, but some participants had reservations on its usefulness, for example, because of cloud cover problems.

In response to question (b), nearly all participants expressed the following;

- Experts in species identification are needed to train them on how to organize, clean up, and catalog the available data in their countries. In most Southeast Asia countries, interested colonial scientists and amateurs initiated most of the marine collections in the early years of colonial rule.
- The need for "references" on species.
- Well-trained taxonomists are rare. There is a need for taxonomists who are familiar with Computer Assisted Techniques.
- Image-processing techniques are needed,
- Major needs are appropriate technology for shallow-water ecosystems – coral reefs where better optical methods are required, for example, high resolution digital cameras that work in the night as well. A group of Philippine scientists expressed the need for expertise in development of DNA probes for species identification, as genetic diversity is large in Southeast Asia.

Other remarks (my own perceptions!)

- Southeast Asian countries have carried out no substantial work on "blue water oceanography". Much of their interest is confined to biodiversity studies in coastal water ecosystems. Most of the participants were drawn from university institutions in Southeast Asia, where research may not be a pressing priority in their job function.
- **Philippines** stands out as the Southeast Asian country with the best-informed and most active group in biodiversity science, in terms of familiarity with DNA probes for species identification.
- **Indonesia** has received a large amount of funding from GEF and has built with this fund a modern biodiversity center with all amenities. Good work can be expected from this country.
- **Thailand** has an excellent center on marine biology at Phuket. But they lack expertise in other disciplines in oceanography, that is, physical, chemical, and geological sciences. They have

received substantial aid from DANIDA - a Danish group that has been organizing workshops in this region for the past decade. A modern coastal vessel was built for the Marine Biological Center in Phuket under a Danish aid program.

- **Vietnam** has a long-standing interest in the oceanographic sciences when compared to the other Southeast Asian countries that have only now begun to realize the need of creating separate oceanographic centers not derived from fisheries programs. For example, Malaysia has set up a Directorate of Oceanography, which will ultimately evolve into an Institute of Oceanography.
- **Cambodia** is perhaps the least developed in marine biodiversity science.
- **Singapore** is a special case, which has well-developed skills in IT and oceanography, largely with resident foreign expertise; hence, it is not representative of Southeast Asia.
- Acoustic technologies are not used widely by these research communities. Under the SEAFDEC program, Myanmar, Malaysia, Vietnam, Philippines and Thailand have conducted trawl surveys, along with sediment grabs and CTD casts. Acoustics is used mainly for fish location. SEAFDEC surveys are a possible platform for more extensive surveys of biodiversity through the Southeast Asia region.

Elgar Desa
National Institute of Oceanography
Dona Paula, Goa 403 004
India