SCOR Panel on New Technologies for Observing Marine Life

Meeting Summary

Meeting #2
Frankfurt, Germany
6 November 2005

Panel Members and Staff Present: Elgar de Sa (chair), Geoff Arnold, John Gunn, Antonio Pascoal, Alex Rogers, Sun Song, Bob Ward, Ed Urban (SCOR)
Guests: Rusty Brainard (CReefs), Mark Costello (OBIS), Francois Gerlotto (ICES), Yoshihisa Shirayama (NaGISA), Mitchell Sogin (ICoMM), Michael Stoddart (CAML)

Objectives of the Meeting, Review of Panel's Terms of Reference, Review of Agenda, and Actions Since Last Meeting

Elgar de Sa, the chair of the SCOR Panel on New Technologies for Observing Marine Life, asked meeting participants to introduce themselves. De Sa then reviewed the Panel's terms of reference and provided an overview of the Panel's work. The job of the Panel is to continuously examine the implementation plans and methods of the CoML projects and to make recommendations about new technologies that could be useful to specific projects. The Panel will publish reviews of CoML-relevant technologies in a variety of general and technical ocean science and engineering publications, including forward-looking "concept" articles. The Panel will also use its Web site to disseminate information, but it has been difficult so far to obtain input for it. The Panel decided at its first meeting in Goa, India to put special effort into two specific technologies: (1) electronic tags for marine animals and (2) molecular methods for identifying individual species, specifically "barcoding."

Ed Urban presented an overview of the Panel's modes of operation and strategy:

1. Focus on technologies that are key to CoML
2. Panel members will attend meetings of the projects, particularly the new projects, both at All-Program Meetings and between these meetings.
3. Involve projects more through seeking their input through questionnaires and meeting with them in conjunction with All-Program Meetings
4. Use the Panel Web site to give review papers on different technologies and to highlight new developments.
5. In the future: Small workshops?

Urban continued with a description of the actions taken since the Panel's first meeting in Goa:

- Circulated minutes of Goa meeting and recommendations to CoML projects
- Article on Molecular Techniques by Alex Rogers and Bob Ward
  - In review for publication in *Oceanography Magazine*
- Article drafted on zooplankton sensors by Gaby Gorsky
- Panel members attend project meetings and All-Program Meeting and participate in the technology session there
- Panel Web site revised
- Identified project technology representatives

Reports on Meetings Attended by Panel Members and Inputs from Projects

Census of Antarctic Marine Life (CAML)

John Gunn began the discussion of the CAML meeting that he and Bob Ward attended earlier in the week. Gunn was impressed with the energy and momentum of the group already, which seems to be a function of their success in already hiring a coordinator. Dan Costa (of the CoML Tagging of Pacific Pelagics [TOPP] project) is a key technology person advising CAML. Costa is using tags on elephant seals to take profiles of oceanographic parameters, although better calibration is needed to make these data more usable by oceanographers. TOPP is linking to the Sea Mammal Research Unit (**see http://www.smru.st-and.ac.uk/** of St. Andrews University in the United Kingdom. The data-logging aspect of tags is well worked out. For animals from which researchers expect to get the tags back, very sophisticated tags can be deployed. The situation is different for fish because the return rate for tags is much lower (generally 20% or less); less expensive, and thus less sophisticated, tags must be used. Toothfish are being tagged now, which has applications to CAML.

The TOPP and CAML scientists who are accumulating data on tagged animals need help in analysis of data and correlations between animal behavior and environmental characteristics, for example, using systems science and complex systems modeling. Other problems that need to be overcome are battery life in polar environments (with temperature fluctuations from 2°C in water to -70°C in air) and taxonomy of organisms sampled. CAML is interested in barcoding. Novel benthic sampling is being used by the Antarctic benthic deep-sea biodiversity (ANDEEP) project.

Gunn asked Michael Stoddart (chair of CAML) whether remotely operated vehicles (ROVs) are being considered by CAML. (Diving is difficult and expensive in the Antarctic, so it is useful to explore the use of ROVs.) Stoddart answered that not many icebreakers are equipped to handle ROVs. However, CAML is planning to work with the Census of Continental Margins (CoMargE) where the French and Australian areas of Antarctica abut; a French ROV-capable ship will work with an Australian icebreaker. It would be useful to increase the capabilities of ROVs on Antarctic

research vessels. Antonio Pascoal added that an Italian group headed by Gianmarco Veruggio **(veruggio@ian.ge.cnr.it)** has developed an ROV (Romeo) that is currently being used to transmit video pictures from Antarctica. The ROV is operated through a hole in the ice, and is used primarily for habitat mapping, but also is being used to provide live video to schools in Italy. Pascoal also mentioned an on-going project named Exocet (Extreme ecosystem studies in the deep Ocean: Technological Developments - **http://www.ifremer.fr/exocetd**), coordinated by IFREMER (FR) that aims to push the development of technologies for marine habitat mapping, namely in what regards the combined use of vision and acoustic sensors. De Sa noted that the issue of cameras is important to consider in relation to ROVs.

CAML will put significant effort into barcoding and will even have a barcoding subprogram. Ward offered to help CAML with barcoding of fish and Alex Rogers offered to help in relation to small invertebrates. Stoddart continued by adding that Alison Murry from CAML is interested in barcoding microbes, which will be a major effort in CAML. The British Antarctic Survey has requested funding for a barcoding manager for CAML. Ward reminded meeting participants that a Barcode of Life Database has been established **(http://www.barcodinglife.org/),** but there is no requirement for CoML projects to submit data to it. Australia and France will cooperate in a fish survey.

Census of Coral Reefs (CReefs)

Rusty Brainard (co-chair of CReefs) noted that his program in NOAA **(http://www.pifsc.noaa.gov/cred/**) has thousands of hours of video of reef areas. It is very time consuming to analyze such videos manually. It would be great to have a way to automate identification of organisms from video, such as through techniques of image analysis, pattern recognition, and anomaly detection. Ed Urban responded that Gaby Gorsky works in this area and might be able to identify experts to help deal with this challenge.

Brainard continued to report on the CReefs meeting. The group realizes that they need a project manager to make faster progress. As Nancy Knowlton mentioned this week, there are an enormous number of species on reefs (estimates are 1 to 9 million). They need to train para-taxonomists to speed identifications. One activity that CReefs is planning is to deploy standardized matrices on reefs in different places to be able to quantify which organisms colonize the materials. Another idea that may be explored by CReefs is to monitor and analyze the noise created on reefs by different organisms. The acoustic signatures collected from different reefs can be compared. Elgar de Sa suggested that reef health also could be monitored by placing instrumented pods in reef areas, including video cameras for the public to view. Brainard responded that NOAA has deployed reef monitors for physical oceanographic measurements, but they need to improve imaging technology to reduce fouling and make time-series photos possible.

Census of Seamounts (CenSeam)

Alex Rogers reported on the CenSeam meeting he had attended earlier in the day. The project is starting to attract some ship time, with the approval of four months of ship time for exploration on seamounts in the Fiji Islands from end of 2006 to the end of 2007. The CenSeam group has adopted the Panel's earlier recommendations. Barcoding is also a technology of interest for this project. One goal of the group will be to continue to improve the Seamounts Online database (**http://seamounts.sdsc.edu/**). Acoustics will be used in the Fiji explorations for physical oceanography and mapping, and for studies of the acoustics of the deep scattering layer versus topography. Benthic sampling also will be conducted. It is possible to add other measurements and sampling, if new national funding is provided. Rogers will be involved in the cruises, as well as a meeting sponsored by the International Seabed Authority (ISA), to produce a report for the Intergovernmental Oceanographic Commission (IOC) that summarizes existing data.

Rusty Brainard asked how CenSeam is doing its habitat mapping. (NOAA is using laser line scans.) Rogers replied that they will do the mapping using multibeam acoustics, and should work with CReefs, since the seamounts are relatively shallow ones with coral reefs. It would be nice to be able to put a laser line scan on an AUV, but these laser devices are currently very large and are typically towed. Brainard added that there will be NOAA work in American Samoa. Elgar de Sa and John Gunn asked about using AUVs in the Fiji expedition**.** Rogers replied that there won't be time to add this aspect of sampling. Gunn noted that his agency (Commonwealth Scientific and Industrial Research Organisation: CSIRO) is using clusters of AUVs for exploration on the Great Barrier Reef.

Antonio Pascoal noted that most AUVs are designed to "fly" along a preferred direction of motion, without slow-motion or even hovering capabilities. What is needed for some applications are vehicles that are more like ROVs, capable of moving slowly in all directions and exploring the complex topography of seamounts, but without resorting to an umbilical connection. This concept is now slowly materializing in the form of so-called "Intervention AUVs" that are designed to manipulate underwater, like an ROV, but without a tether (**http://www.scandoil.com/moxie_issue/issue_1-2/2004_1-2/alive-an-autonomous-light.shtml**). These AUVs move slowly, commanded through acoustic links. Most of the intelligence and decision-making capacity resides onboard the AUV. Pascoal reported that his institution has been involved in joint work with the Department of Oceanography and Fisheries (DOP) (**http://www.horta.uac.pt/**) of the University of the Azores in Portugal towards the development of technologies (including ROVs and AUVs) for the study of seamounts. DOP has a strong program devoted to the study of seamounts and marine habitat mapping around the Azores islands.

John Gunn suggested that integrating a suite of technologies would provide a significant increase in understanding of marine systems. For example, tags could be deployed with other technologies around seamounts to determine the residence time

of animals around seamounts. Alex Rogers responded that this could help study the idea of the role of seamounts in trophic focusing. Evidence suggests that seamounts don't promote primary production, but that the main reason for the observed productivity of seamounts is that they offer a location where the deep scattering layer can intersect hard substrate. Little energy needs to be expended by organisms on seamounts because the currents and movement of the deep scattering layer bring food to them. Fish tagged on seamounts in the Azores did not move significantly from one observation to the next one, two years later.

Francois Gerlotto confirmed the value of integrated multiple data sources, as shown by the observations of a change in the North Sea ecosystem around 1982.

CoML Barcoding Meeting and Other Molecular Technology Discussion

Mitchell Sogin (Chair of the International Census of Marine Microbes: ICoMM) reviewed the topic of pyro-sequencing **http://www.nature.com/nbt/journal/v21/n12/full/nbt1203-1425.html**). This technique is an alternative to standard polymerase chain reaction (PCR) methods and creates sequences of 100-120 base pairs. It is fast and inexpensive because it can be conducted in massively parallel format. The cost of the technique is primarily in the sequencing machine ($500,000), with each sequence read costing about US$0.02 (standard PCR costs about US$2-3 per read). One machine could potentially be used CoML-wide because of the high throughput. It is not useful for analyzing single organisms, but is well suited to doing environmental genomics/metagenomic sequencing. With these approaches, the molecular composition and population structure of one ecosystem can be compared with that of another ecosystem. Typically, the analyses are conducted on particles between 1 and 20 microns in diameter filtered from seawater.

Bob Ward reported that the CoML barcoding meeting earlier in the week was attended by about one dozen individuals, who helped Ann Bucklin finalize a proposal to the Sloan Foundation for a CoML barcoding workshop. The current plan is to hold the workshop on 15-17 May 2006 in Amsterdam, The Netherlands. Ed Urban listed the draft working group topics in two sessions:

1. Working Groups on Taxonomic Groups
    - Viruses, microbes, and protists
    - Meiofauna (infaunal)
    - Mesofauna (invertebrates)
    - Megafauna (vertebrates)
2. Working Groups on Major Issues
    - Database and data management needs
    - Specimen and materials handling
    - Capacity development: training workshops, student exchanges
    - Molecular protocols

- Use of museum specimens; formalin preservation
- Implementation: sequencing centers, at-sea sequencing

Other Technologies

John Gunn commented that the U.S. Mars Lander is designed to operate relatively autonomously and to do a lot of onboard decision making. How can we transfer such technologies to underwater use? Can we get some scientists from space agencies to meet with ocean scientists?

On controlling AUVs, Alex Rogers suggested that AUVs could have antennae like the wires on XBTs. Antonio Pascoal suggested that an autonomous surface vehicle could serve as a communication link between AUVs and a surface ship. Alex Rogers added that an array of communication buoys could be deployed in a survey area to work with the AUVs.

On the idea of new ways to get data back from tags remotely, Gunn noted that ship-mounted Simrad fish sonar collect data from individual fish tags within 7 km of the sonar. Alex Rogers suggested that similar data loggers could be attached to Continuous Plankton Recorder (CPR) units, which are self-contained plankton sampling devices towed behind commercial vessels in some ocean areas (**http://192.171.163.165/cpr_survey.htm**); the longest record is from the North Atlantic Ocean. Geoff Arnold noted that getting data back from animals is a real bottleneck to using tags. He noted that Simrad has produced a system to encode the GPS position of a vessel and transmit it underwater via a sonar signal and Star-Oddi has built a data storage tag with an integral hydrophone to receive the sonar signal. The tag records the encoded GPS signal and the time of reception. The maximum range is 7 km and will probably be less in most circumstances. The system is under evaluation and results can be found on the Star-Oddi web site (**www.star-oddi.com**). Like most other simple data storage (archival) tags, the Star-Oddi tags don't have the ability to transmit data. Two manufacturers, however, make pop-up archival tags that transmit data via Argos satellites and Vemco make a system for downloading data from acoustic tags, using fixed listening stations. Data transmission with both types of system is currently rather limited.

Francois Gerlotto reported that the International Council for the Exploration of the Seas (ICES) has a Fisheries Technology Committee (see **http://www.ices.dk/iceswork/FTC.asp**), which sponsors a Working Group on Fisheries Acoustics Science and Technology (see **http://www.ices.dk/iceswork/wgdetail.asp?wg=WGFAST**). This working group has common interests with the Technology Panel in new techniques for observing marine life. The ICES working group could take up some issues identified by the Panel and both could help implement new technologies.

On speeding up taxonomy, Yoshihisa Shirayama made a PowerPoint presentation. In places sampled for the first time, most species have not been described previously. There is a need to speed up the following process:

1. Field sampling
2. Sorting of organisms. Sorting is time consuming and requires knowledge. It can be expensive to have it done. Attempts have been made to design an automatic sorter, but this is not yet successful.
3. Mounting of organisms. This step is also time consuming, and requires knowledge and skill. It is probably not amenable to automation because it requires delicacy to put the specimens on slides and put on a cover slip.
4. Microscopic observation. The steps in this phase include optical section observation, reconstruction to a three-dimensional image (in the observer's brain), and drawing a two-dimensional image showing the characteristic structures. Available software for two- and three-dimensional visualizations do not fulfill research needs. Some promising techniques that also present challenges include the holographic microscope and the x-ray microscope
5. Identification
6. Description
7. Data analyses

Digital information may be utilized in terms of the original description database, automatic identification (application of fingerprint identification technology), automatic description (e.g., the DELTA system aids is creating an automatic description), and GIS analyses (e.g., through OBIS).

Other Comments from the All Program Meeting

Alex Rogers reported from the MAR-ECO meeting. One major concern was about the user friendliness of OBIS and the curation of OBIS data. What happens to records in OBIS when taxonomic names are changed? MAR-ECO is also concerned about communication and coordination among projects.

Ed Urban reported that the NaGISA project is interested in automated sorting, identification, and digital taxonomy, as described by Yoshihisa Shirayama in his presentation to the Panel.

OBIS—Alex Rogers asked Mark Costello if OBIS updates species names when they are changed. Costello responded that the component databases are usually up to date. The International Commission on Zoological Nomenclature (ICZN**:** **http://www.iczn.org/**) is responsible for international recognition of new species names. In principle, OBIS will eventually allow data without associated species names to be put in, which will be necessary for getting environmental genomics data into OBIS, particularly related to microbes and meiofauna. Costello asked the Panel to re-visit this issue later.

OBIS would like to do a companion article to the Panel article planned for *Sea Technology*.

Panel Representation at Project and Other Meetings

- 11th Deep-Sea Biology Symposium (9-14 July 2006 at Southampton, UK) -- see **http://www.noc.soton.ac.uk/GDD/DEEPSEAS/symp_pages/symphome.html**). Alex Rogers will attend this meeting and an associated CenSeam meeting.
- New Zealand meeting on Marine Acoustic Telemetry – John Gunn
- International Seabed Authority Meeting – Alex Rogers
- CoML Scientific Steering Committee, Iceland, Summer 2006 – Elgar de Sa and David Farmer
- TOPP Meeting, Monterey – John Gunn and Geoff Arnold
- Look for a nanotechnology meeting to send a Panel member or two to.
- CAML – June 2006 in Bremerhaven – Gunn or Ward?
- CoML Barcoding Meeting (funding pending) – Amsterdam, The Netherlands, 15-17 May 2006 – Bob Ward, Alex Rogers, Ed Urban

Panel Web site

Elgar de Sa reviewed the current version of the Panel Web site and described its operation. He encouraged Panel members to contribute articles for the Web site, to describe emerging technologies relevant to CoML. Some actions still to pursue:

- List all the CoML projects on the top navigation bar
- Work on copyright permissions for materials on site
- Still need to populate the site. Panel members can load information themselves or can ask Ed or Elgar to do it.
- Need to replace draft agenda (for first meeting) with final agenda.
- What do the usage statistics mean?
- Get CoML to link new Panel site on the CoML portal
- Add ICES WG on Fisheries Technology to Web site

Additions/Replacements to Panel

Yogi Agrawal has resigned from the Panel due to time constraints. Meeting participants discussed potential replacements, but asked for additional time to develop potential nominations. The Panel chair and staff will work with members over the coming months to identify one or two additional members.

Next Panel Meetings

2006—The next meeting of the Panel will be held in Kobe, Japan on 18-20 October 2006, in conjunction with the NaGISA World Congress (18-20 October) and Techno-Ocean 2006 (16-18 October). The Panel will participate in a session on technologies relevant to CoML on the afternoon of 18 October. The purpose of the session is to motivate manufacturers to commercialize some of the technologies needed by CoML

projects. John Gunn noted that the best way to motivate companies is to tell them how they can make money selling the technologies. The presentations should present the science and its challenges.

Meeting participants discuss five potential topics for the Kobe meeting, including

1. Tags – can a standard tag be developed and manufactured in large numbers, to reduce costs? What features would the ideal standard tag include?
2. Long-range acoustics for detecting marine life;
3. Underwater sampling and observing technologies – AUVs, ASVs, landers;
4. Barcoding and other molecular techniques; and
5. Sorting/imaging/digital taxonomy for organisms.

It was decided that it would be appropriate to pick two of these topics and the tags and underwater sampling and observing technologies were selected as being most appropriate. An abstract for the tags session will be developed by John Gunn and Geoff Arnold and an abstract for the underwater sampling and observing technologies will be developed by Elgar de Sa and Antonio Pascoal. Abstracts are due by the end of March 2006. Yoshihisa Shirayama will plan the session, with input from the Panel. All the papers would be invited, rather than contributed.

2007—Panel members appreciated the opportunity to attend the CoML All Program Meeting and tentatively plans to participate in the 2007 All Program Meeting.

Actions Items

Actions	Who	By when
Update de Sa PowerPoint slides to include all 14 CoML projects	De Sa	ASAP
Transmit de Sa's PowerPoint presentation to Urban	De Sa	ASAP
Article about formation of the Panel, in *Sea Technology* and/or *EOS*	De Sa/Urban	Dec. 31
Read document on technologies being used by CoML projects and send comments	Panel	Jan. 31
Make suggestions of new Panel members: industry, acoustics, satellite technology, visualizations	Panel	Jan. 31
Produce summary article about pyro-sequencing for Panel Web site	Mitchell Sogin	
Look for a nanotechnology meeting to send a Panel member or two to.	All	Continuing
Find out whether alternatives are being considered to the Argos satellites	Ed	Dec. 31

Approach tag manufacturers to see if they will attend Techno-Ocean 2006	John, Geoff	March 31
Approach AUV manufacturers to see if they will attend Techno-Ocean 2006	Elgar, Antonio	March 31
Finalize article on zooplankton sensors for Web site and/or publication	Gaby	Jan. 31
Investigate what panel could do in terms of advancing image analysis applications	Gaby	Jan. 31
Plan special session at Kobe Techno-Ocean meeting	Shira, Elgar, David	After registration closes in March
Web site actions: • List all the CoML projects on the top navigation bar • Work on copyrights for materials on site • Still need to populate the site. Panel members can load information themselves or can ask Ed or Elgar to do it. • Need to replace draft agenda (for first meeting) with final agenda. • What do the usage statistics mean? • Get CoML to link new Panel site on the CoML portal • Add ICES WG on Fisheries Technology to Web site	 Elgar Ed Panel Elgar Elgar Ed Ed	ASAP

Recommendations

- OBIS should allow input of data without species names, to make it possible to input molecular data from environmental genomics. OBIS should also determine how constituent databases will update species names and how OBIS should deal with this issue.

Web sites related to topics in report:

Web site	Mentioned by (see text)
Sea mammal Research Unit, St. Andrews University: http://www.smru.st-and.ac.uk/	John Gunn
Extreme ecosystem studies in the deep	Antonio Pascoal

Ocean: Technological Developments http://www.ifremer.fr/exocetd	
Barcode of Life database: http://www.barcodinglife.org/	Bob Ward
NOAA Coral reefs: http://www.pifsc.noaa.gov/cred/	Rusty Brainard
Seamounts Online: http://seamounts.sdsc.edu/	Alex Rogers
AUV movie http://www.scandoil.com/moxie_issue/issue_1-2/2004_1-2/alive-an-autonomous-light.shtml	Antonio Pascoal
Department of Oceanography and Fisheries (DOP) http://www.horta.uac.pt/	Antonio Pascoal
Pyro sequencing: www.nature.com/nbt/journal/v21/n12/full/nbt1203-1425.html 1425.html	Mitchell Sogin
Data loggers behind CPR: http://192.171.163.165/cpr_survey.htm	Alex Rogers
Star-Oddi web site www.star-oddi.com	Geoff Arnold
WG on Fisheries Acoustics S&T: http://www.ices.dk/iceswork/FTC.asp), http://www.ices.dk/iceswork/wgdetail.asp?wg=WGFAST**)**	Francois Gerlotto
International Commission on Zoological Nomenclature: http://www.iczn.org/	Mark Costello
11th DeepSea Biology Symposium: http://www.noc.soton.ac.uk/GDD/DEEPSEAS/ symp_pages/symphome.html	Alex Rogers