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 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 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 was to identify the major technical challenges confronting observers of marine life. To do this the group was 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 it, 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 project leader, Fred Grassle summarised the technical challenges facing this project, which were to locate deep hydrothermal vents and sample high temperature effluents and surrounding benthos. The fauna around deep vents, which included microbes, tubeworms and specialised shrimps, was adapted to high temperature and pressure. It was very different to the fauna surrounding seeps on the continental margins, which supported different communities, and was thought to offer considerable industrial potential in the form of new pharmaceuticals and specialised enzymes, for example. New vents had recently been discovered in mid-Atlantic using chemical sensors and this technology would be used in conjunction with an autonomous vehicle, such as AUTOSUB, which would also need to carry still and video cameras. REMUS, whose development was part-funded by the US Navy, was a possible vehicle; it had 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 would contract Cindy Van Dover for information about REMUS.

5. Coastal Survey of the Western Pacific (DIWPA) (Yoshihisa Shirayama)

The scientific aim of this project (Diversitas International of the Western Pacific Area), was 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 included lakes and forests, as well as the marine environment - would be published at the end of 2001. A major sampling effort was planned during 2002, which would be designated as International Biodiversity Observation Year (IBOY).

Identification and counting of meiobenthos presented a major technical challenge and it was necessary to find an accurate, cheap way of locating the positions of samples taken by SCUBA divers in the 0-10 m depth band. Advice was 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 were also major issues associated with the taxonomy and long-term preservation of type specimens of soft-bodied species, such as nematodes, of which there could 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, offered one possible solution to the taxonomic problem. Because the literature was generally poor and there were only a few taxonomists with relevant knowledge, the project would have to rely heavily on parataxonomists, who would require computer-aided, self-learning identification systems. It would also be highly desirable to automate the process of sediment sorting, which was a slow, skilled and expensive job. The requirement was for a machine, which would 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 would 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 location. 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 was to use a pop-up buoy with a GPS receiver, which the diver could deploy when he wanted to fix his 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 wanted to determine his 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 was critical to get processing costs down, 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 (e.g.) Japan. Fred Grassle drew attention to the existing link between the British Museum (NH) and Thailand for the identification of polychaetes.

Ken Foote asked if there were any value in obtaining data for which identification was only taken to order and genus. If there were, 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 did not allow sorting or manipulation (rotation and orientation) of organisms for the initial identification; and (b) having identified the genus, it was usually quite easy (and thus more cost-effective) to identify the species at the same time. Ian Perry questioned whether it was necessary to sort and identify material from all samples, or whether it was 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 was towed by a research ship, generated a huge amount of data but used 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 was no forum for discussion but one was needed.

Commenting on the time-scales on which solutions were required, Olav Rune Godø pointed out that, although a means of accurately recording the position of SCUBA divers was an urgent requirement, the technology was already available and the problem could be solved quickly. The taxonomy for large organisms was also well established and a preliminary description of latitudinal distribution was therefore feasible by 2004. Comparable work with meiobenthos would not, however, be practical until the necessary taxonomic tools became available in 2004/05. 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 big 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 (*reference?*), which was available for a few hundred dollars. Fred Grassle commented that Skin Diver magazine was a good source of simple, cheap solutions 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 offered the potential for wide-scale synoptic surveys that could not be achieved with research vessels, provided standard sounders had 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, offered the potential of four scientific sounders looking simultaneously in different directions. A quantitative signal with a good dynamic range was, however, an essential prerequisite.

Turning to the specific problems of the Gulf of Maine census, Ken Foote provided a list of species (Annex B) for which it would be appropriate to use acoustic surveys and identified four challenges in the development and application of this technology (Annex C). The first and second challenges were to make good acoustic measurements and quantitative biological measurements. The third entailed target classification, for which better acoustic bandwidths were required. The WG could help by supporting the case and stimulating manufacturers to provide solutions. The fourth challenge involved 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 was a census of intertidal and sub-tidal benthos. Distribution and abundance would be surveyed from 0 to 20 m in specified areas, using transects and standard protocols. Soft sediments would be sampled using cores, or a cheap sediment profile-imaging camera. Epifauna would be recorded with a digital still camera prior to physical sampling and the bottom would 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 would be obtained with interferometric sidescan sonar. Oceanographic data would be obtained from nearshore GoMOOS moorings and data acquisition would be designed to complement parallel offshore benthic studies. The results of the pilot inshore and offshore studies would be fully integrated.

Data would 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 was the distribution of biomass by taxon and habitat. This question, which had been highlighted by Van Holliday at the inception of the CoML programme, had 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 offered great opportunities in both developed and undeveloped countries, provided various problems could be overcome. François Gerlotto pointed out that developing countries could afford neither expensive equipment, nor expert observers. Sorting and cleaning up data was therefore a major issue, especially as ships of opportunity afforded the only way of carrying out large-scale synoptic surveys in such countries. Experience in Japan (Yoshihisa Shirayama) and Canada (David Welch) had, however, demonstrated the wide-spread need for simple, reliable, automated 'black box' instruments, which could be readily used by fishermen or other mariners, and easily serviced and calibrated by scientists after each voyage. Fishing vessels, which could also provide 'ground-truthing', would 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 usefully harnessed.

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 replaced 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 to which would have world-wide application; a link to OBIS might be useful. In reply Ken Foote said that, given that species identification was 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 was a key area for scientific advancement and that increasing the bandwidth of instruments was a key technical issue. François Gerlotto drew the WG's attention to the ICES Symposium "Acoustics in Fisheries & 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 was an international project that involved France, Peru and Chile and would last from 2001 to 2008; it was hoped that it would be of interest to CoML. The objective was to explain how the very large fluctuations in fish catches off the coast of South America were linked to climatic variation and to understand how the multi-species ecology of the Humboldt Current responded to the huge environmental variations associated with ENSO. The approach was to study the behaviour of both individuals and schools and to relate these to stock behaviour and stock characteristics. There were significant technical challenges in making direct observations and also in surveying whole populations, which spanned a vast region subject to rapid environmental fluctuations, and also extended into inaccessible areas.

The solutions to these problems were 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 entailed a two-day survey by a large fleet of commercial fishing boats, which was equivalent to a 1.5-month survey by a research vessel. The data were not quantitative, however, and there were major acoustic problems associated with calibration and noise. The technical challenge was 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 allowed large areas to be surveyed quickly at low cost. The instrument was non-intrusive and produced data very similar to those from acoustic instruments. The technical challenges were 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 could 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 were 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 were needed to overcome these limitations.

In discussion François Gerlotto and David Farmer agreed that calibration was absolutely vital to the success of the project. Otherwise, it was agreed that the project was an exciting one, given that – as Olav Rune Godø pointed out – the inability to make 'snap-shot' surveys was a key constraint in attempting to understand ecosystem dynamics. The help of the international community was 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 aimed 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 would be tagged internally with surgically implanted acoustic tags, a well-tried technology. The plan was to install ~25 lines of acoustic receivers across the shelf at strategic points, and also to instrument all west-coast rivers from Sacramento northwards. A total of 600-700 receivers was envisaged. The technical requirement was for autonomous units with lithium batteries providing a 3-5 year life. Each unit would 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 would be encapsulated in resin inside a low-profile cast iron, or concrete mount that would not readily be trawled up. A research vessel would recover data every few months. Acoustic receivers were readily available at low cost, but information was 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 had been in use for fish tracking in Europe since 1970 and that electronic circuits for high-frequency tags (76 – 300 kHz) had been published by both CEFAS and the University of Aberdeen in the UK (Annex D). 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 would be alongside the acoustic unit. At all other times, when unattended, the acoustic unit would only be listening. Low power tag transmissions were not regarded as significant sources of noise for marine mammals. In relation to data retrieval, David Farmer commented that many acoustic modems were available and that experts at WHOI would be well placed to advise. Fred Grassle commented that ROVs had 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 came to the surface on command. Other technical issues included: 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 was an emerging international ecosystem study that had recently received a planning grant as a CoML Pilot Project. It aimed to conduct the first large-scale coherent study along the mid-Atlantic ridge, which was a poorly described environment. The objectives were 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 would cover the 1500-km from Iceland to the Azores, a poorly mapped area with depths of 500-3500 m characterised by rugged terrain, sea-mounts, steep slopes, hard substrates and variable currents. The project would focus on fish, cephalopods, crustaceans and gelatinous plankton and nekton, and would encompass bentho-pelagic and epibenthic macrofauna, as well as pelagic organisms. There would be a general pelagic survey plus detailed surveys and 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' would be available to participate in the planned multi-ship operation. Acoustic surveys would 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, would 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 of 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, Olav Godø and Olav 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 were both needed to sample jellyfish and cephalopods effectively. Multiple opening and closing nets would also be used and trawling would be possible to 3000 m using very large pelagic trawls towed at 5 knots. It was intended to use standard trawl instrumentation, although this was only rated to 1200 m and, as David Farmer pointed out, there was an important technical challenge to be overcome in extending the capability to 3000 m. Observing and capturing jellyfish and cephalopods also presented a major problem. A number of solutions were suggested, including imaging techniques and ROVs, which offered some catching ability (Gaby Gorsky). A range-gated laser scanner developed at MBARI (Ron O'Dor), offered 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 sea-mounts off New Zealand. Olav Rune Godø commented that the project would include a research vessel cruise in late 2002 to trial deep-water technology.

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

The aim of this program was to generate a detailed understanding of how marine animals from several trophic levels use distinct oceanic regions in the North Pacific. These included 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 would identify migration routes and critical habitats and link behaviour and distribution to oceanographic processes, would employ advanced electronic tags, whose use had 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, were now known to range over the whole North Pacific and to show striking differences in distribution between the two sexes.

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

The project would use available electronic tags, or new tags that could be field-tested in 2002; the target species had been partly selected on their ability to carry these tags without difficulty. Archival tags, which could be implanted or attached externally, and pop-up tags, which were towed by the fish until release, both incorporated light sensors, which were sufficiently sensitive to detect dawn and dusk at depths of 200-300 m in relatively clear water. From these measurements it was possible to determine geographical location (latitude rather less accurately than longitude) with sufficient precision for the proposed aims. There had been technical problems with the first generation of archival tags for use on large pelagic species, but these had been relatively minor and had now reportedly been solved by the respective manufacturers. In once 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 were now needed. Pop-up tags that could transmit data via the Argos satellite system were 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 was low, but no alternative was available in the short-term. Standard GPS tags for use with marine mammals had high power consumption, but it was hoped to use a new tag currently under development in the UK, which would record a rapid 'snapshot' of the GPS satellites each time the animal surfaced, but would not process the data.

A key technical issue would 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 would 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, could 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 had been entered in the World Ocean Database. Problems were, however, envisaged as a consequence of having to collect information on a variety of spatial or temporal scales. It was 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 was a general phenomenon and the behaviour of crab-eater seals in the Antarctic, for example, followed a similar pattern. Krill surveys were time consuming, however, and whilst it was easy to describe the behaviour of individual seals it was difficult to obtain an integrated picture of the local densities of their prey to which the seals were 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 was used to track vehicles and other items, had a transmitter that was generally too large for use with animals. The system was, however, suitable for retrieving oceanographic data and Geoff Arnold reported that CEFAS was routinely using Orbcomm to recover data from buoys on the European continental shelf. Iridium, which had a smaller transmitter and should be practical for animal telemetry, was 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 had 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 (*reference needed*). This would provide a good guide to the location of floating objects (FADs) which, as François Gerlotto pointed out, were known to attract tuna and possibly alter their migration routes. Behaviour also changed when individual tuna aggregated 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 Quingdao, Peoples Republic of China in 2002 (18-26 October). The theme of the meeting would be 'Technological Advances in Marine Scientific Research' and there would 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 Climate Change & Carrying Capacity Program. The meeting, which would be organised by the PICES Monitor Task Team, would 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:

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Annex B: List of species to be investigated by acoustic surveys (Gulf of Maine)

Annex C: List of challenges for acoustic technology (Gulf of Maine)

Annex D: 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 E: Species identified for investigation in TOPP project

Annex F: Web sites

CoML: http://www.coml.org

SCOR WG 118: http://pulson.uvic.seos

MAR-ECO: http://www.efan.no/midatlcensus/