A CPR-Based Plankton Survey Using Ships of Opportunity to monitor the Gulf of Alaska
“Submitted Under the BAA”

Project Number:	
Restoration category:	Monitoring
Proposer:	Sonia Batten (Sir Alister Hardy Foundation for Ocean Science) & David Welch (Pacific Biological Station, DFO, Canada)
Lead Trustee Agency:	
Cooperating Agencies:	
Alaska SeaLife Center:	No
Duration:	1st year, 1-year project
Cost FY 02:	\$120,600
Cost FY 03:	\$000,000
Geographic Area:	Prince William Sound, Gulf of Alaska, Bering Sea
Injured Resource/Service:	Pacific salmon, Commercial fishing

ABSTRACT

This proposal presents the rationale for developing a plankton monitoring program for the Gulf of Alaska using ships of opportunity. Plankton are a critical link in the marine food chain whose dynamics are poorly understood, but respond rapidly and unambiguously to climate change and form the link between changes in the atmosphere and valuable upper trophic level populations, such as salmon, herring, shrimp, and groundfish. We review the evidence that many of the most valuable marine resources in the Gulf of Alaska are strongly influenced by changes in ocean climate. SoOPs are a cost effective platform for large scale monitoring and this proposal builds on recent experience gained with the CPR in the N. Pacific to prepare for the GEM program.

INTRODUCTION

During 2000, and again in 2001, Continuous Plankton Recorders (CPR) have been deployed along an oil tanker route originating in Prince William Sound to initiate an ocean observing system for the Gulf of Alaska. This proposal seeks to make the experience gained during this study available to the GEM program. The current GOA CPR program was built on the long experience of using CPRs in the Atlantic where ships of opportunity have been towing them for over 70 years. The Sir Alister Hardy Foundation for Ocean Science (SAHFOS) has a long track record in working with a variety of commercial shipping companies, in some cases decades of collaboration with the same company, and operates CPRs on upwards of 20 different routes every month in its traditional sampling area. This experience was invaluable in setting up the north Pacific sampling (Fig 1 and described below) in 2000/2001 and successfully acquiring samples.

A cost effective monitoring program under GEM is likely to use ships of opportunity as the fundamental platform for collecting a wide variety of data because of the costs and time restrictions on using oceanographic vessels. Consistent timing in the scheduling of research ships over many years is unfeasible, and the costs of running special-purpose vessels prevents repeated sampling within a year. Repeat sampling is critical if changes in seasonal timing are to be identified. Our experience so far, which we describe so far, has been restricted to plankton and some basic physical data but this could be extended.

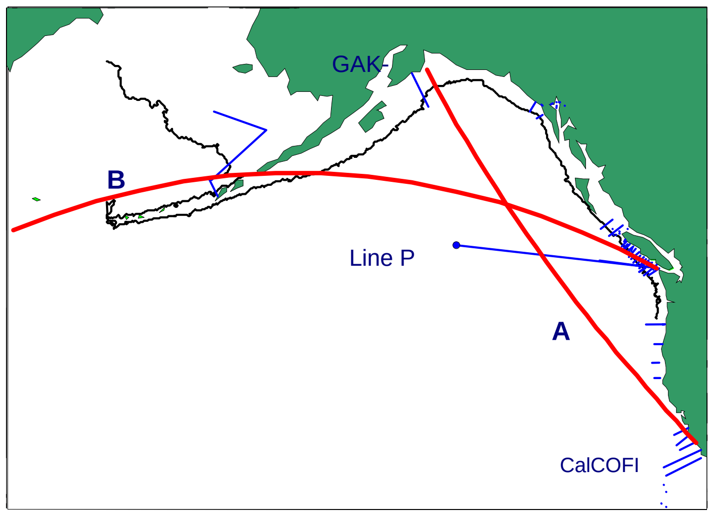

Fig. 1. The CPR plankton monitoring lines (A & B; in red), compared to other NE Pacific ocean monitoring locations (blue). The continental shelf edge is shown in black.

Zooplankton provide the link between primary production and higher trophic levels, providing food directly for some species such as herring, young salmon, and some whales and indirectly for all marine fish, birds, and mammals. They are sensitive to environmental change and because they have short life cycles (typically less than one year and often only months) provide a rapidly responding indicator of the state of the ecosystem and important scientific information on how climatic changes (such as regime shifts) alter ecosystems to affect marine fish populations. Furthermore, interpretation of their fluctuations is free from the considerations of fishing effort because they are not a harvested resource.

This proposal seeks funding for 2001/2002 to support the monitoring program recently begun under the North Pacific Marine Research (NPMR) fund. Significant progress towards a monitoring program for the Gulf of Alaska has been made with this two year project using ships of opportunity and the CPR. These data will provide some baseline information on plankton populations. However, if an optimum monitoring program is to be designed and implemented by GEM and other agencies it is necessary to continue this sampling and build on the approach. The NPMR project was advocated and supported by PICES and has been included as a pilot project by the Living Marine Resources panel of the Global Ocean Observing System. Current funding finishes in Fall, 2001.

NEED FOR THE PROJECT

A. Statement of problem

Placement of oceanographic instrumentation packages on ships of opportunity has been proven as a cost effective means of acquiring useful data; however, implementing an effective program requires substantial expertise. The flexibility of the ship of opportunity platform needs to be considered so that appropriate measurements and the most suited instruments to obtain them can be used. The short-term objective of this proposal is to develop the sampling infrastructure, the spatial and temporal scales necessary to establish changes in the ocean distribution and abundance of plankton.

Monitoring of the physical environment to aid interpretation of the changes is in some ways simpler than acquiring the detailed biological information. The CPR is a proven (with quantifiable limitations), rugged, cost effective oceanographic instrument that provides species level information. GEM's mission is to *"sustain a healthy and biologically diverse marine ecosystem in the northern GOA and the human use of the marine resources in that ecosystem through greater understanding of how its productivity is influenced by natural changes and human activities".* Our proposal will aid that mission by providing essential data and building a bridge to a much larger international monitoring effort for the North Pacific.

Large scale changes in Pacific salmon populations in all regions of western North America have been related to climate change in this century. Although best studied in salmon, similar influences are also thought to occur for other important upper trophic level organisms. The initial cause is likely due to changes in the structure of the atmosphere and then the ocean, which then pass up the food chain through the plankton to affect the fish and mammal populations at higher trophic levels. These changes are known to affect the abundance, productivity, and community structure of both continental shelf and open ocean plankton communities. The changes in plankton abundance have been related to the changes in salmon abundance, and reduced ocean productivity is probably the causal link leading to poor survival of salmon and other important resources in the ocean. These changes appear to have extended back centuries (e.g. Ware 1995), and to have affected a wide variety of Alaskan resources including shrimp and groundfish (e.g. Anderson and Piatt 1999) and salmon (e.g. Finney 1998).

Both the Pacific Ocean and Bering Sea lack the long-term monitoring necessary to detect changes in the ocean. This hampers our ability to detect and respond to either short or long-term climate change. Climate change seems to have driven the overall dynamics of Pacific salmon populations in the past, and to have been as important as the effect of commercial fisheries in determining population levels. Friedland (1998) has suggested that ignorance of decadal-scale changes in ocean productivity will doom salmon management efforts to failure in the Atlantic. Such comments probably apply equally to the Pacific. In addition, the effects of anthropogenic climate change due to global warming over the next few decades are expected to dwarf the climatic changes observed to date. To put the amount of future climate change expected in perspective, global warming is expected to successively add as much warming each following decade as has been observed over the entire 20th century. The cumulative change over the next century is projected to be ten times that experienced in this century—and the changes in this century are the greatest in 1,000 years.

The climatic changes experienced in recent years are consistent with expectations from models for the early stages of global warming. In all regions of the West Coast of North America there have been abrupt changes in the productivity of salmon populations. These changes have not been expected from the standard fisheries management theories, nor could they be forecast from available data. However, the changes have had devastating economic impacts on coastal communities from Oregon to (most recently) Alaska. The pattern of failure in year-class strength of western Alaska chum and chinook populations or Bristol Bay sockeye salmon, as well as other many stocks and species in British Columbia and the Pacific Northwest demonstrates that the cause of the sudden downturn has a largely marine origin (e.g. Welch *et al* 2000). However, salmon spend part of their life history in both coastal and oceanic marine environments, and are therefore subject to environmental changes occurring in both regions.

An advantage of developing the CPR as oceanographic instrumentation on ships of opportunity for the GEM program is that it builds on existing work that has been endorsed by the scientific committee of PICES. Funding this proposal would put in place a monitoring framework that will build on the existing two years of baseline data collected using the CPR. At the PICES VIII annual meeting in October 2000 the PICES community struck a CPR Advisory Committee, which has begun moving towards developing a monitoring program that would eventually include a much broader range of environmental parameters using ships of opportunity (T, S, nutrients, Chl-a, photosynthetic rates from Fast Repetition Rate Fluorometry, and zooplankton size-structure (using OPCs (optical plankton counters)).

The changes that the Atlantic CPR program has documented in the 1990s are now being linked to the decline in Atlantic salmon populations, which are also experiencing substantially increased ocean mortality. Funding for our proposal would allow continued sampling of the plankton in multiple regions of the offshore and coastal regions of the eastern North Pacific and southern Bering Sea (Fig. 1). The monitoring lines would (a) sample the plankton along the coastal migration routes of the juvenile salmon in four locations, (b) quantify the distribution and abundance of plankton in the offshore (which appears to drive the abundance of shelf plankton populations in the Atlantic (Steele 1998); the relationship of shelf to offshore populations is unclear in the Pacific because of a lack of data), and (c) permit cross-comparisons with almost all existing eastern Pacific ocean surveys (CalCOFI in California; Line P in Canada; and GAK-1 near Seward, Alaska).

The lack of large-scale Pacific monitoring in the past has the advantage that setting up a proper basis for monitoring is not limited by worries about disrupting existing time series. Developing the new survey now, with the benefit of 70 years of experience in the Atlantic, is allowing us to tailor-make a survey specific to the ecosystem of the north Pacific that will take advantage of the revolution in automated monitoring sensors now occurring, and which will eventually complement the detailed zooplankton species identification possible with the CPR. This proposal seeks the support to extend the two year survey while we put in place the foundations of a long-term monitoring programme. Funding will also be sought elsewhere to broaden the survey and strengthen the involvement of other North Pacific agencies.

We are already in a time of apparently unprecedented climatic change. We relate the existing proposal to parallel initiatives to develop improved scientific monitoring and secure long-term funding in a later section of the proposal. This initiative has been discussed by both the Monitoring Task Team at the PICES Annual Meeting in Hakodate Japan (October 2000), and designated as a GOOS-LMR pilot project for the North Pacific by the IOC Living Marine Resources Panel of the Global Ocean Observing System (GOOS), Third Session, Talcahuano Chile, in December 1999. This followed on an earlier LMRP report that noted: “In the PICES region, work was described in the north-west Pacific that could constitute an LMR (Living Marine Resources) pilot project, as could a north-east Pacific plan being developed for use of the Continuous Plankton Recorder (CPR)”.

B. Rationale/Link to Restoration

The Trustee Council is planning the future of the oil spill restoration program through the formulation of a long-term research and monitoring effort, GEM. A ships of opportunity program originating in Prince William Sound using CPR technology makes a direct contribution to the development of GEM. The types of data acquired by CPR and other instruments that may be deployed using our approach would be appropriate to evaluating hypotheses regarding sources of change in productivity from earlier restoration projects (i.e. Sound Ecosystem Assessment, SEA). In particular, the role of changes in climate (i.e. “weather”, when considered on decadal scale averages) in changing productivity would be amenable to evaluation by CPR and related data collected from ships of opportunity. Observations of climate change in the atmosphere and simple physical variables such as sea temperature and atmospheric pressure are readily available. These data show that large scale physical changes are evident which seem to be associated with changes in ocean productivity observed in upper trophic levels (i.e. fish production). However, correlative relationships frequently break down, and the lack of a mechanistic understanding of how the North Pacific can rapidly shift from one state to another (“regime shifts”) limits our ability to manage these resources by setting harvest rates appropriate to the productivity of the populations. The data necessary to show directly that changes in primary or secondary plankton production are occurring have not been collected in a systematic fashion in the North Pacific, and have largely depended on opportunistic sampling from Japanese research ships sampling a series of transects only once a year.

The existing data linking intermediate trophic levels to the changes in the physical environment and to the changes in fish production are sporadic and based largely on mid-summer ocean sampling, and have not been collected in a way that allows identification of species composition changes. Mackas (1998) has demonstrated that the timing of the movement of the dominant zooplankton species to the surface mixed layer where they are available to salmon has shifted forwards by at least two months in the eastern North Pacific, emphasising the need for replicate sampling to establish seasonality. Neither the changes in seasonality observed in the Pacific (Mackas 1998) or the large changes observed in the Atlantic (Reid and Planque, 1999) would be identified by simply supporting the existing plankton collection framework in the Pacific Ocean; without the CPR survey the only repeated open ocean sampling of plankton in the eastern Pacific Ocean is the Canadian Line P, which is now typically occupied only 3 times per year (February, May-June and August-September). Batten *et al* (1998) used the Atlantic CPR data to evaluate the changes in the plankton before and after the Sea Empress oil spill in the Bristol Channel to see whether that oil spill had a measurable effect on the plankton community. Without similar data from baseline monitoring programs in the Pacific it will be impossible to address questions of how marine communities may change over time or whether specific anthropogenic effects have caused changes in the ecosystem.

It is important to study the ecosystem dynamics of regions outside of Prince William Sound or even the continental shelf region seaward of the Sound. The ocean outside Prince William Sound apparently forces plankton abundances within the sound (Cooney, *pers. comm.*). In the Atlantic, where much more plankton sampling has been carried out, shelf populations of *Calanus* are known to be driven by off-shelf populations. Steele (1998) comments "*The Calanus story described earlier, and corresponding work in the Pacific (Parsons and Lalli, 1988) indicates the need to consider the open ocean as the starting point for major shelf populations [of zooplankton]*".

In the Pacific Ocean, Cooney (1986) noted that "*The degree to which the* [Alaskan] *shelf is enriched by oceanic biomass can be estimated by measuring both the standing stocks and the rate of onshore surface flow. Cooney (1984) proposes that over an eight month period from March to November of each year, ~$10x10^6$ mt of zooplankton biomass are advected shoreward from the upper 50m of the bordering ocean. This biomass then moves into the outer edge of the Alaska Coastal Current along 1000 km of coastline in the northern Gulf of Alaska. This advected zooplankton biomass compares to the ~$2x10^6$ mt estimated as the production yielded by zooplankters resident in the Alaska Coastal Current. If this calculated contribution is at all accurate, the bordering ocean supplies an immense and significant amount of biomass to both shelf and coastal food webs each year*".

C. Location

For these reasons, it is important to place an ocean monitoring program in a broad context, and not to artificially restrict the study to only a small geographic area, since climatic change and environmental forcing may be expressed on much broader scales. Line A from our proposal would allow cross-comparison with historical plankton sampling done on the GAK-1, Line P, and CalCOFI lines (Fig. 1). Line B would provide comparison with the central Gulf of Alaska, the shelf on the south-western end of the Alaska Peninsula, and the southern Bering Sea and western Aleutians. These are all regions extensively used by Alaskan salmon during their ocean migrations, and therefore have relevance to Alaskans from many areas of the state.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

With only one year it is not practical to set up a local analysis facility since training in plankton identification takes many months before sufficient proficiency is acquired. However, in the long term a local station where such analyses could be carried out, with quality control and exchange procedures facilitated by an organisation such as SAHFOS, would be sensible and desirable. The keen understanding of nature shown by many native communities suggests that in the future it may be possible to train local individuals as technicians in the art and practice of taxonomic identification.

PROJECT DESIGN

A. Objectives

1. To develop and apply the ship of opportunity approach to oil tankers and other large merchant vessels in order to obtain data on lower trophic levels for the Gulf of Alaska and adjacent waters.
2. To deploy the CPR from ships of opportunity on selected transects and to process the samples obtained for plankton species abundances. This third year of data would significantly enhance our understanding of the plankton communities of the Gulf of Alaska; determination of the extent of large scale spatial heterogeneity in the plankton of this region will aid the planning of the GEM sampling program and go some way towards establishing the expected degree of seasonal and interannual variability.
3. To further enhance the use of ships of opportunity by supplementing the biological data with physical sensors. The first year of data collection has identified large changes in plankton community composition and biomass within different regions of the Gulf of Alaska. A desirable long-term goal is to extend the sampling program to include a broader range of physical, chemical, and biological variables. As a first step, we suggest that sensors be installed to collect data on temperature, salinity, and fluorescence that can be compared with the zooplankton data from the CPR. A self-contained T-S-F unit that can be mounted on the towed CPR is available at modest cost (ca. $15,000 plus operating costs), but collaboration with the proposal by Okkonen and Royer to place a thermosalinograph and fluorometer internal to the ship would be preferable because of the scientific collaboration that would result. The ultimate goal of a ship of opportunity monitoring program would be to have a fully self contained suite of sensors either internal to the ship or on a towed body. This objective would go some way towards realising that goal.

B. Methods

Standard CPR methodology

CPRs are towed in the surface mixed layer at a depth of about 7m by commercial ships of opportunity on their regular routes of passage. Water enters the front of the CPR through a small square aperture (1.27cm), passes along a tunnel and through a silk filtering mesh (with a mesh size of 270µm) which retains the plankton and allows the water to exit at the back of the machine. The movement of the CPR through the water turns an external propeller which, via a drive shaft and gear-box, moves the filtering silk across the tunnel at a rate of approximately 10cm per 18km of tow. As the filtering silk leaves the tunnel it is covered by a second band of silk so that the plankton are sandwiched between these two layers. The silk and plankton sandwich is then wound on into a storage chamber containing preservative. At the end of the tow the machine is returned to the laboratory and the silks are processed in a routine way. The silk is cut into separate samples (each representing 18kms of tow and about $3m^3$ of seawater) which are randomly apportioned amongst the analysts for plankton analysis. (The $3m^3$ sample volume analyzed is comparable to that which would be measured by an OPC towed along the same track line).

The first step is the assessment of phytoplankton colour (the greenness of the sample) which is determined by comparison with standard colour charts. It is a representation of the total phytoplankton biomass and includes the organisms that are too fragile to survive the sampling process intact but which leave an impression on the silk. Hard-shelled phytoplankton are then semi-quantitatively determined under a microscope by viewing 20 fields of view and recording the presence of all the different taxa in each field. Small zooplankton are identified and counted into categories of abundance from a subsample (1/50 of the sample) whilst all zooplankton larger than about 2mm are counted with no subsampling. Identification is carried out to the highest practicable taxonomic level and is a compromise between speed of analysis and scientific interest. Since copepods make up the vast majority of the zooplankton most copepods are identified to species level whilst rarer groups are identified to a lower level. Although CPR sampling is continuous, the midpoint of the sample is used to label it with latitude, longitude, time and date. All of this information is stored on a relational computer database so that the questions of when, where, and how much can be answered. All of the samples are archived after analysis so that they can be re-examined at any time, for example, if a scientist with an interest in a specific group wishes to study it in more detail, or an incident occurs which warrants closer examination of the samples from that area.

The CPR is a relatively simple, rugged piece of oceanographic equipment. It can withstand being deployed from large ships moving at speeds of around 20 knots and still function, and over 95% of tows successfully record plankton. It has the ability to carry instruments to record the physical environment of the plankton which can be invaluable supplementary information when distinguishing between communities. A high level of expertise is needed to carry out the taxonomic analysis but SAHFOS has an excellent team of analysts, some members with over 30 years of experience.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

We propose that the collection of temperature, salinity and fluorometric data be assigned to Drs Okkonen and Royer (UAF and Old Dominion Universities) under their proposed project, but in the event that they are unable to do so SAHFOS can arrange for the purchase and maintenance of a self-contained instrument to collect this data. Welch is employed by DFO in Canada and is chairman of the PICES *"Climate Change and Carrying Capacity"* program. PICES also sponsors the CPR research with its CPR advisory panel, which is constituted under the Monitoring Task Team of the 4Cs program. These agencies will contribute staff time and institutional resources to the project but do not require funding from this proposal.

SCHEDULE

A. Measurable Project Tasks for FY 02 (October 1, 2001 – September 30, 2002)

January 14-23:	Attend annual restoration workshop
January:	Liase with shipping company regarding 2002 schedule. Arrange and carry out any necessary davit transfer or testing.
February:	Ship equipment to vessel in Long Beach
Late March :	First sampling from Alaska to California
Late April:	Second sampling from Alaska to California
May:	Ship equipment to vessel in Vancouver
Early June:	Third sampling from Alaska to California
Mid June:	Sampling from Vancouver to Kamchatka (coincident with Line P cruise)
Mid July:	Fourth sampling from Alaska to California
Mid August:	Fifth sampling from Alaska to California
Early October:	Attend PICES XI meeting, China.

B. Project Milestones and Endpoints

April:	Sampling schedule will be confirmed (although still subject to change according to requirements of the Shipping companies)
August 31st:	All 2002 sampling completed Integrate biological data with physical data acquired by Okkonen and Royer
September 30th:	Preliminary taxonomic processing complete. Quality control will be ongoing
October, 2002:	Attend PICES X meeting (China) and CPR Advisory Panel to present and review results and collaborate for development of broader scientific program.

C. Completion Date

All sampling will be completed during Fiscal year 02. Taxonomic processing will also be completed during FY02 although it is anticipated that quality control will be ongoing after September 2002, according to normal SAHFOS procedures. Analysis of the results and completion of the final report will be achieved by the deadline of April 15th 2003.

PUBLICATIONS AND REPORTS

It is not expected that publications will be submitted during FY02, since sampling will not be completed until the latter part of the year. However, at least one publication will be prepared upon completion of the analyses.

PROFESSIONAL CONFERENCES

Funding is already secured for attendance at the PICES X meeting which occurs just in FY02. Although the PICES XI meeting will be held just after the end of FY02 (in mid October 2002) we ask for support for one CoPI (Batten) to attend this meeting. PICES has been instrumental in the setting up of the Pacific CPR sampling and the results from this proposal will be reviewed at the CPR advisory panel and MONITOR task team meetings. Review and collaboration with the Pacific science community will be essential to strengthening future monitoring efforts.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Primary collaboration is most simply achieved by coordination of this project with the Okkonen & Royer proposal to collect basic physical oceanographic data on the same oil tankers, which will provide useful synergies and a broader base to the monitoring effort. The collected CPR data are freely available to other investigators and we have already had discussions with Weingartner et al's GAK-1 project (EVOS Project 340: Long-Term Oceanographic Monitoring), and the Canadian Line P program (Dave Mackas has also taken on the role as chair of the PICES MONITOR task team, and Charlie Miller of OSU is the chair of the PICES CPR Advisory Panel).

PROPOSED PRINCIPAL INVESTIGATOR

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PRINCIPAL INVESTIGATOR

Sonia Batten –. Will oversee the sampling program, processing of samples and carry out statistical analyses of the acquired data. Will coordinate production of the final report and publications. Qualifications: PI on NPMR project, SAHFOS Assistant Director

David Welch – Will take responsibility for co-ordinating the broader scale monitoring effort, and developing a co-ordinated program amongst the Pacific science community. Welch is currently co-PI on the NPMR project, and chairman of the PICES 4Cs program and the Alfred P. Sloan Foundation's Census of Marine Life Pacific project, "POST".

Experience of SAHFOS

The Continuous Plankton Recorder (CPR) was devised in the 1920s by Sir Alister Hardy, who wanted a simple, cost effective way of sampling the plankton. He intended the CPR to provide information on plankton for the herring fishermen (then an important commercial North Sea fishing industry) to enable them to better assess fishing prospects on the basis of the type of plankton present. Right from the beginning Hardy intended that the results of the survey be used as an aid to understanding changes in stocks, to improve fishery management and help determine the potential productivity of the seas. He designed the CPR to be towed behind commercial ships on their regular routes of passage and so avoided expensive research ships. The first operational tow took place in 1931 and since then, apart from a break for the Second World War, the CPR survey has operated continuously in the seas around Britain and now world-wide. It is one of the longest running marine monitoring programmes in the world and since 1931 more than 200,000 samples have been analysed and CPRs have been towed for over 4 million miles.

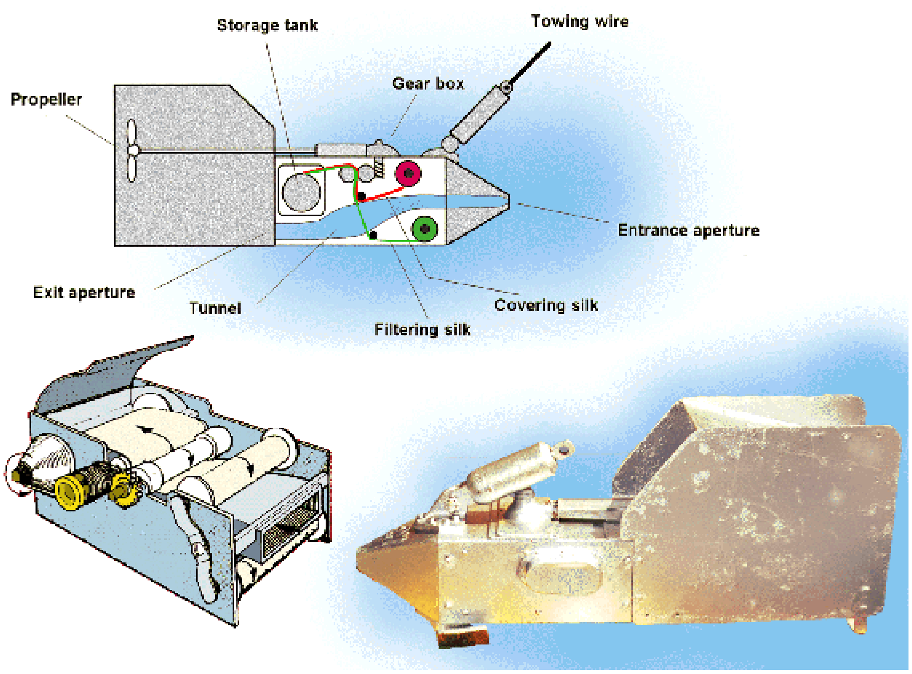
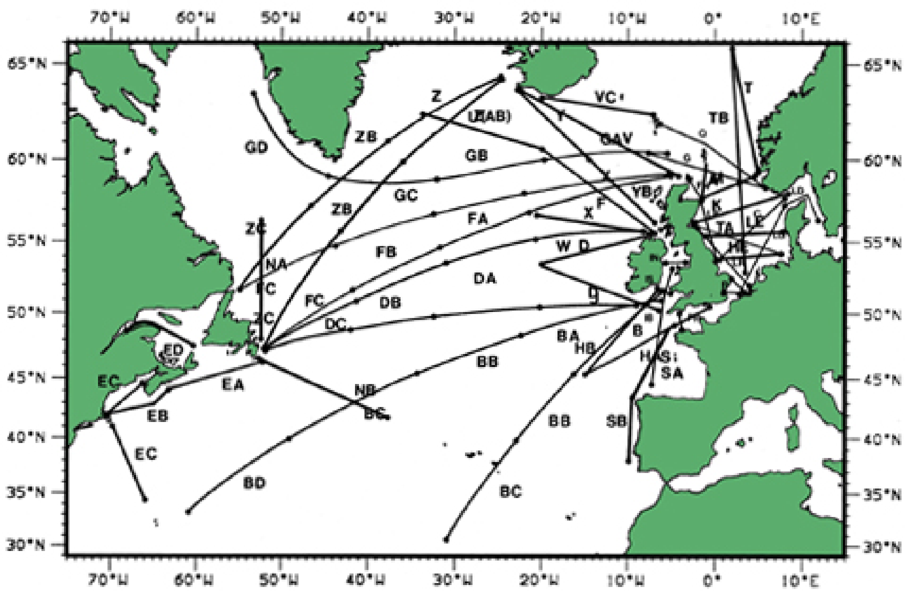


Diagram showing a cutaway view of the original CPR , the plankton filtering mechanism, and a photograph of the instrument.

The CPR survey today

Although originally publicly funded, a change in science policy forced the closure of the survey in 1989. International concern compelled a rescue package to be immediately set in place to enable the team of analysts and technicians to stay together until the official establishment of the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) which was set up as a charitable trust to operate the CPR survey. Since its inception in 1991 SAHFOS has grown into a dynamic research operation receiving funding from all over the world to maintain and deploy Hardy's device across the seas and oceans, to analyse and interpret the results and provide this information to the scientific community. The staff complement of around 18 includes two technicians who service the Recorders, administrative and logistics staff and a team of 13 analysts (including some part-time) who carry out the taxonomic analysis, manage the database and undertake research. SAHFOS also hosts students and researchers from all over the world who want to use the data for their own studies. The business of the Foundation is overseen by a Council of Management made up of a President, Vice-President, Treasurer and Trustees. Sponsoring Governors from each of the agencies contributing to the funding are also invited to participate in Council meetings.

At present, approximately 25 routes operate each month from the SAHFOS base in the UK (Fig. 2). These routes cover the North Sea and North Atlantic which has historically been the main area of coverage, however, in 1996 sampling began in the Gulf of Guinea, West Africa, during 1997 a Mediterranean survey began and in 1998 the Baltic was sampled for the first time.



Plankton survey routes in the North Atlantic. At present, equivalent monitoring of the eastern North Pacific Ocean does not exist, except for point samples taken 2-3 times per year along the Canadian survey, Line P.

OTHER KEY PERSONNEL

Captain Peter Pritchard is the operations manager of SAHFOS and has over 10 years experience in liasing with shipping companies to arrange towing of CPRs. Will be responsible for coordinating the sampling program through regular communication with shipping agents and Masters/crew and arranging dispatch and return of equipment.

LITERATURE CITED

Anderson, P.J., and J.F. Piatt. (1999). Community reorganization in the Gulf of Alaska following ocean climate regime shift. Mar. Ecol. Prog. Ser. In press.

Batten,SD; Allen,RJS; Wotton,COM (1998): The effects of the Sea Empress Oil Spill on the plankton of the Southern Irish Sea. Mar. Poll. Bull. 36(8)

Cooney, R.T (1984). Some thoughts on the Alaska coastal current as a feeding habitat for juvenile salmon. In: *The influence of ocean conditions on the production of salmonids in the North Pacific.* (Editor, W. Pearcy). Oregon State University, Corvallis, OR, pp 256-268

Cooney, R.T (1986). Zooplankton. In: *The Gulf of Alaska. Physical Environment and Biological resources.* (Editors, D.W. Hood and S.T. Zimmerman). Alaska Office, NOAA. pp 285-299.

Finney,BP (1998): Long-term variability in Alaskan sockeye salmon abundance determined by analysis of sediment cores. N. Pac. Anadr. Fish Comm. Bull. 1, 388-395.

Friedland,KD (1998): Ocean climate influences on critical Atlantic salmon (*Salmo salar*) life history events. Can. J. Fish. Aquat. Sci. 55, 119-130. (Suppl.1)

Mackas, D. L, Goldblatt, R. and Lewis, A.G. (1998). Interdecadal variation in developmental timing of *Neocalanus plumchrus* populations at Ocean Station P in the subarctic North Pacific. *Can. J. Fish. Aquat. Sci.* ***55***, 1878-1893.

Parsons, T.R., and C.M. Lalli. 1988. Comparative oceanic ecology of the plankton communities of the subarctic Atlantic and Pacific oceans. Oceanogr. Mar. Biol. Ann. Rev. 26: 51-68.

Reid, P.C. and Planque, B (1999). Long-term planktonic variations and the climate of the North Atlantic. In: *The ocean life of Atlantic salmon. Environmental and biological factors influencing survival.* 153-169.

Steele, JH. (1998). Fisheries Oceanography 7:

Ware,DM (1995): A century and a half of change in the climate of the NE Pacific. Fish. Oceanogr. 4:4, 267-277.

Welch, D.W., B.R. Ward, B.D. Smith, and J.P. Eveson. (2000). Temporal and Spatial Responses of British Columbia Steelhead (*Oncorhynchus mykiss*) Populations to Ocean Climate Shifts. Fisheries Oceanography 9(1):17-32.

Accomplishments To Date

The first year of sampling with the CPR in the North Pacific went exceptionally well. Excellent co-operation and support for the program was achieved with two shipping companies who operated on the desired routes. Polar Tankers Inc. (originally ARCO Marine Inc.), who towed an initial pilot survey for SAHFOS in 1997, operated the crude oil carrier *Polar Independence* from Valdez to Long Beach throughout 2000. Seaboard International Shipping Company Ltd operated the container ship *Skaubryn* from Vancouver to Japan and offered to tow a CPR on any of these trips. Both companies gave considerable support and assistance to SAHFOS over and above helping with logistics by communicating ship schedules as soon as was practicable. All six deployments (Fig. 2) successfully collected samples and although a few samples were lost owing to mechanical glitches, over 95% of the target sampling was achieved.

Initial taxonomic processing of the 2000 samples is complete although quality control of some samples is still ongoing. Preliminary findings from these data show that *Neocalanus plumchrus*, the largest contributor to mesozooplankton biomass in the Gulf of Alaska, varies its developmental duration, and therefore the timing of its peak biomass, by as much as five weeks according to latitude (Batten *et al.,* in prep.). Much of this variability can be explained by temperature differences, and is not surprising given that temperature is known to influence the duration of invertebrate development. However, the extensive CPR sampling enabled such a pattern to be described, and potentially quantified, for the first time. Understanding the variability of zooplankton biomass determined by ocean climate conditions is essential to interpreting the data collected through monitoring efforts.

The community composition of the samples collected on the single east west transect was examined and an ordination of the data (Fig 3) showed that distinct communities could be identified. This is an encouraging result, verifying that the CPR approach is capable of distinguishing different regional communities, and thus allowing changes in their distribution, or community composition, to be tracked.

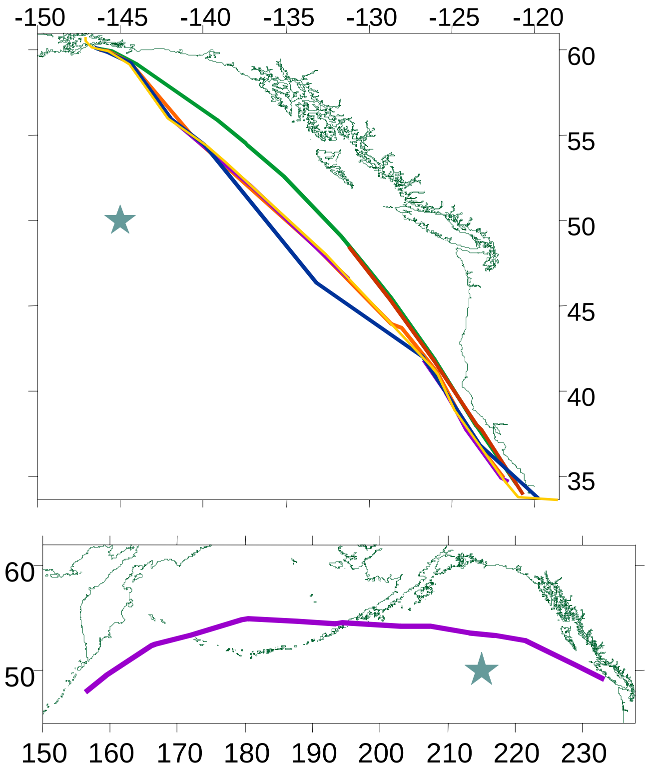


Figure 2. The positions of the transects operated in 2000. (a) Monthly N-S and (b) E-W in June. Key to colours: March (Green), April (Red), May (Brown), June (Violet), July (Blue), August (Orange). Station Papa is shown for reference (Star).

The sampling programme for 2001 is underway, as this proposal is submitted, with a similar sampling strategy to 2000. Further analyses of the 2000 data will be undertaken, including statistical determinations of the spatial variability (decorrelation length scales for example) and continued assessments of temporal variability as the 2001 data become available.

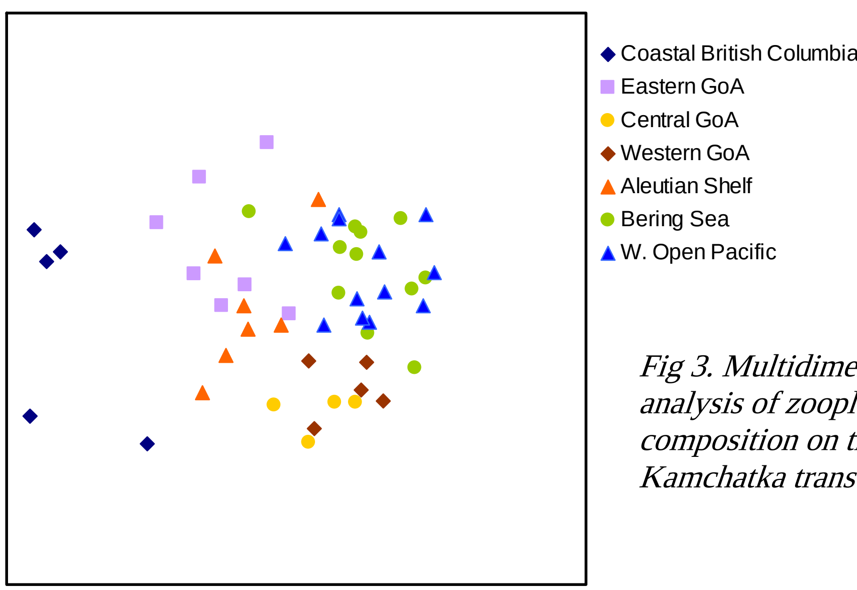


Fig 3. Multidimensional scaling analysis of zooplankton community composition on the Vancouver to Kamchatka transect in June/July 2000.

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002						
Personnel		$57.7						
Travel		$5.2						
Contractual		$21.3						
Commodities		$5.5						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$89.7	Estimated FY 2003					
Indirect		$23.0						
Project Total	$0.0	$112.7						
Full-time Equivalents (FTE)		1.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

Indirect rate is 40% of salary (personnel) costs

$0 for NEPA compliance (Not Applicable)
$2 for annual restoration workshop attendance
$3.8 for report writing (1 month for S.Batten)
$0 for publications (peer reviewed publications will be submitted, however, the results from FY02 will not be published within FY02 on current publishing timescales)
$3.2 for professional conferences (PICES XI)
$0 for community involvement.

No other funds are anticipated, although efforts will be made to obtain funding for further sampling or processing of collected samples.

FY02

Prepared: 11/26/2001

Project Number: 02624
Project Title: A CPR-Based Plankton Survey Using Ships of Opportunity
Name: Sir Alister Hardy Foundation for Ocean Science

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:				Months	Monthly		
	Name	Position Description		Budgeted	Costs	Overtime	
	S. Batten	Principal investigator/lead researcher		3.5	3.8	0.0	
	P. Pritchard	Operations Manager		1.0	4.1	0.0	
	R. Barnard	Technician		1.0	2.8	0.0	
	L. Gregory	Technician		1.0	2.8	0.0	
	Various	Taxonomists (team of ~12 people)		11.5	2.9	0.0	
	D. Stevens	Data Manager		0.5	2.5	0.0	
		Subtotal		18.5	18.9	0.0	
						Personnel Total	

Travel Costs:		Ticket	Round	Total	Daily	
	Description	Price	Trips	Days	Per Diem	
	S. Batten and D. Welch to attend annual restoration workshop	0.8	2	4	0.1	
	S. Batten to attend PICES XI meeting	1.2	1	10	0.2	
					Travel Total	

FY02

Project Number: 02624
Project Title: A CPR-Based Plankton Survey Using Ships of Opportunity
Name: Sir Alister Hardy Foundation for Ocean Science

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Contractual Costs:	
Description	
Leasing of Continuous Plankton Recorders ($0.9 per tow) Transport of CPRs for servicing between tows, and servicing costs Computing services (these are provided by the Plymouth Marine laboratory at an agreed rate PA. Pro rata costs indicated)	
Contractual Total	
Commodities Costs:	
Description	
Filtering mesh ($0.2 per unit)	
Commodities Total	

FY02

Project Number: 02624
Project Title: A CPR-Based Plankton Survey Using Ships of Opportunity
Name: Sir Alister Hardy Foundation for Ocean Science

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	
none needed			
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	

Existing Equipment Usage: Description	Number of Units	
existing CPRs will be used. Rental costs charged above cover replacement and repair		
external bodies	2	
internal mechanisms	11	

FY02

Project Number: 02624
Project Title: A CPR-Based Plankton Survey Using Ships of Opportunity
Name: Sir Alister Hardy Foundation for Ocean Science