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GEM PROPOSAL SUMMARY PAGE

(To be filled in by proposer)

Project Title:	Acquisition and Application of CPR data in the Gulf of Alaska Submitted under the BAA
Project Period:	FY 04- FY 06
	Proposer(s): Dr Sonia D. Batten, Sir Alister Hardy Foundation for Ocean Science Dr David W. Welch, Fisheries and Oceans, Canada
Study Location:	Alaskan shelf and Gulf of Alaska
Abstract:	**Plankton are a critical link in the marine food chain that respond rapidly to climate change and form the link between the atmosphere and upper trophic levels. Many important marine resources in the GoA are strongly influenced by changes in ocean climate. Recent CPR data have shown significant changes occurring in all plankton communities in the GoA, associated with the recent climate shift. We will continue the acquisition of CPR data in the Gulf of Alaska on the current transect that crosses the ACC and add an additional transect in FY05 that will sample the ACC further 'downstream' and provide baseline, seasonal plankton data for the lower Cook Inlet and it's transition to the Gulf of Alaska. We also propose analysis of data already collected to investigate the links between plankton and juvenile salmon migrations, and the larval distribution of commercially important decapods sampled by the CPR.**
Funding:	EVOS Funding Requested: FY 04 $ 124.0 FY 05 $ 197.0 FY 06 $ 178.3 TOTAL: $499.3 Non-EVOS Funds to be Used: FY 04 $ 20.2 FY 05 $ 13.6 FY 06 $ 6.7 TOTAL: $40.5
Date:	6th June 2003

(NOT TO EXCEED ONE PAGE)

Acquisition and Application of Continuous Plankton Recorder data in the Gulf of Alaska

I. NEED FOR THE PROJECT

Background

This proposal is a response to the GEM Invited Proposals request for the Alaska Coastal Current, to continue the collection of biological data from ships-of-opportunity. The Continuous Plankton Recorder (CPR) has been deployed from ships-of-opportunity in the North Pacific on a routine basis since March 2000. Originally implemented to fulfill the requirements of the North Pacific Marine Science Organisation (PICES) to collect seasonal plankton data from the North Pacific, the survey also demonstrated its relevance to the EVOS GEM program and received support in FY02 and FY03 (Current Project G-030624). Funding was also obtained from the North Pacific Research Board (NPRB) to fund collection of data on one of the two currently occupied transects in 2004/5. The proposal submitted here is, therefore, a revision of the request to EVOS GEM for support in 2004 to continue sampling on one transect only through to 2006.

We will first summarise the progress made since the last annual report and proposal that were submitted in September 2002:

SAHFOS training of personnel (Prof. Benda) at the Prince William Sound Community College, Valdez, Alaska was completed in the fall of 2002 using NPRB funding. A total of 3 transects have now been serviced locally in Valdez and procedures to supply the components and receive the samples are working smoothly. Training in CPR sample processing was also given to D. Moore, from the Institute of Ocean Sciences (IOS), Sydney, British Columbia, in April 2003. The first Alaska to California (north-south) transect sampled in March 2003 has been unloaded in Valdez and shipped to IOS for processing. At the time of writing, local facilities are being set up and the first samples are currently being processed at IOS. Regional processing will enable rapid assessment of the state of the NE Pacific ecosystem, a concept that is being evaluated in 2003 and 2004 with PICES' support.

Funding to support sample collection on the east-west transect (from Vancouver, across the Gulf of Alaska and the southern Bering Sea to Japan) in 2004 and early 2005 was successfully obtained through a proposal to the NPRB. We now propose that from 2004 and onwards, EVOS GEM supports N-S transect sampling (which most closely fits with it's research objectives since it crosses the ACC) while NPRB supports the E-W transect and that EVOS GEM and NPRB contribute equally to the program co-ordination costs and data analysis. We emphasise, however, that the data from all the CPR activities in the North Pacific will be integrated where appropriate to provide a more comprehensive view of the large-scale plankton dynamics.

Data analysis is ongoing, and two further manuscripts using the Pacific CPR data have been recently accepted for publication. Batten and Welch (*in press*) describe the changes in the zooplankton communities in the Gulf of Alaska associated with the probable climatic shift of 1999 and Batten and Crawford (*in press*) describe the role of anticyclonic eddies in structuring oceanic plankton communities in the eastern Gulf of Alaska. The results described in these manuscripts were summarised in the previous proposal to EVOS GEM and because of space limitations will not be repeated here. Copies of both papers are available on request.

Continued sampling and acquisition of data is important, particularly to maintain momentum and the value of the working relationships with the ships of opportunity and the local Valdez technicians. Maintaining such collaboration is vital to a long-term ship of opportunity program. Second, simultaneous acquisition of thermosalinograph data on the Alaska to

California transect was started in 2002 via a collaborative GEM project (#02614). A fluorometer is also planned for installation and we are confident that insights will result from a comparative analysis of the plankton and the salinity/temperature data. Sea surface altimetry data have also been used with the CPR plankton data to describe mesoscale processes occurring in the Gulf of Alaska (Batten and Crawford, *in press*).

During April 2002 GEM and PICES co-sponsored a workshop on acquiring data from Voluntary Observing Ships. The workshop report (PICES Scientific Report no 21) resulted in a description of a Ferry-Box type instrument for Ships of Opportunity that would measure physical, optical and chemical parameters in addition to CPR surveys. The current GEM invitation seeks proposals to develop and implement such a system. We plan to collaborate with successful applicants to work towards including a CPR on an instrumented route by 2006.

In order to confidently detect ecosystem change less dramatic than witnessed during a regime shift, sufficient baseline data must be available. Although we have published evidence that an ecosystem shift occurred between 1998 and 2000 and was detected in CPR data (Batten and Welch, *in press*) the current CPR database contains only a few data from the previous warm regime. Better defining the extent of interannual variability is central to a confident assessment of ecosystem variability and change.

During FY03 we are testing the concept of ‘fast response sample analysis’. There is increasing evidence to suggest that zooplankton are good detectors of ecosystem change. A subset of the CPR samples are being processed rapidly and an assessment made of the ecosystem status relative to previous data. This assessment will be published on a website from the end of June 2003, and will be updated monthly, providing a mechanism for rapid distribution of evidence for sudden ecosystem change. Full processing will be carried out by SAHFOS in a routine way so that all data should be fully processed within 9 months of collection (following current practice) and more rigorous analyses made to confirm initial assessments. We propose to continue this rapid analysis, modifying as necessary in subsequent years after evaluating its usefulness through 2003 and 2004.

In addition to continuing the acquisition of CPR data we wish to demonstrate its validity to the issues of importance to GEM. This proposal also describes studies using the CPR samples and data related to commercially important resources.

A. Statement of Problem

Ecosystem regimes have a typical duration on the order of a decade and shifts in regimes may occur very rapidly – within a year. A notable regime shift occurred in the late 1970s in the eastern North Pacific but was not recognised as such for about another decade (Ebbesmeyer *et al.* 1991). The most recent shift occurred in 1999 (Bograd *et al.*, 2000; Schwing & Moore, 2000). Ecosystems contain species of commercial importance whose abundance, distribution and productivity differ from regime to regime. Early warning of regime shifts could improve the management and study of such commercial species.

Biological variables may also provide a more consistent diagnostic signal of regime shifts than climate indices (Ebbesmeyer *et al*, 1991; Hare & Mantua, 2000) since ecosystems may filter out some of the noise and amplify the signal. Commercial fish landings provide a useful measure of the state of the ecosystems that each species occupies, but are sensitive to fishing effort. Furthermore, many commercial species have relatively long life spans and take several years to recruit to the fishery, so rapid detection of a climate event is unlikely. Zooplankton, which have short life spans and are not directly harvested, should provide a useful way of detecting regime shifts in near real time. The International Research Institute for Climate Prediction notes that '*Zooplankton species composition appears to be a sensitive indicator of water mass changes that may be key elements in marine ecosystem regime shifts*' (IRI, 2002). The North Pacific has few zooplankton time series where samples have been processed to the species level. The time series of zooplankton information that do exist in the eastern North Pacific, off southern California, Oregon and British Columbia, have for the most part been collected in shelf or slope waters. Open ocean time series are even rarer, and are limited to the data collected at Ocean Station Papa, the outermost stations of the CalCOFI program, and the recent CPR sampling. Regime shift changes have been previously identified in each of these time series, primarily as changes in zooplankton biomass (Brodeur & Ware, 1992; Roemmich & McGowan, 1995; Mackas, *et al*., 2001; Peterson, *et al*. 2001). Studies have also been published detailing the taxa, principally calanoid copepods, whose abundances have co-varied with changing oceanographic conditions (Mackas *et al*., 2001 ; Peterson *et al*., 2001). We have already demonstrated that the CPR data reveal these same changes in copepods from the 1999 regime shift, together with broader changes in the community composition and changes in biomass (Batten & Welch, *in press*), demonstrating that the open ocean is as responsive to such climate events as more coastal regions, and that not all coastal regions of the North Pacific respond in the same way.

Large scale changes in Pacific salmon populations in all regions of western North America have been related to climate change in this century (e.g. Mantua and Hare, 1997). 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. 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. 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. These changes appear to have extended back centuries (e.g. Ware, 1995; Finney et al 2000, 2002), 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). Higher trophic level responses to the recent 1999 regime shift are now beginning to appear.

Climate change seems to have driven the overall dynamics of Pacific salmon populations in the past, and to have been at least as important as the effect of commercial fisheries in determining population levels. 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. We currently have little understanding of how global warming will affect the frequency and intensity of regime shift type events in the North Pacific, and the development of consistent baseline datasets will be crucial to defining how climate change or global warming will affect the food chain supporting Pacific salmon dynamics.

Continued support for CPR surveys on ships of opportunity in the North Pacific through the GEM program builds on existing work that has been endorsed by the scientific committee of PICES and the Global Ocean Observing System (the Atlantic CPR program is part of the GOOS

Initial Observing System, and the Pacific CPR program was endorsed by the Living Marine Resources Panel of GOOS as a pilot project).

B. Relevance to GEM Program Goals and Scientific Priorities

A Ships of Opportunity program originating in Prince William Sound using CPR technology makes a direct contribution to the development of GEM and specifically addresses the objectives raised in this call for proposals (Invited Proposals, section F, the Alaska Coastal Current).

The types of data acquired by the CPR and other data collections now being undertaken on the same vessels 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 in changing productivity are 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). Recent North Atlantic studies link increasing northern hemisphere temperatures with changes in zooplankton biodiversity (from Atlantic CPR data) and effects on North Sea fish stocks, including salmon (Beaugrand *et al.*, 2002; Beaugrand and Reid, 2003). However, the lack of a mechanistic understanding of how the North Pacific rapidly shifts from one regime to another 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 to date have largely depended on opportunistic sampling from Japanese research ships sampling a series of transects only once a year. Without detailed information on the "natural" level of variability occurring between months or over years, it will be difficult to establish whether variations in timing or abundance of plankton reflect climate driven change (e.g. interdecadal differences in the timing of a key species, *Neocalanus*, Mackas et al., {1998}) or the effect of anthropogenic influences such as oil spills (e.g. the impacts of the *Sea Empress* oil spill on plankton populations, Batten *et al* {1998}).

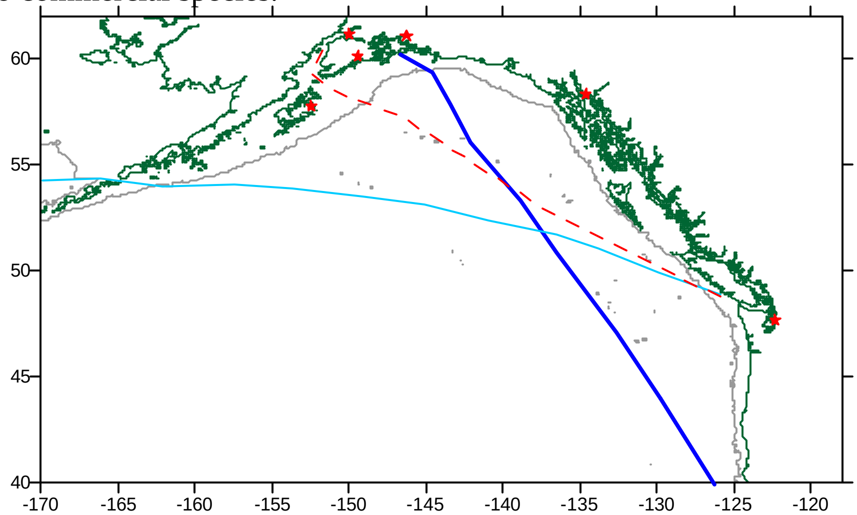
The GEM document states that '*prudent use of the natural resources of the spill area requires increased knowledge of critical ecological information about the northern GOA* [Gulf of Alaska]. Plankton are a fundamental component of the marine ecosystem, upon which many of the natural resources directly depend, and monitoring their distributions and variability is crucial to GEM's mission. Furthermore, the first identified goal of GEM is to '*serve as a sentinel (early warning) system by detecting annual and long-term changes in the marine ecosystem from coastal watersheds to the central gulf*'. A monitoring program that provides an early indication of ecosystem regime shifts clearly addresses this goal. The current CPR transects cross the continental shelf regions south of Prince William Sound, the Aleutians and British Columbia as well as the oceanic Gulf of Alaska and the southern Bering Sea. We will thus be sampling two of the GEM identified habitats (the Alaska Coastal Current and the offshore) in a systematic and continuous way. A monitoring system that works seamlessly between habitats is beneficial to assessments of change and to identifying the impacts of that change.

The key area of interest to GEM is also connected to adjacent waters, both in terms of the origins of the water itself (the shelf and slope areas off California up to British Columbia feed in to the GEM area through the current system of the North East Pacific) and because higher trophic level animals move between many of these areas without recognising political boundaries. The data from the CPR survey reveal that the Alaskan shelf is responding to climate influences in a different way to the open Gulf of Alaska. We will try to establish the mechanisms by integrating physical data with the biological data.

II. PROJECT DESIGN

The project proposed here has two components. Firstly to continue the acquisition of CPR data through 2006 on north to south transects (Fig 1) which cross the ACC and sample the Gulf of Alaska. Secondly, we propose to undertake investigations on the data already collected to demonstrate their relevance to commercial species.

Fig 1. The location of CPR transects, existing and proposed. Thick dark blue line is the current N-S transect that we propose be supported by GEM. Dashed red line indicates an additional route to commence in 2005. Thin light blue line is the current E-W transect supported by the NPRB. The 1000m isobath is also shown



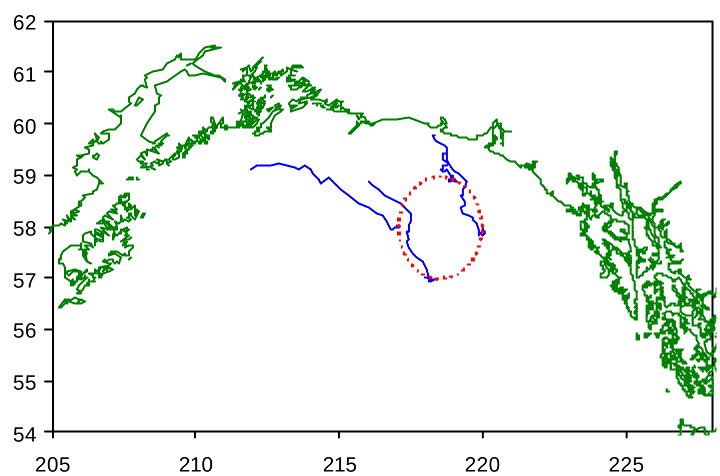
At the time of submitting this proposal, agreement is being sought from Polar Tankers to continue using the crude oil carrier *Polar Alaska* to tow the CPR from Valdez towards California for the duration of the proposal (until 2006). We also propose an additional route, using the cargo vessels that travel between Anchorage and Seattle (Fig 1) to start in 2005. This route would also cross the ACC and the Gulf of Alaska, filling in the region between the current CPR transects. This would allow us to explore how signals that influence lower trophic levels in the ACC are transmitted along the south-western Alaskan shelf. Furthermore, there are currently no plankton data from the Cook Inlet transition to the Gulf of Alaska so this CPR route will provide valuable baseline data.

Two specific investigations with existing data will be undertaken in FY04, although we anticipate further studies in subsequent years as more data become available. The first has arisen from the recent work described in Batten and Crawford (*in press*).

Recruitment is a key factor in the strength of commercial stocks of decapods such as red and blue king crab, Tanner crab, snow crab and Dungeness crab. Sources of larval populations may be far removed from the adult stocks and recruitment will be affected by environmental conditions as well as fishing effort. Successful management of these resources requires an understanding of the recruitment origins and the impacts of the physical environment. The meroplanktonic larvae of decapod crustacea are well sampled by the CPR although routine sample processing currently does not identify them beyond this classification. Decapod larvae occurred in about 12% of the CPR samples processed from the northern Gulf of Alaska and surrounding shelf. Occurrences were higher where the transect was on the shelf, but occurrences also occured in open ocean samples. One mechanism which may contribute to the dispersal of decapod larvae is the anti-cyclonic eddies that are formed in winter along the eastern continental margin of the northeast Pacific. Two regions that consistently generate eddies are the Queen Charlotte Islands in British Columbia, Canada (which creates the Haida eddy) and the Alexander Archipelago of Alaska, USA (which creates the Sitka eddy). Large volumes of warm, low salinity, coastal water are transported into the ocean in late winter/spring by these eddies

The fate of the biological entities entrained within the eddies, and the influence of the eddies on the oceanic fauna, have recently begun to be addressed. Mackas and Galbraith (2002) describe the results of zooplankton surveys across the Haida 2000 Eddy and show elevated levels of entrained near-shore and slope species that persist within the eddy for over a year. Batten and Crawford (in press) use CPR samples to describe the occurrence of shelf species of phytoplankton and zooplankton in both the Haida and Sitka eddies of 2000. As the eddies decay and the organisms leave the eddy, the plankton become subjected to surface wind-driven currents. The OSCURS simulation (Ebbesmeyer and Ingraham, 1999) of ocean surface currents has been applied to examine the possible influence of these non-eddy currents on plankton distributions (Batten and Crawford, *in press*). Large scale westerly movements across the northern Gulf of Alaska are possible and may be a potential mechanism for the spread of shelf species throughout the region. Furthermore, the intensity of the eddies varies inter-annually and Batten and Crawford (*in press*) show that shelf organisms were significantly more abundant in the open Gulf of Alaska in 2000, when the eddies were strong, than in 2001 when the eddies were weak. An example of larval dispersal using the OSCURS simulation is shown below. A Tanner crab larvae entrained in an eddy off Sitka in April 2000 and then carried westward in the eddy for one month before leaving the eddy would move along the tracks in Fig 2 during the subsequent 30 days before settlement (depending on where it left the eddy). Once an organism enters the Alaskan Stream, rapid westerly movements are possible.

Fig 2. OSCURS simulation showing the path of a particle leaving the Sitka eddy (red oval) on May 31st 2000 over the subsequent 30 days (blue lines).



This demonstrates that the spread of populations from the northern British Columbia shelf to the Aleutian Island shelf are possible on short time scales. Genetic studies would ultimately be needed to link the larval and adult populations. In order to pave the way for a more detailed study in the future we propose an exploratory effort on the CPR samples that have already been collected. Dr Alistair Lindley, a research fellow with SAHFOS, has 20 years of experience in larval decapod taxonomy and will spend four months in FY04 and FY05 processing the samples. Dr Carl Schoch (Kachemak Bay Research Reserve) will collaborate on the study and it is expected that a publication will result.

The second study that will be undertaken results from observations made when the CPR has been unloaded after a sampling trip. The samples collected on the Alaskan shelf, particularly around the Aleutian Islands, consistently show high densities of euphausiids, even well into fall and winter 2002. Although many of these samples have not yet been processed (Fig 3) high abundances of euphausiids in these shelf regions could be an explanation why juvenile salmon from the West Coast continue their migrations to this region in winter without moving off the shelf (Welch et al., 2002). The CPR data will be used to explore this relationship and evaluate the potential importance of this region as a winter feeding ground for Pacific salmon.

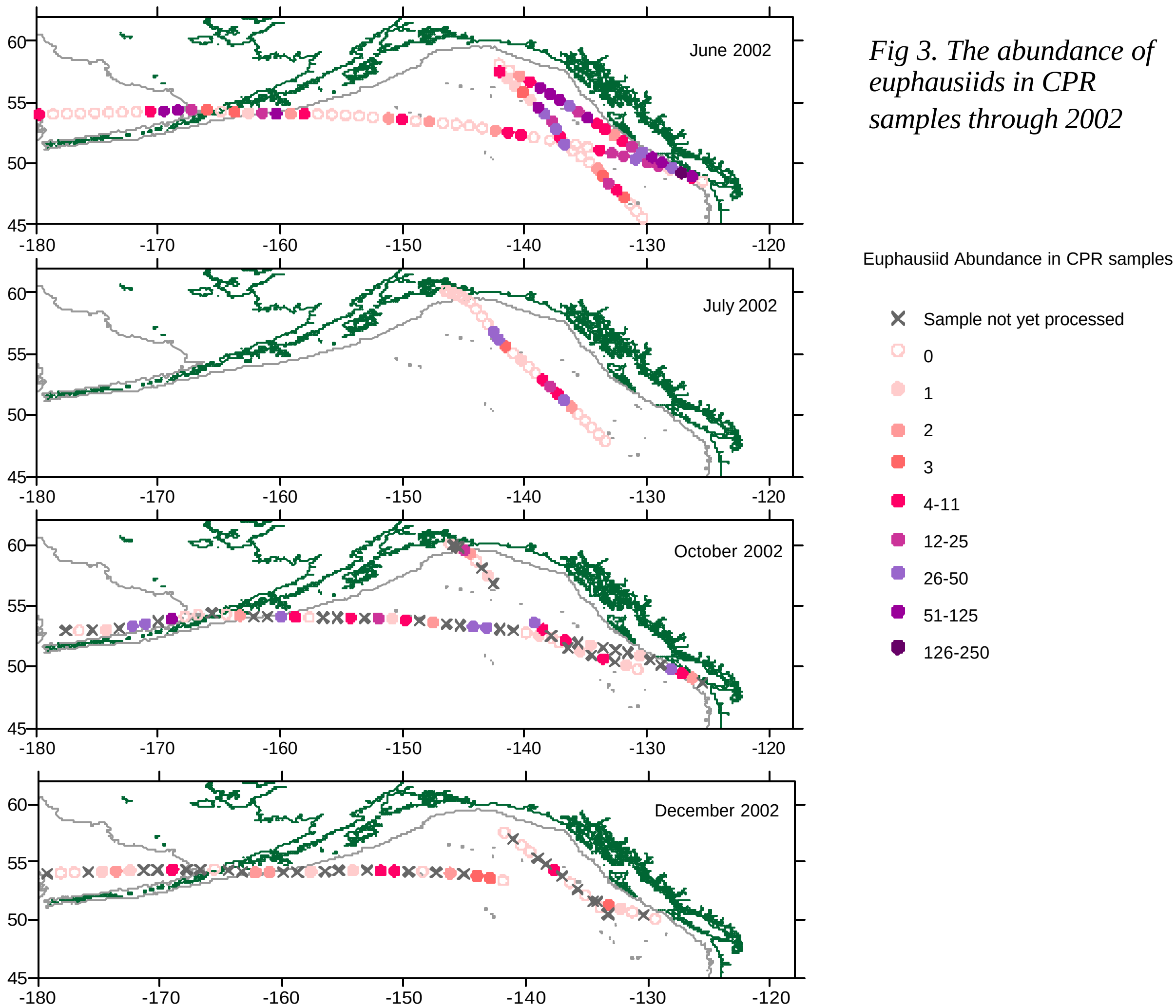


Fig 3. The abundance of euphausiids in CPR samples through 2002

A. Objectives

1. Add to the existing database of seasonal plankton data acquired by the CPR on the existing transect (Fig 1, Prince William Sound to California) in FY04 through FY06. A subset of samples will continue to be processed rapidly (within 1-2 months of collection), with observations and comparisons regularly updated on the SAHFOS website.
2. Integrate physical data and fluorescence/chlorophyll data collected on the same vessel (via an expected continuation of project 03614) with the plankton observations.

3. Commence a new route starting in FY05 to collect CPR data on a transect from Anchorage to Seattle (Fig 1). This transect would fill in the gap between the existing CPR transects in Alaskan waters, and help to determine the linkages between the upstream and downstream portions of the ACC in the south-western part of the Alaskan shelf.
4. Investigate the seasonal and interannual distribution of euphausiids and how this may influence juvenile salmon survival and migration.
5. Carry out a taxonomic analysis of decapod larvae on existing CPR samples and map their distributions.

B. Procedural and Scientific Methods

Objectives 1 and 3:

Standard CPR methodology

The collection and processing of CPR samples and issues of quantitativeness are detailed in Batten et al. (in press) and have been described in previous proposals. Methods are summarised here:

CPRs are towed in the surface mixed layer at a depth of about 7m. Water enters the front of the CPR, 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 mesh across the tunnel. As the filtering mesh leaves the tunnel it is covered by a second band of mesh so that the plankton are sandwiched between these two layers, which then wind on into a storage chamber containing preservative. At the end of the tow the machine is returned to the laboratory and the mesh 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 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 mesh. 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 the samples are archived after analysis so that they can be re-examined at any time.

The CPR is a relatively simple, rugged piece of oceanographic equipment. It can withstand being deployed from large ships moving at speeds of >20 knots and over 95% of tows successfully record plankton. It has the ability to carry instruments to record the physical environment. 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.

Objective 2.

Integration of plankton and physical data. We are actively collaborating with Dr S. Okkonen, lead on GEM project 03614. Analysis of the physical data under project 03614 should provide our project with an understanding of the hydrodynamic features (such as fronts or eddies) and processes, the origin of the water for example, and any anomalies which we will use to explain the plankton distributions. Satellite-derived data will also be used where appropriate to explain the plankton distributions.

Objective 4.

Evaluation of the abundance and distribution of euphausiids throughout the on the Alaskan shelf year (from the CPR database) to determine whether they may be a valuable food resource for migrating juvenile salmon in the fall/winter. The results of trawl surveys from this region (D. Welch) will be used to compare with the plankton data.

Objective 5.

The samples collected from 2000 to 2003, where decapod larvae have been recorded, will be examined to identify the species of decapod larvae found on each. The distributions of the different species along the two transects that have been sampled will be mapped. Satellite altimetry will also be used to determine if there is a possible link between eddy movement and transport/dispersal of decapod larvae. This work will contribute to the knowledge of important commercial decapod species and in the future may lead to the routine identification to species of all decapod larvae sampled by the CPR. As well as the existing ~1000 processed CPR samples from 2000-2002, there are also a further ~2000 CPR samples from between the processed samples that have been archived. These samples are available should finer resolution of the larval distributions be required.

C. Data Analysis and Statistical Methods

Two analyses have been undertaken with existing CPR data to verify that the proposed sample density is valid and that the level of subsampling proposed for the 'fast response' component of this proposal is likely to be successful. These are summarised below;

i. Large scale patchiness (on the order of 10s to 100s of kms) needs to be considered as a factor that may contribute to the observed variability in the plankton data. The maximum resolution possible from CPR data is 18.5 km, however, to maximise coverage with the resources available we plan for a resolution of 74 km in the open ocean (every fourth sample being processed). Under the original NPMR funded CPR program we carried out an analysis of the CPR data to examine the size of observed patches of particular organisms. Sequentially lagging an abundance series and calculating its autocorrelation enables the decorrelation length scale to be determined, i.e. the point (distance) at which the series no longer significantly correlates with itself. At this point samples are statistically independent. The April 2000 transect was sampled as normal but every sample collected was processed instead of every fourth. Samples were therefore continuous with the midpoint of consecutive samples being 18.5 km apart. The entire transect from Alaska to California takes about 5 or 6 days to cover. For this analysis we ignored samples collected on the shelf at the extremes of the transect as the shelf break causes an abrupt change in the number and/or type of organisms present. Similarly, surface species composition often changes at twilight and dawn because of diel vertical migration by some species. More day-time samples were collected than night-time and so the analysis only used samples collected after dawn but before twilight. The oceanic section of the transect was sampled over 4 days and we have considered each day of sampling as a replicate. 15 to 18 consecutive samples were collected and processed for each of the four replicate days. For the most commonly occurring taxonomic entities on each day (ranked according to frequency of occurrence) autocorrelations of abundance were carried out by lagging the series of sequential abundances by 1 sample, 2 samples, 3 samples etc until only the first and last samples were paired. With each additional lag the number of paired samples to correlate decreases and so the threshold correlation coefficient for a significant correlation increases. For most of the taxonomic entities there are sporadic significant correlations but no clear pattern (Fig 7 is a sample of the results). This suggests that patches are occurring either at scales smaller than 1 CPR sample (i.e. less than 20 km) or larger than 15-18 samples (larger than 300 km). This supports the belief that the CPR sampling resolution is adequate for a synoptic large-scale survey. An individual sample will pass through small patches of plankton and so provide an 'average' of the small-scale patchiness. Samples that are spaced well apart, such as every 74 km, are likely to be representative and not likely to be within or outside of a patch.

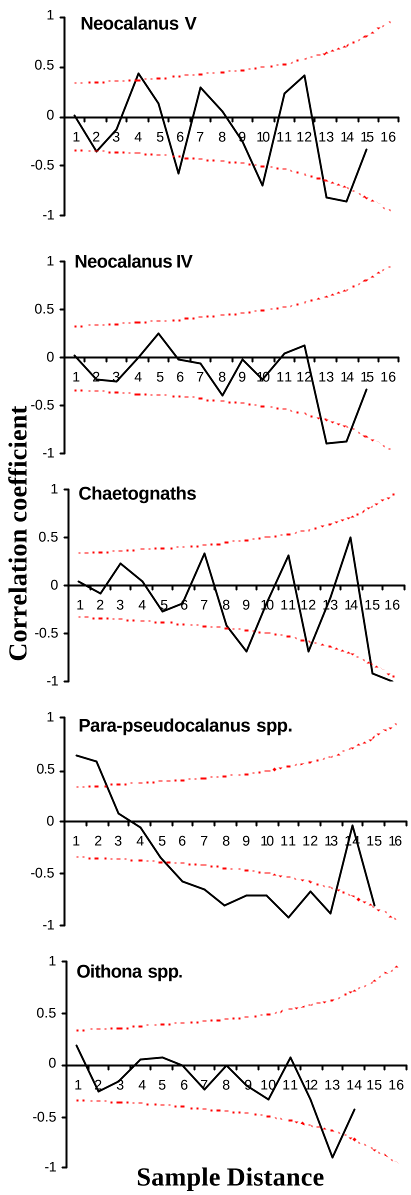


Fig 7. Autocorrelations of abundances of common taxa for the first sampling day in April 2000 along the Alaska to California transect. Only day time samples were used. Red dashed lines show 95% confidence limits.

ii. A subset of the extensive CPR data set in the North Atlantic was examined to determine the frequency of sampling in space and time required to reveal significant ecosystem changes. CPR sampling in the northeast Atlantic during the last five decades has produced more than 200,000 samples processed by standard procedures. How many of these samples would actually have been necessary to detect low frequency changes in the sampled ecosystems? The signal sought was that of the steady decline in abundance of *Calanus finmarchicus* across much of the survey area, shown to be associated with a change in the North Atlantic Oscillation (NAO) (Planque and Fromentin 1996; Fromentin and Planque 1996; Planque and Reid 1998). The Planque and Reid time series of *Calanus finmarchicus* was recreated by extracting data for the same area of the northeast Atlantic. A total of 58,768 samples was used, about 100 samples per month between 1958 and 1999. Monthly mean abundances and annual means were calculated from log transformed sample abundances, and overall annual means were calculated by averaging over seven areas. The resulting time series is essentially the same as that of Planque and Reid (correlation coefficient of 0.96). Two indices were selected to determine how well any subsampling of the data set would reproduce the signal. The first index, the r^2 value from a regression of abundance against time (the full data set has a value of 0.69), would provide information on how well the decline in abundance is measured by the subsampled data. The second index, the correlation coefficient of the subsampling time series against that of the full data set, measures how well the signal from the subsampled set compares with that from the full set.

Two strategies for subsampling were used. First a randomized approach was applied to determine the possible variability of the resulting indices. For each year fixed proportions of the original data set were randomly extracted (e.g., 90%, 80%, etc) and the areal, monthly, and annual means calculated as before, this being repeated 100 times for each proportion to find average index values and their variability. Second, in a more realistic strategy, subsampling was planned, for example spread more evenly or based on some knowledge of the system being studied. This subsampling included only odd or even months, only months between March and September, and only every fourth, sixth, eighth, etc. of the data set. Means and the two indices were calculated as before. In short, the random multiple simulations were used to determine the reliability of the subsampling indices, while the planned strategies were used to show how successful a restricted survey might be in identifying the *Calanus* decline.

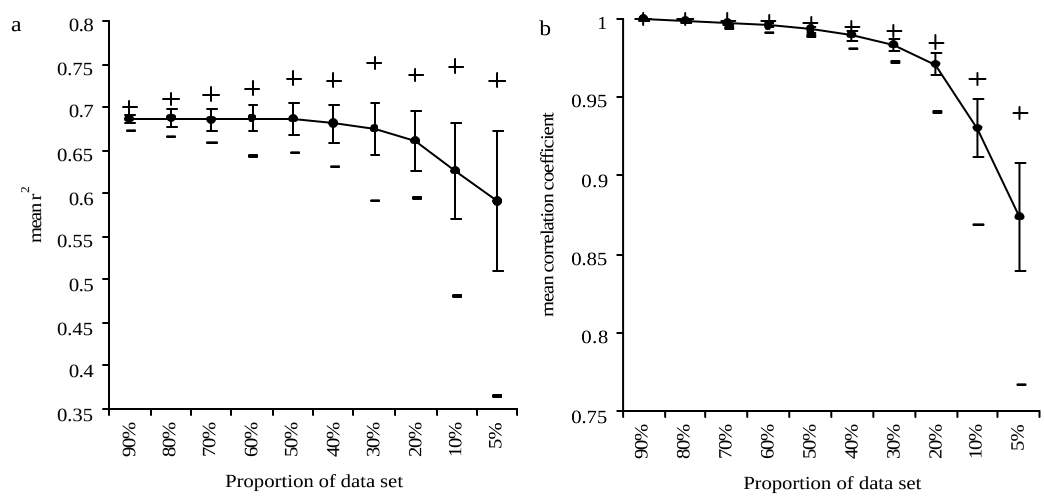


Figure 8. The resulting mean values of each index (a: r^2 of decline in abundance with time, b: correlation coefficient when test time series was correlated with original time series) after randomly selecting samples 100 times for each chosen percentage. Error bars indicate standard deviations in each case, + = maximum value of index in 100 extractions, – = minimum value of index in 100 extractions.

The results are shown in Fig. 8. Surprisingly, only a small fraction of the data was needed to reveal the signal. Even with only 5% of the samples used (about 60 or 70 samples per year across all months and the whole sampling area) each of the 100 random selections produced statistically significant declines in abundance with time, and correlated significantly with the original time series. The planned subsampling produced similar results with somewhat higher values of the indices.

These two studies have demonstrated that our proposed approach is statistically valid. The samples can be considered as independent of each other and a subset should be sufficient to detect a strong change in the ecosystem. The full processing available within 9 months of the sampling will add certainty to any earlier conclusions.

D. Description of Study Area

The project will sample waters on one transect from Prince William Sound to California. Sampling is usually carried out from south to north, commencing either in Long Beach (33.4667°N, 118.217°W) or San Francisco (38.003°N, 123.127°W) and continuing through the Hinchinbrook entrance of Prince William Sound, typically 60.117°N, 146.233°W. The second transect will start from Anchorage, traverse down Cook inlet and across the shelf break and the Gulf Alaska. Sampling will continue until the Straits of Juan de Fuca (48.45°N, 125°W, Captain's discretion). See Figure 1 for a map of the transects. Ship tracks vary minimally from month to month.

E. Coordination and Collaboration with Other Efforts

This project first came about as a PICES initiative, following the 1998 Annual meeting and recommendations of the Climate Change and Carrying Capacity Implementation Panel. It was financially supported during 2000 and 2001 by the North Pacific Marine Research program (final report submitted June 2002). Funding was provided for 2002-2003 sampling by EVOS (project number 02624, then G-030624). Further funding was obtained from the North Pacific Research Board to sample the fall and winter of 2002 and carry out additional data analyses and in the last month funding for sampling the east-west transect has been approved by the NPRB for 2004 to June 2005. From 2004 onwards we anticipate that several funding sources will contribute to the Pacific CPR activities. Throughout this period, and into the future, the CPR activities continue to be endorsed by PICES which, in 2000, set up a CPR Advisory Panel.

We are actively collaborating with Dr S. Okkonen, lead on GEM project 03614. Owing to the late fitting of the TSG in field season 2002 there is only one plankton transect so far that has the simultaneous physical data (the transect was towed in early August and the samples are currently undergoing quality control). We anticipate an additional three transects run between September and December 2002, and five during the 2003 field season. We expect the chlorophyll sensor to be fitted in early summer 2003 which will enable us to explore the links between the physical structuring of the surface waters, chlorophyll, hard-shelled phytoplankton sampled by the CPR, and the secondary producers. Analysis of the physical data under project 03614 should provide our project with an understanding of the hydrodynamic features and processes, the origin of the water for example, and any anomalies which we will use to explain the plankton distributions. The northern end of this transect crosses the Alaska Coastal Current in a similar fashion to the more western GAK-1 line. Multi-parameter repeated sampling along these two lines should provide opportunities for further analysis.

During April 2002 GEM and PICES co-sponsored a workshop on acquiring data from Voluntary Observing Ships (Ships of Opportunity). The workshop report (PICES Scientific Report No. 21) resulted in a planned proposal to develop a Ferry-Box type instrument for Ships of Opportunity that would measure physical, optical and chemical parameters in addition to CPR surveys. The current EVOS GEM invitation seeks the submission of proposals to implement a Ferry-Box, and we would expect to collaborate closely with successful applicants.

A portion of the sample processing and analysis is now being done at DFO in Canada (the Institute of Ocean Sciences at Sidney, Vancouver Island) as set out in the 2002 proposal. DFO are offering in kind support for this project through a collaborative agreement with

SAHFOS. They provide laboratory facilities, library facilities, desk space and administrative support. Many scientists in the PICES community are based at IOS and there is a wealth of oceanographic expertise that will enhance our data interpretation.

III. SCHEDULE

A. Project Milestones

Objective 1. Sample collection and processing will be ongoing throughout FY04 to FY06. Full, quality-controlled data from each transect will be available 9 months after collection. E.g. all samples collected in FY04 will be available by June 2005 (but earlier sampled transects will be available earlier). In addition, a subset of samples will be processed within 2 months of collection and results from this processing (e.g. comparison with other data) will be published on the website within 3 months of collection.

Objective 2. To integrate physical data and fluorescence data collected on the same vessel (via an expected continuation of project 03614) with the plankton observations made from Prince William Sound to California. Each transect will be compared as plankton data become available (see Objective 1)

Objective 3. Setting up of a new transect from Anchorage to Seattle. Discussions with shipping and port agents (including site visit) will be made at latter part of FY04. Davit will be fitted to ship in early FY05 and sampling will commence in late spring of FY05. If a second local servicing facility is needed (i.e. if it proves unfeasible to ship CPRs to and from Valdez) then training will take place in spring 2005. Sample processing and data availability will then proceed as for Objective 1.

Objective 4. Euphausid distribution/abundance and juvenile salmon comparison will take place in FY04. Results to be available spring 2004, including manuscript submission.

Objective 5. Decapod larvae taxonomy will be undertaken during FY04 and will be completed by the end of FY04. Data analysis, including manuscript submission, will be completed by April 2005.

B. Measurable Project Tasks

FY 04, 1st quarter (October 1, 2003-December 31, 2003)

October:	Project funding approved by Trustee Council
	Attend PICES annual meeting, Seoul, Korea, 10-18th
	Begin taxonomic analysis of decapod larvae (ongoing hereafter)

FY 04, 2nd quarter (January 1, 2004-March 31, 2004)

January 12-16 (tentative):	Attend Annual GEM Workshop
February:	Shipping of CPR from UK to west coast
March:	Probable first transect sampled

FY 04, 3rd quarter (April 1, 2004-June 30, 2004)

April	Begin sample processing (ongoing hereafter)
April	Submit manuscript on euphausiid/juvenile salmon study
April-June	Two transects sampled
June	First results from 04 sampling on website (ongoing hereafter)

FY 04, 4th quarter (July 1, 2004-September 30, 2004)

July-Sept	Two transects sampled
September	Visit by Capt. Pritchard to new transect vessel in Port (depending on vessels schedule)

FY 05, 1st quarter (October 1, 2004-December 31, 2004)

October	Attend PICES annual meeting (Hawaii, USA)
October	CPR shipped from west coast to UK for overhaul

FY 05, 2nd quarter (January 1, 2005-March 31, 2005)

(dates not yet known)	Attend Annual GEM Workshop
Jan-Feb	Fitting of davit to new vessel
Feb	Shipping of CPRs from UK to west coast
March	First 2005 tows from Valdez and from Anchorage

FY 05, 3rd quarter (April 1, 2005-June 30, 2005)

April to June	2 transects, each sampled twice
April	Submission of manuscript on decapod larvae distribution

FY 05, 4th quarter (July 1, 2005-September 30, 2005)

July to September	2 transects, each sampled twice

FY 06, 1st quarter (October 1, 2005-December 31, 2005)

October	Attend PICES annual meeting (venue TBC)
October	CPRs shipped from west coast to UK for overhaul

FY 06, 2nd quarter (January 1, 2006-March 31, 2006)

(dates not yet known)	Attend Annual GEM Workshop
Feb	Shipping of CPRs from UK to west coast
March	First 2006 tows from Valdez and from Anchorage

FY 06, 3rd quarter (April 1, 2006-June 30, 2006)

April to June	2 transects, each sampled twice

FY 06, 4th quarter (July 1, 2006-September 30, 2006)

July to September	2 transects, each sampled twice
September	CPRs shipped from west coast to UK for overhaul

FY 07, 2nd quarter

April 15th	Submission of final report (which will consist of a third draft manuscript for publication) to Trustee Council Office

IV. RESPONSIVENESS TO KEY TRUSTEE COUNCIL STRATEGIES

A. Community Involvement and Traditional Ecological Knowledge (TEK)

During fall 2002 technicians at the Prince William Sound Community College were trained in CPR servicing and set up (as funded by the NPRB). At the time of writing this proposal a total of three transects have been successfully serviced and set up in Valdez. We propose to continue this sub-contracting and have agreement from Robert Benda (a biologist at PWSCC) that they are willing to continue.

Dr Batten visited Valdez in January 2003 and spoke with members of the Regional Citizens Advisory Council. They were interested and supportive of the project and felt that it could be useful to them in detecting non-indigenous species. Now that contact has been established with both the RCAC and PWSCC, local dissemination of the results of this project can be achieved.

Our web site (www.sahfos.org/pacifc_project), currently being developed for 2003 sampling results, can be linked to the Trustee Council web site to further disseminate results. We would welcome other suggestions from the Council as to how best to inform local communities.

B. Resource Management Applications

Dr. Carl Schoch (Kachemak Bay Research Reserve, ADF&G) has agreed to collaborate on the study described earlier, investigating the taxonomic composition and dispersal of decapod larvae. While we do not expect the results to immediately feed into resource management, we do anticipate further studies building on this one, which could be more directly relevant.

V. PUBLICATIONS AND REPORTS

The results from the first few years of the CPR survey have been published in peer-reviewed journals, with one paper published (Batten *et al*, 2003) and two others in press (Batten & Welch and Batten & Crawford). We anticipate further publications, particularly related to the euphausiid/juvenile salmon study and the decapod larvae study described here. We have requested publication support at the rate of one manuscript per year.

VI. PROFESSIONAL CONFERENCES

PICES has been instrumental in the setting up of the Pacific CPR sampling through its MONITOR Task Team since 1998 and the CPR Advisory panel that first met in 2000. This is the most significant meeting to promote the project and seek collaboration and to date, two funded collaborative projects (GEM project 02614 and the NPRB project with Point Reyes Bird Observatory) have resulted from discussions at PICES annual meetings. The 2003 annual meeting will be held in Seoul, Korea and 50% travel support has already been approved from the NPRB for S. Batten to attend. A contribution/presentation will be made in the 2-day workshop '*Examine and critique a North Pacific Ecosystem Status Report*' as well as the CPR Advisory Panel meeting. The 2004 annual meeting will be held in Hawaii in October 2004 (dates and venue of this and subsequent annual meetings yet to be confirmed) and we ask for 50% support for one of the co-PIs (S. Batten) to attend these meetings in 2004 and 2005. The remainder of the funding for this Annual meeting will come from the NPRB funding. We will make a presentation to the CPR Advisory Panel at each, and although the session topics are not yet available it is anticipated that a paper will also be given in the main meeting.

Resume: Sonia Dawn Batten Ph.D.

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C/o 4737 Vista View Crescent
Nanaimo, British Columbia, V9V 1N8, Canada
Tel/FAX: 1-250-756-7747
Soba@mail.pml.ac.uk

QUALIFICATIONS

1990–1994. PhD. Marine Biology. '*Correlative studies of the ecophysiology and community structure of benthic macrofauna'* Southampton University, UK.
1987–1990. BSc. *Honours Degree in Oceanography with Biology*, 2(i). Southampton University, UK

CAREER HISTORY

2003. Temporary Instructor, Malaspina University College, Fisheries and Aquaculture program.
2001 to present. Part-time Research Associate. Kintama Research Corporation, Canada.
2000 to present. Part-time Research Fellow. Sir Alister Hardy Foundation for Ocean Science, UK.
1996–2000. Assistant Director. Sir Alister Hardy Foundation for Ocean Science, UK
1994–1996. Postdoctoral Research Fellow. Sir Alister Hardy Foundation for Ocean Science, UK

During the past eight years I have been working with the Continuous Plankton Recorder Survey at the Sir Alister Hardy Foundation for Ocean Science, which operates and maintains the multi-decadal, basin-wide database of plankton abundance and distribution from the North Atlantic. Since 2000 I have been based in western Canada, co-ordinating the north Pacific CPR survey. My main research focus has been the mesozooplankton; their distribution, ecology and role in the upper pelagic ecosystem. I have extensive experience of analysing and interpreting CPR data and have worked on several multidisciplinary projects in European waters. I have extensive project management, data analysis and publication/presentation skills through my experience as Assistant Director of SAHFOS and as acting as a PI on numerous research projects (including the current GEM and NPRB projects in the North Pacific).

FIVE RECENT RELEVANT PUBLICATIONS

Batten, S.D and Crawford, W.R. (In press). The influence of coastal origin eddies on oceanic plankton distributions in the eastern Gulf of Alaska. *Deep Sea Research II*
Batten, S.D. and Welch, D.W. (In press). Changes in oceanic zooplankton populations in the North-east Pacific associated with the possible climatic regime shift of 1998/1999. *Deep Sea Research II*
Batten, S.D., Walne, A.W., Edwards, M. and Groom, S. B. (In press) Phytoplankton biomass from Continuous Plankton Recorder data: An assessment of this index. *J. Plankton Research*.
Batten, S.D., Clarke, R.A., Flinkman, J., Hays, G.C., John, E.H., John, A.W.G., Jonas, T.J., Lindley, J.A., Stevens, D.P., and Walne, A.W. (In Press). CPR sampling – The technical background, materials and methods, and issues of consistency and comparability. *Progress in Oceanography*

Batten, S.D., Welch, D.W., and Jonas, T. (2003). Latitudinal differences in the duration of development of *Neocalanus plumchrus* copepodites. *Fisheries Oceanography*, **12** (3), 201-208.

OTHER SIGNIFICANT PUBLICATIONS

Planque, B. and **Batten, S.D.** (2000) *Calanus finmarchicus* and the North Atlantic planktonic ecosystem. The year of *Calanus* in the context of inter-decadal changes. *ICES J. Mar. Sci.* **57** 1528-1535.

Batten, S.D., Allen, R.J.S. and Wotton, C.O. (1998) The effects of the Sea Empress oil spill on the plankton of the southern Irish Sea. *Marine Pollution Bulletin*. 36, 764-774.

Batten, S.D., Fileman, E.S. and Halvorsen, E. (2001).The contribution of microzooplankton to the diet of mesozooplankton in an upwelling filament off the north west coast of Spain. *Progress in Oceanography,* **51,** 385-398.

COLLABORATORS ON PROJECTS/ PUBLICATIONS IN LAST 4 YEARS

Douglas Beare, Fisheries Laboratory, Aberdeen.
Robin Clark, Centre for Environmental, Fisheries and Aquaculture Science
William Crawford, Department of Fisheries and Oceans, Canada
Martin Edwards, SAHFOS
Elaine Fileman, Plymouth Marine Laboratory
Juha Flinkman, Finnish Institute of Marine Research
Stephen Groom, Plymouth Marine Laboratory
Elisabeth Halvorsen, University of Tromso
Roger Harris, Plymouth Marine Laboratory and GLOBEC
Graeme Hays, University of Wales, Swansea
Andrew Hirst, British Antarctic Survey
David Hyrenbach, Duke Marine Laboratory
Anthony John, SAHFOS
David Johns, SAHFOS
Tanya Jonas, SAHFOS
Richard Lampitt, Southampton Oceanography Centre
Alistair Lindley, SAHFOS
David Mackas, Department of Fisheries and Oceans, Canada
Ken Morgan, Canadian Wildlife Service
Benjamin Planque, IFREMER
P. C. Reid, SAHFOS
Anthony Richardson, SAHOFS
Darren Stevens, SAHFOS
William Sydeman, Point Reyes Bird Observatory Conservation Science
Anthony Walne, SAHFOS
David Welch, Department of Fisheries and Oceans, Canada
Warren Wooster, School of Marine Affairs, University of Washington

Resume: David Warren Welch, Ph.D.

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Nanaimo, British Columbia, Canada, V9R 5K6
Tel: 1-250-756-7218 FAX: 1-250-756-7053
Welchd@pac.dfo-mpo.gc.ca

QUALIFICATIONS

B.Sc., Biology & Economics, 1977. University of Toronto
Ph.D., Oceanography, 1985. "A Study of the Effects of Density-Dependence and Age-structure on the Dynamics of Marine Fish Populations". Dalhousie University

CAREER HISTORY

1986–Present. Program Head, Dept of Fisheries and Oceans, Canada.
2000-Present. President and Founder, Kintama Research Corporation .

I am Program Head for the Department of Fisheries and Ocean's High Seas Salmon Program, a position I have held and developed since its inception in 1990. I am past chair of the PICES "Climate Change and Carrying Capacity" implementation program (finishing my term in 2001), under which I worked to develop improved ocean monitoring programs for the North Pacific. I am currently chair of the Alfred P Sloan Foundation "Census of Marine Life" initiative in the Pacific, POST, or the Pacific Ocean Salmon Tracking Project. The goal of this new initiative is to apply new breakthroughs in electronic technology to allow marine scientists to track animals wherever they go in the ocean. In 2000 I started my own technology development company to provide the measurements necessary to establish the validity of an ocean acoustic array. In all of these roles I have been actively involved in the identification of new research areas, and the development of the managerial and support infrastructure necessary to address the research needs as well as conducting the research. I am the author of over 100 primary scientific publications and technical reports, and have also served as an expert consultant to both governments and the private sector regarding potential societal impacts of climate change.

RECENT RELEVANT PUBLICATIONS

Batten, S.D. and **Welch, D.W**. (In press). Changes in oceanic zooplankton populations in the North-east Pacific associated with the possible climatic regime shift of 1998/1999. *Deep Sea Research II*
Batten, S.D., **Welch, D.W**., and Jonas, T. (2003). Latitudinal differences in the duration of development of *Neocalanus plumchrus* copepodites. *Fisheries Oceanography*, **12** (3), 201-208.
Welch, D.W., B.R. Ward, B.D. Smith, and J.P. Eveson. (2000). Influence of the 1990 Ocean Climate Shift on British Columbia Steelhead (O. mykiss) Populations. *Fisheries Oceanography* 9(1):17-32
Whitney, F.A. and **Welch, D.W.** (2002) Impact of the 1997-8 El Niño and 1999 La Niña on nutrient supply in the Gulf of Alaska. *Prog. Oceanogr*. 54: 405-421

OTHER SIGNIFICANT PUBLICATIONS

Welch, D.W., A.I. Chigirinsky, and Y. Ishida. (1995). Upper Thermal Limits on the Oceanic Distribution of Pacific Salmon (Oncorhynchus spp.) in the Spring. *Can. J. Fish. Aquat. Sci.* 52(3):489-503

Welch, D.W., Y. Ishida, and K. Nagasawa. 1998. Thermal Limits and Ocean Migrations of Sockeye Salmon (Oncorhynchus nerka): Long-Term Consequences of Global Warming. Can. J. Fish. Aquat. Sci. 55:937-948.

Welch, D.W., Y. Ishida, K. Nagasawa, and J.P. Eveson. 1998. Thermal Limits On The Ocean Distribution Of Steelhead Trout (Oncorhynchus mykiss). In: D.W. Welch, D.M. Eggers, K. Wakabayashi, and V.I. Karpenko (Editors), "Assessment and Status of Pacific Rim Salmonid Stocks". N. Pac. Anadr. Fish Comm. Bull. No. 1:396-404.

Welch, D.W., and J.P. Eveson. 1999. An assessment of the geoposition accuracy of data storage (archival) tags using light. Can. J. Fish. Aquat. Sci. 56(7):1317-1327

Welch, D.W., Boehlert, G.W., and Ward, B.R. (2003) "POST–the Pacific Ocean Salmon Tracking Project". Oceanologica Acta 25: 243-253

COLLABORATORS ON PROJECTS/ PUBLICATIONS IN LAST 4 YEARS

Sonia Batten, SAHFOS
David Hyrenbach, Duke Marine Laboratory
Tanya Jonas, SAHFOS
David Mackas, Department of Fisheries and Oceans, Canada
Ken Morgan, Canadian Wildlife Service
William Sydeman, Point Reyes Bird Observatory Conservation Science
George Boehlert, Oregon State University
Bruce Ward, Ministry of Environment, Province of British Columbia
Frank Whitney, Department of Fisheries and Oceans, Canada
Viktor Bugaev, KamchatNiro, Petropavlovsk, Russia

Resume: John Alistair Lindley PhD.

Sir Alister Hardy Foundation for Ocean Science
The Laboratory, Citadel Hill,
Plymouth, PL1 2PB, UK
Jal@mail.pml.ac.uk

QUALIFICATIONS (degree level)

Year	Qualification	Subject	Awarding Body
1998	Ph D	Biology	University of Plymouth
1969	B Sc Lower second class	Botany/Zoology	University of London

MEMBERSHIPS

Date	Membership
1984	Member Crustacean Society
1973	Member Institute of Biology
1970	Member Freshwater Biological Association (Life Member form 1980)

CAREER HISTORY (most recent first)

Date	Event	Organisation
2000	Appointment as Post Doctoral Researcher from April 1	SAHFOS
2000	Appointment to SAHFOS as part time analyst. January 1	SAHFOS
1999	Early retirement from PML.December 3	
1995	Promotion to Unified Grade 7	NERC-PML
1988	PML established. Principal Investigator in Community Ecology Group	NERC-PML
1981	Promotion to Senior Scientific Officer	NERC-IMER
1975	Transfer from IMER Edinburgh to IMER Plymouth	NERC-IMER
1975	Promotion to Higher Scientific Officer	NERC-IMER
1971	Appointed to IMER Edinburgh	NERC-IMER
1970	Seconded from SMBA to IMER Edinburgh	SMBA/ NERC-IMER
1969	Appointment as Assistant Experimental Officer to IMER Edinburgh	SMBA

SAHFOS Sir Alister Hardy Foundation for Ocean Science.
NERC Natural Environment Research Council
PML Plymouth Marine Laboratory
IMER Institute for Marine Environmental Research
SMBA Scottish Marine Biological Association

Research on plankton throughout the period 1969 to present day with nearly 80 publications, over 50 (>40 as sole or senior author) in refereed journals or conference proceedings. This includes research on decapod larvae from 1981, with 21 publications all as sole or senior author. Editor of ICES Identification Leaflets for Plankton from 1991.

FIVE RELEVANT RECENT PUBLICATIONS.

Lindley, J.A. 1998. Diversity, biomass and production of decapod crustacean larvae in a changing environment. *Invert. Reprod. Dev*. 33:209-219.

Lindley J.A. & Hernández, F. 2000. A previously undescribed zoea attributed to *Calcinus talismani* (Crustacea: Decapoda: Diogenidae). *Bocagiana*, 201, 1-5**.**

Lindley, J.A., F. Hernández, J. Scatllar & J. Docoito. 2001. *Funchalia* sp. (Crustacea: Penaeidae) associated with *Pyrosoma atlanticum* (Thaliacea: Pyrosomidae) off the Canary Islands. *J. Mar. Biol. Ass. UK*. 81, 173-174.

Dos Santos, A. & Lindley, J.A. 2001. Crustacea. Decapoda: Larvae. II. Dendrobranchiata. ICES Identif. Leaflets for Plankton, 186, 1- 9.

Lindley, J.A., Hernández, F., Tejera, E. & Jiménez, S. 2002. A protozoea of Solenoceridae (Crustacea: Decapoda: Thalassinidea) from the Canary Islands. Rev. Acad. Canar. Cienc. XIII (4) 181-186. (plus seven other contributions to the same journal. (1999-2002)

FIVE OTHER SIGNIFICANT PUBLICATIONS

Beaugrand, G., Reid, P.C., Ibanez, F., Lindley, J.A. & Edwards, M. 2002. Reorganisation of North Atlantic marine copepod biodiversity and climate. *Science*, 296, 1692-1694.

Lindley, J.A., Donkin, P., Evans, S.V., George, C.L. & Uil, K.F. 1999. Effects of 2 organochlorine compounds on hatching and viability of calanoid copepod eggs. *J. Exp. Mar. Biol. Ecol*. 242, 59-74.

J.A. Lindley, R.Williams, & D. Robins. 1999. Dry weight, carbon and nitrogen content of some euphausiids from the North Atlantic Ocean and the Celtic Sea. *J. Plankton Res*. 21, 2053-2066

J.A. Lindley & S. D. Batten. Long-term variability in the diversity of North Sea zooplankton. *J. Mar. Biol. Ass.* U.K. 82, 31-40.

Lindley, J.A. & Reid, P.C. 2002. Variations in the abundance of *Centropages typicus* and *Calanus helgolandicus* in the North Sea: deviations from close relationships with temperature. *Mar. Biol.* 141, 153-165.

COLLABORATORS ON PROJECTS/ PUBLICATIONS IN LAST 4 YEARS

S.D. Batten, G. Beaugrand, M.Edwards, A.W.G. John, H.G. Hunt, H. McCall, P.C. Reid, A. J. Richardson. SAHFOS, Plymouth UK

D.V.P. Conway, S.H.. Coombs, P. Donkin, S.V. Evans, C.L. George, R.P. Harris, R.N. Head, X. Irigoien, C.Llewellyn, D.B. Robins, R. Williams. PML Plymouth UK

E. Arbelo, J. Docoito, F. Hernández, J. Jiménez, A. Martin, R. Martin, E. Tejera, J. Scatllar. Museo de Ciencias Naturales (O.A.M.) Santa Cruz de Tenerife, ISLAS CANARIAS.

K Brander. ICES Copenhagen, Denmark

A. Corten, Netherlands Institute for Fisheries Research, Ijmuiden, Netherlands

K.F. Uil, Wageningen Agricultural University, Netherlands

A. dos Santos, IPIMAR, Lisbon, Portugal.

F. Ibañez, Observatoire Océanologique, Vilefranche sur Mer, France

EXXON VALDEZ **OILSPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

Budget Category:	Proposed FY 04	Proposed FY 05	Proposed FY 06		TOTAL PROPOSED
Personnel	$68.9	$96.5	$93.1		$258.5
Travel	$4.9	$5.3	$3.1		$13.3
Contractual	$17.3	$34.7	$35.7		$87.7
Commodities	$5.3	$8.9	$9.2		$23.4
Equipment	$0.0	$13.0	$0.0		$13.0
Subtotal	$96.4	$158.4	$141.1		$395.9
Indirect (rate will vary by proposer)	$27.6	$38.6	$37.2		$103.4
Project Total	$124.0	$197.0	$178.3		$499.3
Trustee Agency GA (9% of Project Total)	$11.2	$17.7	$16.0		$44.9
Total Cost	$135.2	$214.7	$194.3		$544.2

Cost-share Funds:
NPRB contributes 3 months pa for S. Batten's salary (for FY 04 and first half FY 05) for co-ordinating Pacific CPR project and research on data.
NPRB contributes 50% funding for S. Batten to attend PICES meeting in FY04 and FY05
DFO (Canada) contributes D. Welch's salary for the project
DFO (Canada) contributes in-kind support (through a collaboartive agreement with SAHFOS) to provide lab facilities and library facilities for local sample processing.

FY 04-06

Date Prepared:

Project Number: 040624
Project Title: Acquisition and Application of CPR data in the Gulf of Alaska
Proposer: S. Batten and D. Welch

FORM 4A NON-TRUSTEE SUMMARY

***EXXON VALDEZ* OILSPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

Personnel Costs: Name	Description		Months Budgeted	Monthly Costs	Overtime	Personnel Sum
						0.0
Dr Sonia Batten	PI/Researcher		3.0	4.5		13.5
Capt. P. Pritchard	Operations manager		0.8	5.0		4.0
R. Barnard/L. Gregory	Mech. Technicians		0.5	3.4		1.7
Team of 12 technicians	Taxonomic analysis		5.5	3.1		17.1
D. Moore	Plankton analyst		5.0	4.0		20.0
D. Stevens	Data manager		0.8	3.3		2.6
Dr. A. Lindley	Researcher		2.5	4.0		10.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	18.1	27.3	0.0	
					Personnel Total	$68.9

Travel Costs: Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Travel Sum
					0.0
P. Pritchard to visit ship for new transect	1.0	1	4	0.2	1.8
S. Batten attending annual EVOS meeting	0.7	1	5	0.2	1.7
S. Batten to attend PICES annual meeting (50% support)	0.6	1	8	0.1	1.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$4.9

FY 04

Project Number: 040624
Project Title: Acquisition and Application of CPR data in the Gulf of Alaska
Proposer: S. Batten and D. Welch

FORM 4B
Personnel
& Travel
DETAIL

EXXON VALDEZ OILSPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 04 - FY 06

Contractual Costs: Description	Contract Sum
Leasing of Continuous Plankton Recorders	6.2
Transport of CPRs to and from UK at start/end of field season	4.3
Servicing and setting up of CPRs (inc. repair and shipping) between tows contracted out to Prince William Sound	6.3
Computing services (these are provided by the Marine Biological Association at an agreed rate PA. Pro rata costs	0.5
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$17.3

Commodities Costs: Description	Commodity Sum
Filtering mesh	4.0
Tow wires	0.6
Lab supplies	0.5
Publishing costs	0.2
Commodities Total	$5.3

FY 04

Project Number: 040624
Project Title: Acquisition and Application of CPR data in the Gulf of Alaska
Proposer: S. Batten and D. Welch

FORM 4B
Contractual & Commodities
DETAIL

EXXON VALDEZ **OILSPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
existing CPRs will be used. Rental costs charged above cover replacement		
external bodies	1	
internal mechanisms	5	
Existing microscopes will also be used, (including one purchased in FY03)	7	

FY 04

Project Number: 040624
Project Title: Acquisition and Application of CPR data in the Gulf of Alaska
Proposer: S. Batten and D. Welch

FORM 4B
Equipment
DETAIL

***EXXON VALDEZ* OILSPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

Personnel Costs:			Months	Monthly		Personnel
Name	Description		Budgeted	Costs	Overtime	Sum
Dr Sonia Batten	PI/Researcher		3.0	4.6		13.8
Capt. P. Pritchard	Operations manager		0.8	5.2		4.2
R. Barnard/L. Gregory	Mech. Technicians		0.8	3.5		2.8
Team of 12 technicians	Taxonomic analysis		9.6	3.2		30.7
D. Moore	Plankton analyst		8.8	4.1		36.1
D. Stevens	Data manager		0.8	3.4		2.7
Dr. A. Lindley	Researcher		1.5	4.1		6.2
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	25.3	28.1	0.0	
					Personnel Total	$96.5

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
					0.0
					0.0
SAHFOS technician to travel to Anchorage to train technicians	1.0	1	6	0.2	2.2
S. Batten attending annual EVOS meeting	0.7	1	5	0.2	1.7
S. Batten to attend PICES annual meeting (50% support)	0.6	1	8	0.1	1.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$5.3

FY 05

Project Number: 040624
Project Title: Acquisition and Application of CPR data in the Gulf of Alaska
Proposer: S. Batten and D. Welch

FORM 4B
Personnel
& Travel
DETAIL

***EXXON VALDEZ* OILSPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

Contractual Costs: Description	Contract Sum
Leasing of Continuous Plankton Recorders	12.9
Transport of CPRs to and from UK at start/end of field season	8.8
Servicing and setting up of CPRs (inc. repair and shipping) between tows contracted out to Prince William Sound	12.5
Computing services (these are provided by the Marine Biological Association at an agreed rate PA. Pro rata costs	0.5
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$34.7

Commodities Costs: Description	Commodity Sum
Filtering mesh	7.2
Tow wires	1.0
Lab supplies	0.5
Publishing costs	0.2
Commodities Total	$8.9

FY 05

Project Number: 040624
Project Title: Acquisition and Application of CPR data in the Gulf of Alaska
Proposer: S. Batten and D. Welch

FORM 4B
Contractual & Commodities
DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
Davit to be built and installed on vessel for Anchorage to Seattle transect	1	13.0	13.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$13.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
existing CPRs will be used. Rental costs charged above cover replacement		
external bodies	2	
internal mechanisms	8	
Existing microscopes will also be used, (including one purchased in FY03)	7	

FY 05

Project Number: 040624
Project Title: Acquisition and Application of CPR data in the Gulf of Alaska
Proposer: S. Batten and D. Welch

FORM 4B
Equipment
DETAIL

EXXON VALDEZ OILSPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 04 - FY 06

Personnel Costs:			Months	Monthly		Personnel
Name	Description		Budgeted	Costs	Overtime	Sum
Dr Sonia Batten	PI/Researcher		3.0	4.8		14.4
Capt. P. Pritchard	Operations manager		0.8	5.4		4.3
R. Barnard/L. Gregory	Mech. Technicians		0.8	3.6		2.9
Team of 12 technicians	Taxonomic analysis		9.6	3.3		31.7
D. Moore	Plankton analyst		8.8	4.2		37.0
D. Stevens	Data manager		0.8	3.5		2.8
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	23.8	24.8	0.0	
					Personnel Total	$93.1

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
					0.0
S. Batten attending annual EVOS meeting	0.7	1	5	0.2	1.7
S. Batten to attend PICES annual meeting (50% support)	0.6	1	8	0.1	1.4
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$3.1

FY 06

Project Number: 040624
Project Title: Acquisition and Application of CPR data in the Gulf of Alaska
Proposer: S. Batten and D. Welch

FORM 4B
Personnel
& Travel
DETAIL

***EXXON VALDEZ* OILSPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

Contractual Costs:	Contract
Description	Sum
Leasing of Continuous Plankton Recorders	13.3
Transport of CPRs to and from UK at start/end of field season	9.1
Servicing and setting up of CPRs (inc. repair and shipping) between tows contracted out to Prince William Sound	12.8
Computing services (these are provided by the Marine Biological Association at an agreed rate PA. Pro rata costs	0.5
Contractual Total	$35.7

Commodities Costs:	Commodity
Description	Sum
Filtering mesh	7.4
Tow wires	1.1
Lab supplies	0.5
Publishing costs	0.2
Commodities Total	$9.2

FY 06

Project Number: 040624
Project Title: Acquisition and Application of CPR data in the Gulf of Alaska
Proposer: S. Batten and D. Welch

FORM 4B
Contractual &
Commodities
DETAIL

***EXXON VALDEZ* OILSPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
existing CPRs will be used. Rental costs charged above cover replacement		
external bodies	2	
internal mechanisms	8	
Existing microscopes will also be used, (including one purchased in FY03)	7	

FY 06

Project Number: 040624
Project Title: Acquisition and Application of CPR data in the Gulf of Alaska
Proposer: S. Batten and D. Welch

FORM 4B
Equipment
DETAIL

Budget Justification

Throughout, costs have been increased from FY04 by 3% in FY05 and FY06 to account for inflation. Actual Costs are shown here. Amounts on budget form are slightly different owing to rounding required by EVOS

1. **Salaries and wages**.

Name	Role (objective)	Cost per mnth in FY04	Mnths in FY04	Mnths in FY05	Mnths in FY06
Dr. S. Batten	Project co-ordinator, researcher (all objectives, 1-5)	$4482	3	3	3
Capt. P. Pritchard	Ops. Manager, liaison with shipping companies (objectives 1 & 3)	$5044	0.75	0.75	0.75
R. Barnard/L. Gregory	Mechanical technicians, service CPRs and components, training (objectives 1 & 3)	$3438	0.5	0.75	0.75
Team of 12 technicians	Taxonomic analysts, process CPR samples (objectives 1 & 3)	$3116	5.5	9.6	9.6
D. Moore	Plankton analyst, technician, based at IOS (objectives 1 & 3)	$4005	5	8.75	8.75
D. Stevens	Data manager, maintain database and website (objectives 1 and 3)	$3283	0.75	0.75	0.75
Dr. A. Lindley	Researcher and decapod taxonomist (Objective 5)	$4000	2.5	1.5	
Total			$68,573	$96,024	$92,539

Matching/in-kind funding. The NPRB funds 3 months of Dr S. Batten's time for co-ordinating Pacific CPR activities in FY04 and the first half of FY05. In addition, Department of Fisheries and Oceans, Canada (DFO) will contribute $5,500 per annum in-kind support in the form of Dr Welch's salary for project co-ordination and research (objective 4).

2. **Travel**

SAHFOS experience has shown that a visit by Capt. Pritchard (Ops. Manager) to a new vessel to explain procedures and allay concerns of the officers/shipping company results in a smooth set up of a new transect. We ask for support for Capt. Pritchard to travel from the UK to Anchorage or Seattle in late FY04 (depending on vessel schedule) to set up the new route (objective 3). Air Fare: $1000, + 4 days per diem @150 = **$1600**

Travel is also requested for a SAHFOS technician to travel to Anchorage from the UK to train local technicians in FY05, should it not be possible to add to the servicing carried out in Valdez (objective 3). Air Fare: $1000, + 6 days per diem @150 = **$1900**

Support is requested for attendance by S. Batten at annual EVOS meetings in Anchorage and a contribution (50%) for S. Batten to attend annual PICES meetings.

FY04: Annual meeting in Anchorage, Travel from Nanaimo, British Columbia to Anchorage, Air Fare: $700 + 5 days per diem for lodging and meals @ $150 per day = $1450
50% Travel to PICES annual meeting (Korea in 2004), 50% Air Fare : $600 + 8 days per diem (@$150 per day x 50%) = $1200. Total FY04 = **$2650**
FY05: As FY04 + 3% = **$2730**
FY06: As FY05 + 3% = **$2811**

3. **Contractual**
   a. Servicing and repair of CPRs will be carried out at PWSCC, Valdez (objectives 1 and 3). Includes salary costs, repair materials and shipping of samples. In FY05 it is anticipated that the new transect from Anchorage to Seattle will also be serviced in Valdez (CPR will be transported there after each trip, as happens in the UK). In the event that this is not feasible, an additional servicing centre will be set up in Anchorage, however costs are expected to be the same per transect (to allow for transport).FY04 = **$6,255**. FY05 = **$12,513**, FY06 = **$12,826**
   b. Leasing of CPRs per transect (to cover replacement) $1249 per transect in FY04 (objectives 1 and3).
      FY04 = **$6245** (5 transects from Valdez to California)
      FY05 = **$12865** (5 transects from Val. to Cal. and 5 transects from Anchorage to Seattle)
      FY06 = **$13251** (5 transects from Val. to Cal. and 5 transects from Anchorage to Seattle)
   c. Shipping of CPRs to/from UK at start/end of each field season for major overhaul at $2138 per shipment in FY04 (objectives 1 and 3)
      FY04 = **$4276** (1 CPR shipped out and back)
      FY05 = **$8809** (2 CPRs shipped out and back)
      FY06 = **$9073** (2 CPRs shipped out and back)
   d. Computing facilities are provided to SAHFOS by the Marine Biological Association at an agreed rate. Pro-rata costs are included here at **$450** pa.

4. **Commodities**
   a. Filtering mesh @ $200 per unit, 4 units needed for each Valdez to California transect. 3 for each Anchorage to Seattle transect, FY04 = **$4000**, FY05 = **$7210**, FY06 = **$7426**
   b. Tow wires @ $200 per wire, 3 new wires in FY04, 5 new wires in FY05 and FY06 (two transects will be sampled). FY04 = **$600**, FY05 = **$1030**, FY06 = **$1061**
   c. Misc. lab supplies @ $500 pa, FY04 = **$500**, FY05 = **$515**, FY06 = **$530** and publishing costs at $200 pa.

5. **Equipment**
   A davit will need to be fitted for the new Anchorage to Seattle transect (objective 3) in FY05. The costs of the davit built and fitted to the Polar Independence (in California) in 1999/2000 totalled $12960. The davit had to be fitted offshore (because of the danger of welding igniting fumes from the crude oil) which increased costs. However, to allow for increases since then we are asking for the same figure for the davit to be fitted in 2005 FY05 = **$13000**

6. **Indirect costs**

Indirect costs to cover administrative support, office costs etc are charged at 40% of personnel costs.