Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA

Project Number: 01452-BAA

Restoration category: Research

Proposer: Prince William Sound Science Center

Lead Trustee Agency: NOAA
Cooperating Agencies: ADF&G (matching), OSRI (matching)

Alaska SeaLife Center: No

Duration: 1st year of 2

Cost FY01: $55.6K
Cost FY02: $83.6K

Geographic Area: Prince William Sound

Injured Resource/Service: Walleye pollock, pink salmon fry, Pacific herring

ABSTRACT

The EVOS Trustee Council invested in the development of improved forecasting methods for pink salmon. Research suggests that macro zooplankton and adult walleye pollock densities are the primary biological forcing variables affecting pink salmon fry survival. A program to make these estimates was initiated in spring 2000 by a partnership of organizations including OSRI, SERVS and ADF&G. We propose to expand this effort to provide data on annual and seasonal variation of both predators and food availability for juvenile pink salmon and to interact with another EVOS Trustee Council project that is studying the use of pristine concentration in mussels to estimate pink salmon fry survival.

INTRODUCTION

In 1989, the National Science Foundation GLOBEC program defined the limitations of observing and predicting animal population change in marine ecosystems (GLOBEC 1990a,b.c). One of the primary failures in past marine research was identified as the use of sparse, discrete measurements with nets to estimate abundance. GLOBEC recommended the combination of acoustical and optical quasi-continuous measurement technologies with discrete net sampling to resolve confounding temporal and spatial variation. Thomas (1992a) concluded that implementation of such methods were the single most important improvement that could be made to improve fisheries science and management. With the publication of new two-stage, acoustic-discrete sampling methods, the use of traditional discrete-only sampling methods to estimate fish and plankton abundance has become obsolete (Thomas and Kirsch 2000a,b; Kirsch et al. 2000).

The absence of quantitative information on prey and predator densities has long been recognized as a limiting factor to describing the mechanisms that affect juvenile fish survival (Cushing 1974; Jones 1973). Cooney (1993) and Willette et al. (1999a,b) have shown this to be true for pink salmon fry in Prince William Sound (PWS). Thomas et al. (1998) and Kirsch et al. (2000) developed acoustic-plankton net techniques to synoptically measure zooplankton prey and fry predator densities along the outmigration route of pink salmon fry in PWS. These data are prerequisites to run the models that predict pink salmon fry survival in the Sound (Cooney 1993; Mason and Patrick unpublished), and to empirically estimate survival until such models are developed and applied.

The annual run of pink salmon, which is composed of up to 90% hatchery fish, is a valued resource to the residents of the Sound (Thomas et al. 1991; Thomas and Mathisen 1993). The timing of release of pink salmon fry from the hatcheries in PWS is determined by measuring an abundance of macrozooplankton prey with a plankton net. However, Cooney et al. (1995) noted that the data from this plankton-watch program was not always consistent with other measures of productivity. Our observations show gradients between nearshore and offshore zooplankton could easily confound the data obtained from discrete sampling with a 0.5 m plankton net from 20 m to the surface. We have calculated that the sampling volume of an acoustic survey is a minimum of 20,000 times that of the 0.5 m plankton net survey of similar effort, and that the resolution is at least a 50 times greater. Furthermore, we have shown that hundreds of 0.5 m plankton-net samples are needed to estimate zooplankton densities with acceptable precision along any given transect. Thus, we conclude that it is impractical to accurately monitor zooplankton abundance with plankton nets.

Since acoustic surveys of macrozooplankton provide the distribution of the population that is being measured, and they require plankton net sampling to ground-truth the targets (McClatchey and Thorne 2000), proportional allocation of the plankton-net subsample is possible to increase sampling efficiency (Cochran 1967). Another advantage of acoustic surveys of macrozooplankton is the capability to threshold or use multi-frequency techniques to synoptically estimate nekton predators. In PWS, researchers have shown that adult walleye pollock are the primary competitor with juvenile fishes for macrozooplankton prey in the spring (Thomas et. al 1997, 1998; Willette et al. 1999a,b). This compounds their importance to the survival of juvenile fishes since they also represent the dominant pelagic predator in the Sound. Thus, spring monitoring of zooplankton prey and fry predators is the critical first step needed to assess marine survival of the pink salmon fry.

Assessment of changing the ocean survival of North Pacific pink salmon is also a primary objective of the Global Ocean Ecosystem Dynamics program (GLOBEC). Thus the monitoring that we advocate in this proposal is both timely and relevant. It is highly unlikely that GLOBEC can accomplish its "overarching" goal, to understand the basis of interannual variation in juvenile salmon mortality, without the information this program will obtain. Pink salmon from PWS hatcheries are the primary component of GOA salmon, and the major source of mortality occurs in the early marine stages, i.e., in Prince William Sound. Recognizing this weakness of the ongoing GlOBEC program, we have initiated contact with several GLOBEC projects and plan collaborative work.

In FY00, the Oil Spill Recovery Institute (OSRI), in cooperation with the Prince William Sound Aquaculture Corporation (PWSAC), the Ship Escort Response Vessel System (SERVS) and the Alaska Department of Fish and Game (ADF&G) initiated a program to observe fry predator and zooplankton prey densities along the spring outmigration corridor of pink salmon fry in PWS. This proposal requests the funds to expand this program to include greater survey coverage in time and space, more in-depth data analysis and further development of the technique, as well as provide a linkage to an ongoing EVOS Trustee Council project (#01195) that is using pristane concentrations in mussels to predict pink salmon survival.

In summary, we have developed new methods and understanding of the Sound's complex ecosystem. We know that pollock dominates as a pelagic predator of pink salmon fry in the spring, and that it filter feeds on the same zooplankton the fry depend on for growth and survival. We have developed new acoustic-net sampling techniques that give us synoptic and representative estimates of these prey and predators. An application of this new methodology and information is to apply it to make annual estimates of fry survival and use this information to improve the forecasts of adult returns. Recognizing the importance of pink salmon to the Sound ecosystem, we have developed a collaborative program between OSRI, PWSAC, ADF&G and industry to monitor annual changes in the zooplankton prey and fry predator densities. Expanding this partnership to include the EVOS Trustee Council is a natural step because pink salmon are a large part of the restoration program, and the Council has made significant investments in the development of new methods and information.

Our objectives are to:

- Measure macrozooplankton density, distribution and abundance in PWS several times during the spring using echointegration-plankton net techniques,
- Make synoptic measurements of dominant fry predators, relying on the thousands of

past net samples and the simple composition of the pelagic fish assemblage for ground-truthing purposes,

- Use the predator-prey information along with physical oceanography information from the OSRI nowcast-forecast program to predict pink salmon fry survival,
- Exchange information on zooplankton and fish distribution and density with the pristane project to test assumptions, underlying mechanisms and compare results.

NEED FOR THE PROJECT

A. Statement of the problem

One of the original questions sought by the SEA program was to explain why the survival of juvenile salmon fluctuated dramatically after the oil spill. Pink salmon suffered major declines in 1992 and 1993. Declines in abundance may have resulted from changes to habitat, food supply, predator and competitor populations, genetic degradation, the commercial fishery and management, or unknown natural events. In 1990, GLOBEC scientists concluded that only with the development of the new population measurement techniques and survival models, would it be possible to hind-cast, now-cast and forecast accurately enough to separate the effects of natural from anthropogenic forcing on animal populations (Cullen 1989). The proposed monitoring program resulted from the development of new predictive tools for pink salmon survival. Specifically, the abundance of spring prey and predators is critical input for assessment of pink salmon marine survival. Improving predictive capability is the path for designing restoration activities that promote the conservation and sustainable use of the pink salmon stocks of Prince William Sound.

The EXXON VALDEZ oil spill occurred n 1989. In this same time period, the GLOBEC program was defining the limitations of predicting animal population change in marine ecosystems,. Armed with the only tools available, Alaska and federal agencies, and industry, began a massive, expensive and controversial damage assessment program. In 1994, the EVOS Trustee Council made a commitment to invest some resources into improving observation and prediction capabilities in the region.

The development and testing of new predictive models requires accurate and precise observational data. The new measurement tools that we developed in the past eight years are useful to both research and management because they are accurate and precise, which helps in the verification of predictions. In addition, they are cost-effective. This proposal requests EVOS Trustee Council provide a 25% match to the existing monitoring program and become a partner in the continued observation of spring predators and prey of juvenile pink salmon.

B. Rationale/Link to Restoration

This project provides the observational data that is necessary to explain annual changes in the marine survival of pink salmon. It also provides "best-available" technology and information to agencies and industry for management purposes. The goal of these observations is to increase the capability to predict natural changes that are occurring in the pink salmon populations. This capability is a prerequisite for assessing anthropogenic impacts, such as those caused by an oil, assessment of restoration, and prediction of run size. The relevance of this research will be measured in its contribution to establishing a healthy salmon population that provides sufficient production to support abundant fish, seabirds and marine mammal predators and human use.

We are looking for a two-year partnership with EVOS Trustee Council to complete the transition from the research program to a fully operational model-based monitoring program. Concurrent with this project is the development of the physical nowcast-forecasting efforts (an OSRI, EVOSTC, RCAC, ADF&G and Industry partnership). The nowcast-forecast program provides important information on the spatially and temporally variable physical conditions that force changes in the predator-prey assemblage and affect population bioenergetics of all the species. Implementation of both biological and physical monitoring to determine juvenile fish survival was the original goal of the GLOBEC and SEA programs.

C. Location

Research will be conducted in Prince William Sound where the fishing industry in the communities of Cordova, Valdez, Tatitlek, Chenega Bay, Whittier and Seward will benefit. Transfer of this technology to outlining areas could result in benefits throughout Alaskan coastal communities.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

Traditional and scientific knowledge has led to the development of regional applications of new acoustic methods. Local and Native fishermen were responsible for first applications of new quantitative acoustic technologies for fish stock assessment and research 1) after the herring collapse in 1993 (Gerald McCune, Cordova District Fishermen United, personal communication), 2) after the pink salmon collapse in 1993 (R.J. Kopchak and Jim Gray, Cordova fishermen, personal communication) and 3) at the beginning of the walleye pollock commercial fishery in 1995 (Jay Stinson, Alaska Draggers Assoc., pers. comm.) After repeated applications over the last seven years, management is slowly integrating this technology into its harvest management practices in the Sound. Full implementation of the information from these stock assessments and transfer of this technology to other areas such as Kodiak and Cook Inlet is dependent upon continued community involvement to generate the grass-roots support to obtain funding.

The following procedures have worked well for the SEA program and the Prince William Sound Science Center and will be followed for this project: 1) discusing problems with the Board of Directors of the Science Center and the Oil Spill Recovery Institute, who collectively have four fishermen and four Alaska Natives as local representatives, 2) consulting with community representatives during the conception and design of the project to seek input, 3) advertising all vessel charters and employment opportunities in communities near where the work is to be performed, 4) visiting local communities during the course of the field work with our educational outreach program, and where appropriate, base field work out of the villages using local lodging and/or vessels, 5) providing information to the community through the publication and distribution of newsletters that use non-technical language on project results, 6) the posting of non-technical information on our web page, 7) the presentation of research results as seminars during the year in the community, 8) acknowledging all contributions appropriately, 9) applying the results of the research in ways designed to benefit local communities, people, and cultural practices and 10) living in and becoming part of the community we serve.

PROJECT DESIGN

A. Objectives

- Measure macrozooplankton density, distribution and abundance in PWS during the spring using echointegration-plankton net techniques,
- Make synoptic measurements of dominant fry predators, relying on the thousands of past net samples and the simple composition of the pelagic fish assemblage for ground-truthing purposes,
- Use the predator-prey information along with physical oceanography information from the OSRI nowcast-forecast program to predict pink salmon fry survival,
- Exchange information on zooplankton and fish distribution and density with the pristane project to test assumptions, underlying mechanisms and compare results.

B. Methods

<u>Acoustic and ground-truthing procedures</u>: Acoustic methodology for zooplankton assessment is well developed. Major publications include: Holliday and Peiper 1980; Greenlaw and Pearcy 1985; Peiper et al. 1990; GLOBEC 1990a,c; Stanton et al. 1994, 1996; Wiebe et al. 1997; Thomas and Kirsch 2000a,b. Specific application in Prince William Sound is described in Kirsch et al. (2000). The draft final report of the OSRI monitoring program for FY00 is attached as Appendix 1.

The application of multiple frequencies allows use of scattering models (Holliday and Piper 1980; Greenlaw and Pearcy 1985; Peiper et al. 1990; Stanton et al. 1994, 1996) to improve assessment accuracy. Although a variety of acoustic frequencies have been used in Prince William Sound, from 38 kHz to 1 mHz, comparable applications (acoustic/net sampling applications on *Neocalanus* spps. copepods) were previously limited to single frequency studies, either 120 kHz or 420 kHz (Thomas et al. 1998; Kirsch et al. 2000; Thorne and Thomas 2000a,b). The OSRI monitoring program (Appendix 1) uses three frequencies simultaneously, 38 kHz, 120 kHz and 420 kHz. The 38-kHz frequency is primarily meant for fish, although the surveys in May 2000 found that 38 kHz also detected zooplankton with larger target strengths. The 120 kHz frequency is known to detect *Neocalanus* size zooplankton very effectively, while 420 kHz can detect most calanoid copepod zooplankton. We have found that frequencies higher than 420 kHz (720 kHz and 1 mHz) are impractical in PWS during the spring because the high sound attenuation in plankton layers severely limits the range and volume of the sampling.

In FY00, we used a BioSonics 38 kHz DT4000 with a 6-degree transducer, a 120 kHz BioSonics Model 101 with a 7-degree transducer and a BioSonics 420 kHz Model 102 with a 6-degree transducer. The systems were calibrated with standard targets following procedures of Foote and MacLennan (1982). All three systems were mounted on a single towing vehicle. Triggering for all three was synoptic at one per second, driven by the DT system. The DT4000 stores raw digital echo information directly on computer hard-drive. The data were analyzed using BioSonics Echo Integration Analyzer Program Version 4.0. The 420 kHz data were analyzed in real-time using a BioSonics Model 221 Echo Signal Processor. The 120 kHz data were recorded on DAT and later processed using the BioSonics ESP. Future plans call for using DT (Digital Transducer) technology for all three frequencies. DT systems are available for this purpose, but require some modifications that were not possible for the 2000 surveys because of limited time and funding. The conversion to an all-digital system is one of the improvements that is contingent upon EVOS funding.

The basic echo integration analysis produces estimates of volume backscattering. Estimation of absolute density from volume backscattering measurement requires estimates of species composition and average backscattering cross-section. Species composition information is obtained from the net sampling. Backscattering models for zooplankton are described in several publications (Holliday and Peiper 1980, Greenlaw and Pearcy 1985, Peiper et al. 1990, Stanton et al. 1994, 1996). Kirsch et al. (2000) specifically estimated the reflection characteristics of copepods, pteropods and euphausids in PWS at 420 kHz and details the absolute density estimation procedure. Results from the May 2000 surveys show that the three-frequency volume backscatter combined with the plankton nets readily allows estimation of the absolute densities of the various zooplankton components (Appendix 1).

Backscatter from fish is readily detected and separated from zooplankton backscatter in most cases. Backscatter from schooled or layered fish aggregations is far higher than for zooplankton. When individual fish targets are present within a zooplankton scattering layer, the fish signals appear as high, narrow spikes above the more homogenous zooplankton backscatter. In most cases, it is relatively easy to estimate fish densities in the presence of zooplankton by simple thresholding. The separation is greatly facilitated with digital transducer technology. With this technology, raw signal data can be rapidly examined at various thresholds and the echo integration component from different signal levels can be measured. This procedure can also be done with recorded analog data, as was the case for the FY00 surveys, but the procedure is more time consuming. For data that is analyzed in real-time, the best procedure is to echo integrate over small space/time scales and carefully edit out returns from fish. This procedure works except where fish densities are too low to make an obvious contribution to the backscatter, but in those case the error from misappropriation is minor.

No direct sampling for fish targets is envisioned in this program, at least for the near future. Sufficient pattern classification information is available from historic observations to separate components into adult pollock, juvenile pollock and forage fish categories with reasonable accuracy. In five years of intensive midwater trawling during April and May, we found that 95% or more of the large fish targets in the plankton layers to be walleye pollock (Thomas et al. 1997; 1998). Acoustic backscattering cross-section information is available for these categories for biomass estimation (Thorne 1983a) of schools and layers. Echo counting techniques can provide numerical abundance estimates with high accuracy (Thorne 1983b). Trends in observed fish abundance will be compared with annual biomass estimates of adult herring and adult pollock conducted by OSRI monitoring programs for those species (Thorne and Thomas 2000a,b). The May 2000 surveys showed high densities of both adult and juvenile pollock in central PWS early in May (Appendix 1). Fish densities in the Knight Island/Perry Passage area were very low until the end of the month when the abundance increased dramatically. The increase corresponded with a decrease in abundance in the central basin.

Past sampling of the zooplankton in the Sound during April and May has shown that *Neocalanus* spps. copepods dominate the assemblage (Cooney 1993; Cooney et al. 1995). They are the primary large zooplankton scatter in the surface layers until late May (Thomas et al. 1998; Kirsch et al. 2000). Our plankton net sampling is conducted primarily to verify that the composition of the early spring zooplankton assemblage is dominated by *Neocalanus* spps. copepods. During the FY00 surveys, three to five zooplankton samples were taken within each 4-transect cluster. The zooplankton sampling was a 50 m vertical tow using a 0.335-mm 0.5 m-ring net, following procedures of Cooney et al. (1995). Samples are preserved in the field in 10% seawater formalin. Zooplankton analysis follows standard procedures (Coyle et al. 1990). Samples are processed for to identify and quantify the species composition and dominant zooplankters. The FY00 sampling verified the predominance of *Neocalanus*. Changes in the zooplankton composition were clearly reflected in changes the backscattering ratios among the three frequencies and corresponded to changes predicted from existing scattering models (Appendix 1). In 2001 we will add the use of a closing net and flow meter to improve our capability to sample specific depth layers.

<u>Physical data acquisition</u>: Temperature and salinity data were acquired using a SeaBird Electronics Model 19.03 CTD. Typically, 6-7 CTD stations were taken each cruise and were arrayed to provide inshore/offshore and north/south trends. This information is incorporated into the seasonal physical Oceanographic sampling database funded by the OSRI nowcast-forecast program. A Princeton Ocean Model (POM) is used to assimilate the physical monitoring data and produce nowcast-forecasts of physical structure (current velocities, direction, temperature, salinity, and density) in the Sound. By superimposing the distribution of predators and prey populations on this physical data, the actual physical conditions experienced by these animal populations are estimated accurately

enough to incorporate as parameters into the bioenergetics growth models. Simulations with the POM are also being conducted to reconstruct the distributions we observe on the surveys. These simulations and observations should help us determine if the *Neocalanus* spps. copepods are originating from the Sound or the Gulf (Kline 1999).

Survey design: The methods follow those developed and applied on the OSRI, SERVS, PWSAC and ADF&G program in spring 2000. Effort centers on the early marine life history period of the pink salmon, since the overwhelming consensus of evidence is that this stage is crucial to total survival. This follows the rationale of the PWSAC Plankton-Watch program, which is designed to guide pink salmon fry releases by monitoring food availability. The *Neocalanus* spps. copepod life history strategy anticipates the timing of the spring bloom by placing the earliest life stages in the water column before plant production is initiated each spring (Cooney et al. 1995), providing an ideal food source for pink salmon fry. Peak abundance of *Neocalanus* spps. copepods in the upper 50 m occur during the month of May. In June, *Neocalanus* spps. copepods migrate to deeper waters. The proposed monitoring program is designed to cover this critical period. Three surveys were conducted during May 2000. EVOS funding will allow temporal expansion of this project to five surveys between mid-April and mid-June in 2001.

The FY00 zooplankton survey design was six groups or clusters of four transects (Figure 1). Three clusters (twelve transects) extended along central PWS from Bligh Island to the Hinchinbrook Entrance and three more clusters along the primary pink salmon out-migration corridor west and north of Knight Island, extending to Perry Island. This initial design was based on several criteria: (1) coverage of the historic area of juvenile pink salmon out-migration and hatchery locations, (2) contrast between the traditional western outmigration route and the eastern side or main basin of Prince William Sound, and (3) an area that could be covered within a two-day survey. Transects were designed to be able to contrast near-shore and offshore areas as well as north/south trends. Strong gradients in abundance were observed, with highest densities in the southern portions of Knight Island (Appendix 1). The lowest abundance of zooplankton was consistently observed along the west shore. EVOS funding will support a spatial expansion of this project to nine groups or clusters of four transects that will achieve a better understanding of the over-winter areas/sources of zooplankton, incorporate sampling near more hatcheries and sample adjacent to the mussel-bed areas where pristane is being measured (Jeff Short, NMFS, pers. comm.).

The tactical procedure used in spring 2000 acoustic survey was to complete the acoustic data collection along a four-transect cluster, then backtrack to collect net and sensor samples at selected locations for zooplankton and salinity/temperature measurements. Usually these station locations are where the higher zooplankton densities were observed, but low-density locations were also selected for contrast. This general pattern approximates proportional sampling and will be refined in future surveys. Our analysis of two-stage, proportional sampling shows that we achieve between 600 to 20,000 fold increases in efficiency over traditional discrete-only sampling designs. Zooplankton data collection is limited to daytime hours due to the long daylight hours and the presence of benthic nekton species at the surface during the night.

Pristane links: The initial studies of pristane concentrations in mussels have indicated a positive correlation with marine survival of hatchery pink salmon (Jeff Short, NMFS, pers. comm.). The hypothetical mechanism for this is:

- the pink salmon fry feed on pristane-rich *Neocalanus* spps. copepods;
- the pink salmon fry are the dominant zooplantivores in mussel bed habitats;
- the pink salmon fry defecate pristane-rich feces near the mussel beds,
- the pristane-rich feces are ingested by mussels,
- the pristane accumulates in the mussel tissues in proportion to the amount of feeding by the fry on the copepods.

The acoustic survey will not measure pink salmon fry directly, but it will document the inshore-offshore gradients of *Neocalanus* spps. copepods, herring and other fishes, which should provide supporting data for interpretation of the pristane data. First, high occurrences of juvenile herring and sand lance in the nearshore during the summer is well documented (Stokesbury et al. 2000) and could possibly swamp the effects of pink salmon fry on the mussel beds. Acoustic surveys can determine if these fishes are in the mussel bed habitats where pristane concentrations are measured. It is possible that other fishes may only be inshore at night when the come to the surface and spread out so some nocturnal sampling will be required (Thomas et al. 1995). Second, we will be able to compare the distribution of zooplankton and fish to pristane levels in the mussels. This information should help to resolve questions on zooplankton and pristane origin.

In addition, there are also some assumptions that the pristane index makes that will require new information. Willette et al. (1999a,b) also suggested that the availability of *Neocalanus* spps. copepods inshore were a critical factor in pink salmon survival. However, in our FY00 surveys we frequently observed pink salmon fry feeding on patches of copepods in the middle of the Perry Island and Knight Island passages. It is obvious that the pink fry must cross these passages to migrate so we are not sure at this time what portion of the population resides offshore. Also most of the historical sampling of the pink salmon fry has been based upon visually locating the fry at the surface along the shoreline and then seining them (Willette, pers. comm.).

Estimating fry survival: Historically, fisheries models have not used predator-prey information to predict returns (Ricker 1975). However, with the development of the bioenergetics model (Hewitt and Johnson 1992) and it’s application at the population level (Beauchamp et al. 1995), modeling of population bioenergetics became a numerical process driven by temperature and food, which are measured environmental parameters. With predation being a function of size and size a function of growth, survival is a function of growth. Thus the linking of predator numbers in the environment with the population bioenergetics is the accepted numerical approach to solving for survival.

SEA research has shown that calanoid copepods and adult walleye pollock are the primary prey and predator, respectively of the pink salmon fry in the Sound (Willette et al. 1999a,b; Thomas et al. 1997). Thus, making synoptic measures of the temperature, density of calanoid copepods and adult walleye pollock in the marine rearing areas of the

Sound offers the best approach to solving population survival questions for the PWS pink salmon.

Assimilation of the measurement data can be into spreadsheet formats that are common in fisheries management or into more complex numerical solutions such as the pink salmon fry model developed during the SEA program (Mason and Patrick, unpublished). Since neither of the Principal Investigators in this proposal are modelers, we will outsource modeling work to collaborators in ADF&G, UW and NOAA. First, we have had discussions with Steve Moffit, who has assumed Mark Willette's responsibilities for forecasting pink salmon returns. Steve will be using Mark's spreadsheet to forecast pink survival, and we will be providing Steve with prey and predator numbers to assimilate and compare results with the traditional method.

Second, we will collaborate with the numerical modelers in the GLOBEC program to encourage use of data to estimate the nearshore survival of fry. Since estimation of nearshore marine mortality is a prerequisite for separating ocean mortality from total mortality as measured by marked fish returns, this monitoring program in the Sound provides critical measurement data for estimating nearshore marine mortality. We have had discussions with David Beauchamp, University of Washington, to develop a graduate student program for this effort. David Beauchamp is the modeler working as co-PI with Jake Helle and Lew Halderson on the GLOBEC ocean survival modeling of juvenile pink salmon.

Finally, Jeff Short has developed a Pristane index model as a surrogate to the magnitude of pink salmon feeding on calanoid copepods, which is a surrogate to survival. As stated earlier, this model has several assumptions that we can evaluate with direct measures of copepod and fish abundance. Given that total mortality will be determined the following year by adult pink salmon returning to the Sound, the data we collect will be useful to three independent modeling groups to compare expected survival estimates.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

OSRI, PWSAC, SERVS and ADF&G provided approximately 110K to conduct the FY00 surveys. This level is expected to increase to 150K in FY01. This program makes extensive use of the measurement and computing equipment purchased and used on past EVOS TC research at minimal costs to upgrade and maintain.

SCHEDULE

A. Measurable Project Tasks for FY 01 (October 1, 2000 - September 30, 2001)

Oct 10-12: Attend EVOS workshop in Anchorage

Jan 1 - Mar 31: Review of databases and models for program and survey design;

design and begin refinements of measurement systems, design and begin assembling processing system for making near-real time estimates of abundance, obtain NEPA categorical exclusion

Apr 1 - Jun 30: Implementation of field surveys; continue data analysis.

July 1 - Sep 30: Report, evaluate and refine survey design, make initial predictions of recruitment, and modify sampling for second year implementation, develop manuscript for publication in a peer reviewed journal

B. Project Milestones and Endpoints

FY01 Report on the spring 2001 predator-prey surveys with prediction of future pink salmon survival.

FY02 Report on the spring 2002 predator-prey surveys with estimates of future pink Survival.

C. Completion Date

FY02 (September 2002) with annual report on April 15, 2001.

PUBLICATIONS AND REPORTS

An annual report will be prepared to meet the Council's requirements for work done in 2001. Several peer-reviewed articles are anticipated from past work and some may incorporate this first year's work as well. In the second year, we will prepare manuscripts presenting results of the first two years of work for publication in professional journals.

PROFESSIONAL CONFERENCES

Presentations are planned for the International Council for Exploration of the Seas: Fisheries Acoustics Symposium, PICES, the American Fisheries Society Meetings and the World Fisheries Congress.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project is directly interacting with EVOS Trustee Council projects on physical oceanography modeling and observations, pristane measurement, and stable isotope analysis. We will also make use of preceding Council research through the designation of common field sites and sampling design. This project will also make use of data generated in the SEA, APEX and NSP projects as well as seek the input of researchers involved in other projects within the region.

PRINCIPAL INVESTIGATORS

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Responsibilities: Dr. Thorne will be responsible for project administration and acoustic sampling, analysis and writing. He has been working as a PI on research projects for over 25 years while at the University of Washington and at BioSonics Inc. He participated as a subcontractor to the University of Alaska Fairbanks on the APEX research program.

Dr. Thomas will be responsible for project coordination, field logistics, data analysis and writing running and refinement of the Nekton model. He has worked as a PI on past EVOS TC research programs.

C.V.s for both investigators are attached. Please address all correspondence related to this proposal to Richard E. Thorne.

KEY PERSONNEL

Field assistants (staff):	Assists with all aspects of fieldwork and sampling.

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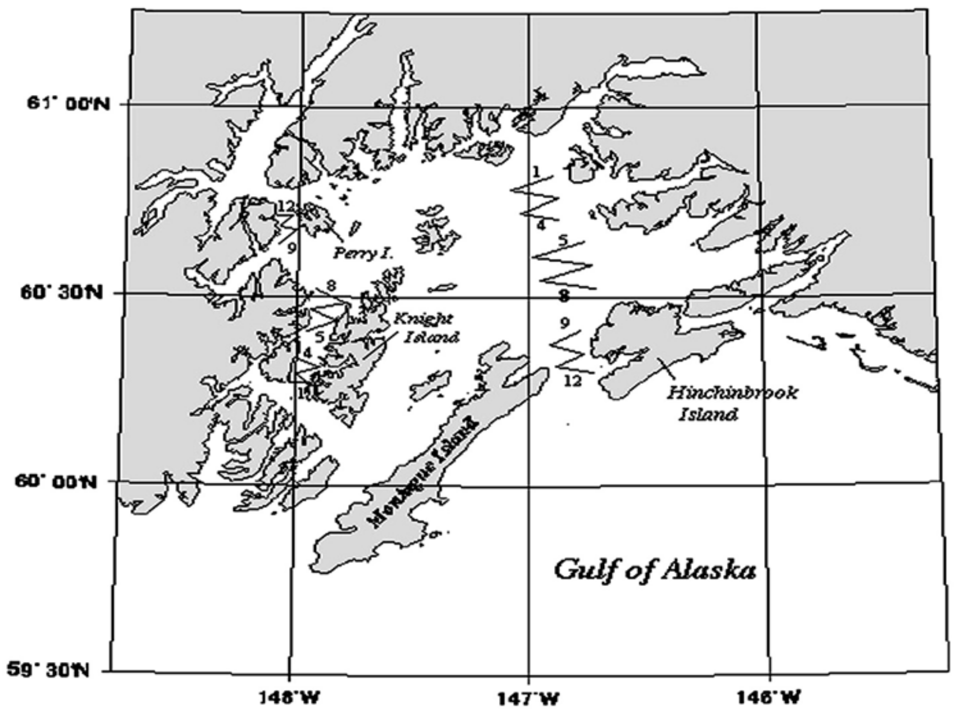

Figure 1. Schematic of approximate transect locations for the May 2000 surveys in Prince William Sound.

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Employment History

BioSonics, Inc.	Vice President	1996-1999
4027 Leary Way NW	Manager Technical Services	1991-1999
Seattle, WA 98107	Senior Scientist	1988-1999
(206) 782-2211		
University of Washington	Affiliate Research Professor	1991-Present
School of Fisheries	Research Professor	1981-1990 (LOA 1988-1990)
Fisheries Research Institute	Research Associate Professor	1976-1981
Seattle, WA	Senior Research Associate	1970-1976
Commercial Fisher (salmon and albacore)	1957-1968	

Academic Background

Ph.D., Fisheries-1970, University of Washington, School of Fisheries
MS Degree-1968, University of Washington, Department of Oceanography
B.S. Degree-1965, University of Washington, Department of Oceanography

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Education
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1973, M.S., Zoology, California State University at San Diego, San Diego, CA.
1970, B.A., Biology, California Western University, USIU, San Diego, CA.

Professional Experience
1992-00, Acting Dir./Executive Director, PWS Oil Spill Recovery Institute, Cordova AK
1990-00, Director/President, PWS Science Center, Cordova, Alaska AK
1995-00, Full Professor (affiliate), RSMAS, University of Miami, Miami FL
1993-95, Associate Professor (affiliate), University of Alaska Fairbanks, Fairbanks, AK
1984-89, Assistant to Leader, Fish Coop Unit, University of Washington, Seattle, WA
1976-92, Assist. Professor (research)/Fish.Biol./Res.Assoc, FRI, Univ. of Wash., Seattle, WA
1973-76, Pre-doc. Research Assoc., College of Fisheries, FRI/FCU, Univ. Wash., Seattle, WA
1972-73, Research Associate, Scripps Institute of Oceanography, La Jolla, CA
1971-72, Biological Technician, GS-5, Southwest Fisheries Center, NMFS, La Jolla, CA

Academic Honors
1999 - Outstanding Service Award, Prince William Sound Science Center
1990 - Outstanding Service Award, U.S. Fish and Wildlife Service, Region 1.
1986 - Outstanding Service Award, North Pacific International Chapter, Amer. Fish. Soc.
1976 - Ellis Memorial Scholarship, College of Fisheries, University of Washington
1974 - Tacoma Sportsmen's Scholarship, College of Fisheries, University of Washington

Professional Memberships
American Fisheries Society (life member)
American Institute of Fisheries Research Biologists
American Association for the Advancement of Science

Public Service
Board Member, Cordova Medical Center, Cordova AK
Served on many science review panels, chaired several symposia and edited proceedings, peer reviewed proposals and journal papers, supported and mentored over 20 graduate students. Two of four Ph.D. students are faculty at major research universities.

Other experience
1965-73, Deckhand on Southern California sport-fishing charters
1983-1993 Commercial Fisher, intermittent and seasonal (Bristol Bay salmon gillnetting, Gulf of Alaska long-lining for blackcod and halibut, West coast trolling for albacore, Nearshore jigging for rockfish)
1978-present, Fisheries Consultant, hydroacoustics, stock assessment, environmental impact

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Technical Reports: I am author on over 100 technical reports.

APPENDIX 1

DRAFT FINAL REPORT

OSRI FY00 MONITORING PROGRAM

Monitoring the Juvenile Pink Salmon Food Supply and Predators in Prince William Sound

by

Richard E. Thorne and Gary L. Thomas

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001						
Personnel		$0.0						
Travel		$0.0						
Contractual		$55.6						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal		$55.6		Estimated FY 2002	Estimated FY 2003	Estimated FY 2004		
General Administration		$3.9						
Project Total	$0.0	$59.5		$89.5	$0.0	$0.0		
Full-time Equivalents (FTE)		4.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 01

Prepared:

Project Number: 01452-BAA
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001						
Personnel		$29.4						
Travel		$3.4						
Contractual		$10.5						
Commodities		$1.2						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$44.5		Estimated FY 2002	Estimated FY 2003	Estimated FY 2004		
Indirect		$11.1						
Project Total	$0.0	$55.6		$83.6				
Full-time Equivalents (FTE)		4.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources		$160.0						

Comments:

The total EVOS TC share of the requested project is approximately 25%

*Salary rate for G.L. Thomas reflects research time at 20% reduction from administrative costs
**OSRI, is contributing $75,000 per year to this project
***SERVES is providing 15 days of vessel charter, valued at $5,000 per day, for $75,000 of in-kind support
****ADF&G is contributing personnel time, equipment and supplies valued at $10,000 of in-kind support
*****PWSAC, CDFU and fishermen are also expected to contribute in-kind services to this program

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4A
Non-Trustee
SUMMARY

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2001
G.L. Thomas	co-Principal Investigator		1.0	10.9		10.9
R.E. Thorne	co-Principal Investigator		1.0	10.5		10.5
TBN	Technician		2.0	4.0		8.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		4.0	25.4	0.0	
					Personnel Total	$29.4

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
Annual Meeting	0.5	1	5.0	0.2	1.5
EVOS and collaborative workshops	0.5	1	7	0.2	1.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$3.4

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Personnel
& Travel
DETAIL

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Contractual Costs:	Proposed
Description	FY 2001
tele, communications, fax, etc.	0.4
maintenance	0.1
Upgrades and calibration of 420 kHz digital transducer	6.0
Vessel Charters	4.0
Contractual Total	$10.5

Commodities Costs:	Proposed
Description	FY 2001
supplies	1.2
Commodities Total	$1.2

FY 01

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Contractual &
Commodities
DETAIL

Prepared:

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2001
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	
420, 120 and 38 kHz echosounding systems		
Towfin and harnesses		
Plankton nets		
CTD		
Processing hardware and software		

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

FORM 4B
Equipment
DETAIL

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001						
Personnel		$0.0						
Travel		$0.0						
Contractual		$46.3						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal		$46.3		Estimated FY 2002	Estimated FY 2003	Estimated FY 2004		
General Administration		$3.2						
Project Total	$0.0	$49.5		$72.0	$0.0	$0.0		
Full-time Equivalents (FTE)		2.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Agency: NOAA

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2000 - September 30, 2001

Budget Category:	Authorized FY 2000	Proposed FY 2001						
Personnel		$22.9						
Travel		$3.4						
Contractual		$4.5						
Commodities		$1.2						
Equipment		$5.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$37.0		Estimated FY 2002	Estimated FY 2003	Estimated FY 2004		
Indirect		$9.3						
Project Total	$0.0	$46.3		$66.0				
Full-time Equivalents (FTE)		2.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

*Salary rate for G.L. Thomas reflects research time at 20% reduction from administrative costs

**OSRI, SERVS, PWSAC and ADF&G are contributing approximately $120,000 to this program for better than a two-thirds matching rate

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

Personnel Costs:		Months	Monthly		Proposed

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

Name	Position Description		Budgeted	Costs	Overtime	FY 2001
G.L. Thomas	co-Principal Investigator		0.5	10.9		5.5
R.E. Thorne	co-Principal Investigator		1.0	10.5		10.5
TBN	Technician		1.0	6.9		6.9
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		2.5	28.3	0.0	
					Personnel Total	$22.9

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2001
Description					
Annual Meeting	0.5	1	5.0	0.2	1.5
EVOS and collaborative workshops	0.5	1	7	0.2	1.9
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$3.4

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

Contractual Costs:	Proposed
Description	FY 2001

tele, communications, fax, etc.	0.4
maintenance	0.1
Vessel Charters	4.0
Contractual Total	$4.5

Commodities Costs:	Proposed
Description	FY 2001
supplies	1.2
Commodities Total	$1.2

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA

FY 01 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2000 - September 30, 2001

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2001
420 kHz Transducer	1	5.0	5.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$5.0

Existing Equipment Usage:	Number	
Description	of Units	

FY 01

Prepared:

Project Number:
Project Title: Assessing prey and competitor/predators of pink salmon fry, Submitted Under the BAA
Name: Prince William Sound Science Center
Agency: NOAA