PROPOSAL SIGNATURE FORM

By submission of this proposal, I agree to abide by the Trustee Council's data policy (*Trustee Council Data Policy**, adopted July 9, 2002) and reporting requirements *(Procedures for the Preparation and Distribution of Reports***, adopted July 9, 2002).

PROJECT TITLE: Ongoing Synthesis and Modeling Activities Restoring Injured Commercial Fishery Services.

Submitted Under the BAA

Printed Name of co-PI: Ken Adams

Signature of co-PI: ______________________________ Date __________

Printed Name of co-PI: Ross Mullins

Signature of co-PI: ______________________________ Date __________

Trustee Council Use Only **Project No:** _____ **Date Received:** _____	**PROPOSAL SUMMARY PAGE**

Project Title: Ongoing Synthesis and Modeling Activities Restoring Injured Commercial Fishery Services –Submitted under the BAA

Project Period: FY06-FY07

Proposer(s): Ken Adams, PWSFRAP kadams@gci.
Ross Mullins, PWSFRAP rmullins@gci.net

Study Location:
Prince William Sound www.pwsfrap.org.

Abstract Our revised proposal requests funding to continue a collaborative synthesis and modeling study designed specifically to help to fully restore the as yet to be recovered commercial fishery in Prince William Sound, Alaska, through an understanding of ecosystem-level processes that affect fisheries production. Using information obtained by the EVOS TC-sponsored SEA program (1994-99), we are working with Alaska Department of Fish and Game, the regional aquaculture corporations, the Prince William Sound Science Center, local fishing organizations and the Universities of Maryland and Alaska and other collaborators, to implement a previously developed pink salmon survival model (PSSM) that we believe will greatly improve resource forecasting and the assessment of ecosystem health. The results of this work are expected to improve the management and enhancement of salmon in the region, substantially assisting the recovery of injured commercial fishing services that are now characterized by the continuing loss of herring resources.

Funding: EVOS Funding Requested: FY 06 $ 108,400
(must include 9%GA)

TOTAL: $108,400

Non-EVOS Funds to be Used: FY 06 $ 13.0 in kind contribution from ADF&G of 1 man month for Steve Moffitt and 1 man month for a department biometrician.

TOTAL: $108,400

Date: September 14, 2005

(NOT TO EXCEED ONE PAGE)

PROJECT PLAN

I. NEED FOR THE PROJECT

A. Statement of the problem

The *historically important fisheries economy* of resource dependent communities in Prince William Sound (PWS) Alaska continues to suffer from oil spilled in March, 1989. Our proposal describes a means to mitigate aspects of this ongoing problem by applying sophisticated numerical tools and new insights on ecosystem form and function leveraged by previous studies funded by the Exxon Valdez Oil Spill Trustee Council (EVOSTC) and other sponsors. One of these studies, the Sound Ecosystem Assessment (SEA) program spent $20 million dollars over a 6-year period describing the factors influencing the survival of juvenile pink salmon and herring in PWS. The modeling activity we propose is a direct extension of that important body of results.

The instability of herring and pink salmon stocks are hindering management practices and the efficient harvest of these resources. Pacific herring have failed to recover following the spill and now contribute nothing to the local economies where once they were a mainstay. Pink salmon (wild and hatchery origin) are abundant, but a recent “boom and bust” pattern of returns is disrupting the fishery – during unexpected boom years (2003, 2005) processing capacity has been unable to accommodate the resource resulting in substantial product waste and a reduced participation of fishers. Similarly, during the weak years (2002, 2004) there has been an over-capacity of fishers compete for a limited resource that must also accommodate spawning escapements, cost recovery and an egg take required to restock local salmon hatcheries. Under both conditions – boom or bust - the overall fisheries economy of the region is diminished.

We contend the economic problems (damaged human services) associated with a wildly fluctuating pink salmon production cycle can be alleviated (in part) by achieving more reliable information about “expected levels of adult returns” a year in advance of the fishery. When this is accomplished, management, stakeholders and the industry will have time to adjust their various activities in appropriate and cost effective ways. Unfortunately, the track record for pink salmon run forecasting (State and private) in PWS has been inconsistent and rarely useful to management or the fishing industry. The inability to identify even the most extreme highs (50-60 million adults) and lows (15-20 million) means that until better information becomes available, there can be no meaningful “planning in advance” to mitigate the continuing economic damages associated with these unprecedented production swings.

To address this issue, a continuing synthesis of SEA findings has resulted in the further development and testing of a numerical model designed to simulate processes affecting the survival of juvenile pink salmon in PWS. When properly initialized and updated with environmental information, this comprehensive mathematical formulation tracks the evolving “state” of the juvenile pink salmon stock while it rears for 3-4 months in the Sound each year. Most believe that losses occurring during this *critical period* establish future production levels. If so, *the key to reliable forecasts of run strength rests with accurately accounting for the survival of juveniles in PWS during late spring and early summer.* We propose to do this using the SEA juvenile pink salmon model.

Unlike the statistical methods commonly used to forecast adult returns by others, the SEA model is deterministic, using biological mechanisms described previously as the important modifiers of juvenile salmon survival (primarily environmentally-modulated predator/prey relationships). When in use, the model is embedded in a matrix of upper-ocean measurements that continuously update (force) the simulation process (see Section VI for model details). Ordinarily, obtaining time-series of forcing variables would involve a very expensive field component for any future forecasting program. However, in a fortuitous twist of fate, this requirement can now be met (in large measure) through partnering with the new and growing Prince William Sound Observing System (PWSOS) sponsored by the Oil Spill Recovery Institute (OSRI) and NOAA. A recently completed PWSOS and Alaska Ocean Observing System (AOOS) workshop in Cordova (June, 2005) clearly demonstrated an area for collaboration between those who track the state of the ocean through elaborate local monitoring schemes, and those who require this same information to model aspects of the system that cannot be observed directly; for example – the crucial time-varying state of local fry stocks each spring and summer.

Commercial fishing is recognized in the EVOSTC 1994 Restoration Plan and the 2002 Update on Injured Resources and Services as an *oil spill injured human service*. It is currently listed as recovering but *in need of enhancement*. The goal of securing and sustaining the recovery of the PWS marine ecosystem and the economic services it provides is a stated priority for the EVOSTC as well as for those living in the PWS spill impacted region. Achieving this goal will require the Council's long-term commitment to environmental surveillance and resource analysis. Given the successes of the Trustee Council's Restoration Plan so far, including the suite of research results produced within the Sound Ecosystem Assessment (SEA) program (1994-99), we believe that much of that goal is now attainable. A continuing synthesis of TC sponsored SEA and other results, the integration (including resource economic issues) of that effort with studies recently completed by the NSF/NOAA GLOBEC program in the adjacent Gulf of Alaska, and new oceanographic monitoring at the Prince William Sound Science Center define the major operational elements required to track the ecological health of PWS and guard its cherished fisheries resources.

It is unlikely these important collaborations would be succeeding were it not for TC sponsorship of the Prince William Sound Fisheries Research Applications and Planning (PWSFRAP) group. This grass-roots association serves to facilitate scientific exchanges between partners working on local fisheries problems (including salmon forecasting), and creates functional and efficient linkages between stakeholders and the TC restoration process.

The marine economies and communities of PWS are natural partners for realizing an eventual overall economic recovery. Commercial fishermen have the involvement, personal resources, and the intense motivation - through long-term financial commitment and risks - to be dedicated and effective partners with the EVOSTC. We have always believed that joint investments can accomplish significantly more toward a common goal than is possible through the same investments expended independently. Our experiences since the inception of PWSFRAP in 2002 clearly demonstrate the EVOSTC's wisdom in promoting and sustaining our activities as a means to more fully engage the resources and historical experiences of those who make their living harvesting the valued resources of this region. This partnership continues to demonstrate the contributions possible with strong public sector involvement. In fact, the communications process we have initiated with EVOSTC support may well become a model for others seeking to find applications for basic science results.

B. Relevance to the 1994 Restoration Plan Goal and Scientific Priorities.

The 1994 Restoration Plan clearly stated its intention that *"restoration will take an ecosystem approach to better understand what factors control the populations of injured resources"*. The work we have undertaken in preparation for the application of previous science results to current economic issues – our proposed juvenile pink salmon modeling - has its roots in the oceanographic and fisheries results produced by the Council with its 6-year SEA program. Without this fundamental background information – achieved through the ecosystem approach - and the synthesis efforts that have followed, we would have no basis for developing a recovery strategy for injured commercial fishing services. However, now that we understand many of the most fundamental aspects of the juvenile pink salmon and herring ecosystems, we are able to offer solutions addressing the continuing production instabilities associated with the non-recovered fishery services. Our goal in proceeding this way is directly aligned with the Trustee Council's 1994 Restoration Plan. While we cannot influence the vagaries of Mother Nature, we are confident that our numerical modeling approach will add to the growing environmental "tool kit" available to those who manage, enhance and use the fishery resources of PWS.

Because of the nature of the ecosystem approach and the expense of large integrated studies, we continuously seek to utilize the knowledge arising from other existing stand-alone programs in PWS: 1) the extensive private hatchery springtime plankton watch; 2) Oil Spill Recovery Institute (OSRI)-supported acoustic and net sampling of zooplankton and fish; 3) Alaska Department of Fish and Game (ADF&G) sampling of late-season surviving juvenile salmon; 4) Global Oceans Ecosystem Dynamics (GLOBEC) pink salmon research in the nearby Gulf of Alaska (GOA); 5) the developing ocean observing systems (Alaska Ocean Observing System (AOOS) and PWS Observing System (PWSOS. In a synthetic sense, our future modeling work is expected to provide a working framework, integration of, and linkages to the above programs resulting in significant research efficiencies and an important sharing of intellectual capital.

ll. PROJECT DESIGN

A. Objectives

1. Modeling: Prepare the PWSFRAP office for future operation of the juvenile pink salmon survival model in Cordova by installing the model code in a local server. Test and refine the model formulations, and update the design to accommodate new information obtained after 1998 with attention to issues of initial values and marking fry, forcing and boundary conditions, data assimilation, and economic applications (see Section VI below).

2. Communication: Continue to expand the PWSFRAP website as a readily accessible portal to research accomplishments of interest to the EVOSTC, commercial fishers and the public, and also use the site as a repository for the results of eventual modeling activities serving all project collaborators, stakeholders and others who wish to access the information.

3. Synthesis: Maintain the PWSFRAP office with funds to support critical collaborations between modeling participants and field investigators inADF&G, AOOS, PWSOS, and other cooperating programs such as GLOBEC. Encourage a continual analysis and understanding of previous field and modeling results (an ongoing synthesis) among program participants through interdisciplinary seminars, reports, peer-reviewed manuscripts and workshops/symposiums.

B. Procedures and Scientific Methods

Objective 1. A copy of the IDL program code defining the model will be transported from the University of Maryland to a server that will be installed at the PWSFRAP office in Cordova. Dr. Patrick (the principle author of the pink salmon model) will obtain the required IDL language license from RSI Inc., and complete the installation. The model will be tested and enhanced in FY06 prior to implementation in coming years. Preparation for model applications will draw on a science planning project undertaken in FY05 and expected to be completed and reviewed in FY06.

An off-site portable computer/workstation is requested so that Dr. Patrick can remain engaged with model modifications as necessary from locations outside Cordova and the University of Maryland. Dr. Patrick has plans to spend the major fraction of the remaining FY05 and FY06 in Cordova to address the above-mentioned modeling tasks and to coordinate the effort with participating individuals and other programs in the region. Dr. Patrick's commitment to the future success of our pink salmon modeling project is one of the most important aspects of our work ensuring that the modeling activity will finally be brought to a point of practical application.

The deterministic SEA juvenile pink salmon survival model is composed of a series of linked evolution equations that specify instantaneous rates of change for variables defining important parts of the pink salmon survival system (see Section VI for model details). From any starting point – for example, the numbers of fry entering PWS (provided by the hatcheries and ADF&G) - the equations compute the direction and rate of change for fry in the system. In the forecasting application we are pursuing, the model will provide a spring/summer survival trajectory *and estimate the numbers of fry successfully completing their first 3-4 months at sea (in PWS).* We believe modeled survivals at this time will generally predict the numbers of actual adults returning the following year – high, low or average numbers.

One might wonder if it would be less expensive and more straightforward to directly census the numbers of fry surviving their period of early marine residence in PWS? Unfortunately, the sampling problems associated with these kinds of statistical estimates (timing, spatial distributions, numbers of samples, and gear considerations) result in huge costs and uncertainties that overwhelm the direct sampling approach. This is precisely why a numerical solution and analysis is required.

Objective 2. Our work during FY05 included the design and posting of a PWSFRAP website (www.pswfrap.org) that is being used to inform local communities of past accomplishments (see Appendix 1 for details), and serves as a point of contact for collaborators and others interested in understanding what we are doing. The site was created, and continues to be updated with substantial in-kind support from investigators within PWSFRAP. We view this integrating and synthesis activity, and the evolving web product it represents, as one of the most useful tools our communications process has undertaken over the past year and we intend to continue to build on what has been initiated by directly supporting its expansion.

Locally, PWSFRAP provides a presence and liaison between the EVOSTC, PWS fishermen and processors, the public, and science and resource management personnel in Cordova and elsewhere. This is a stakeholder initiated project highlighting the need for continued investigation and monitoring of the ecosystem that provides the livelihood for much of the region. Staying in touch with the community that has supported our work is one of our highest priorities.

Objective 3. The continuing analysis and interpretation of our past and present work, and the review and application of the results produced by others defines an *ongoing synthesis activity* that is a major structural element of PWSFRAP. Facilitation of the SEA juvenile salmon survival modeling is a current example of how the organization uses this to draw together expertise and the financial support required to bring real-world problems into alignment with appropriate funding sources. Our past coordinating effectiveness has been enhanced by an identifiable "office" in Cordova where we originate conference calls, internet exchanges and small-person gatherings. In the coming year (FY06), we request continuing support for the office and its work in the community. This work includes maintaining contact with the scientific team that has been creating a science plan to steer future modeling studies, hosting a local workshop demonstrating the pink salmon model and its economic applications, providing the coordination for participation in the further planning of PWSOS and AOOS activities in relation to our salmon modeling, and sponsoring and encouraging the joint publication of reports, manuscripts, and presentations that describe the work the Trustee Council is supporting through grass-roots efforts in Cordova.

The project support we are requesting for FY06 is designed to prepare the way for the eventual full-scale use of the pink salmon survival model at some future date. Deliverables expected in the coming year are: 1) an internally reviewed science plan for future model implementation; 2) a more expansive PWSFRAP website; 3) installation and testing of pink salmon model code in a local Cordova server; 4) hosting a modeling workshop demonstrating the pink salmon model; and 5) a draft plan for the use of PWSOS and other data streams in future modeling efforts.

C. Data Analysis and Statistical Methods

Although the work we envision with the installation of the pink salmon survival model in Cordova is not likely to be stochastic, there will be some comparative analyses of previous runs to assure that the model is behaving correctly. As such, this anticipated work will constitute a model analysis.

D. Description of the Study Area

The PWSFRAP office will be maintained in Cordova and will serve as the communication hub for team collaboration, project administration and public interactions. Presentations of project progress will be made at various locations in Cordova including the PWS Science Center, PWS Aquaculture Corporation, and Cordova District Fishermen United. Continuing project progress will be posted on our website.

E. Coordination and Collaboration with Other Efforts

PWSFRAP will work closely with the developing ocean observing programs on both the state level (Alaska Ocean Observing System (AOOS) and the regional level (Prince William Sound Ocean Observing System (PWSOOS) to discuss and identify physical and biological monitoring products of value to the community and our future modeling effort. We also anticipate participation in synthesis discussions of GLOBEC's recently concluded pink salmon field work conducted over the Gulf of Alaska coastal shelf in the vicinity of PWS. The SEA program investigated the near-shore or estuarine survival of young pink salmon and this work, especially the salmon modeling which incorporates factors influencing juvenile salmon survival, is a direct compliment to GLOBEC's studies on the coastal shelf. Taken together, these two programs offer the promise of even greater understanding of the chief causes of pink salmon marine mortality each year

III. SCHEDULE

A. Project Milestones

October 05-September 06: Continue development of the PWSFRAP website

October 05-January 06: Transfer model code from Univ. of Md. to Cordova site

October 05-April 06: Update the output module for the model that provides real-time assessment of time-varying conditions during each model run.

October 05-Nov 05: Relocate Dr. Patrick to Cordova.

January 06: Attend the annual EVOS workshop in Anchorage.

April 06: Submit a proposal for a pink salmon survival model pilot program.

October 05- Mar 06: Configure and schedule the PI/Collaborator FY06 workshop.

March 06-Sept 06: Hold a Planning workshop for PI's and collaborators that will be open to the public.
October 05-September 06: PWSFRAP would welcome site visits by TC and or staff.

September 06: Submit a report of work completed in FY06

B. Measurable Project Tasks

Complete an internally reviewed Science Plan for the future implementation of the pink salmon survival model in PWS (completes a task begun with FY05 funding).

Development and updating of the PWSFRAP website <www.pwsfrap.org>

Transfer of the computer code from UMD to Cordova; model testing and evaluation.

Development of a draft plan for the use of information streams to and from partnering programs (AOOS/PWSOS, ADF&G, private hatcheries, and other).

Planning workshop for PI's and collaborators that will be open to the public.

Final report of FY06 work.

C. Consolidated View FY05 Accomplishments and FY06 Project Tasks.

Table 1 (pg.15) places the proposed tasks in the context of *a*) general model issues (see p9), *b*) PWS-specific and pink-specific issues (see p11-14), and *c*) the progress during FY2005. The column headers in Table 1 arise directly from *a*) and *b*). The topics "Initial Values," "Boundary Conditions," and "Data Assimilation" are common to all models of this class. Fry marking is region-specific and operationally is part of the initial conditions. However, for this work it is the role of marking in data assimilation that is a priority topic for FY06. (see p14). Routes and pathways is another region-specific topic, one with a large number of applications. Ocean survival is the subject of a companion project that was supported by the Trustees during 2005. The last header reflects the emphasis on economic integration noted several times herein.

The left column of Table 1 is a draft outline of the stages and steps of an application development. Items in this list completed in FY2005 are labeled "05", items starting in FY2006 are labeled "06," and those continuing are labeled "05, 06."

Activities during FY2005 were intentionally broad and diverse. The breadth of the effort is reflected in the distribution of progress across the seven components; the diversity can be seen in the more detailed presentation of FY2005 accomplishments in the bottom three sections. Because of FY2005, the plan for 2006 gives higher priority to the topics of the first, second, fourth, and seventh columns. While all seven subject areas must "work together" in the end, these four are simultaneously the most difficult technically and the most essential for success.

Because of this, the work in 2006 requires much greater direct engagement and interactions with the entities identified in the table because success depends on the effectiveness and commitment of each one. And that goal requires greater immediacy and accessibility and more communication and exchanges by all. The relocation of personnel and of technical capacity to the region is one aspect of the strategy to meet these requirements. A second aspect is the restoration of some of the prior computing capacity in the region and its increased utilization in the planned workshops and online communications

IV. RESPONSIVENESS TO KEY TRUSTEE COUNCIL STRATEGIES

A. Community Involvement and Traditional Ecological Knowledge (TEK)

PWSFRAP is fundamentally a community involvement process or rather, a project continuum seeking to build bridges between the local resource dependent communities, science, and project support providers. In FY'02 and '03, a series of workshops were conducted in Cordova with participation from the public and project advisors to identify community issues and needs. Other targeted workshops were conducted in '04 to address and begin the resolution of the earlier issues. In FY'05 we began the planning process for implementation of the pink salmon survival model, conducted jointly with an ADF&G project to census out-migrating juvenile pink salmon and partition marine and estuarine survivals. The PWSFRAP project continuum was initiated by members of the fishing community in Cordova. Ken Adams and Ross Mullins are the principal architects of the organization, and their work over the past 4 years has kept the organization alive and responsive to local fisheries needs.

B. Resource Management Applications

The wild pink salmon resource in PWS is managed by ADF&G to sustain its productivity over time. Regional escapement levels have been adopted to assure optimal reproduction each year in the face of changing marine and freshwater survivals and the largest pink salmon hatchery program in the world. Over the years, ADF&G attempted to design a reliable forecasting tool to alert managers, and the fishing industry about anomalous returns – huge or very small. For a variety of complex reasons, a reliable forecasting tool has yet to be developed. The pink salmon survival model discussed here has demonstrated predictive capability in a limited evaluation undertaken during the SEA years (1994-98). In the future we anticipate two complementary approaches to define the forecasting work: indexing of numbers of surviving juveniles emigrating from PWS each year by ADF&G (first-order estimates we believe "may" be related statistically to the adult return), and *estimates of calculated juvenile survivals* driven by observed growth conditions (food and temperature) and predator stocks arising as model results.

Fully implemented in a program of long-term monitoring (PWSOS), the pink salmon survival model will provide an increasingly refined means to both understand the ecological processes causing observed changes in annual survivals, and to produce modeled forecasts based on calculated juvenile survivals during early marine residence. The model will also be used to assist hatchery managers in determining optimal release strategies for fry entering the Sound under different conditions of ocean climate. Finally, the model has demonstrated promise for "experimental" studies of wild and hatchery stock interactions in PWS, a long-standing issue in the region. These other uses will be phased in as the modeling program matures.

V. PUBLICATIONS AND REPORTS

Timely quarterly reports will be provided to the project's NOAA project manager. A project interim report will be made available to the EVOSTC by April 1, 2006 and an annual report will be made available by September 30, 2006.

VI. DESCRIPTION OF THE MODEL, STATUS IN 2004, ADVANCES DURING 2005, ADVANCES AHEAD

Description of the model

Models for Prince William Sound (PWS) are a major legacy of the EVOS Restoration Program. The legacy includes models for circulation, plankton dynamics, herring larval drift, age-0 herring winter survival, *Neocalanus* transport, and pink salmon fry survival—each of these a separate product of the Sound Ecosystem Assessment Program (*SEA*). The legacy also properly includes the continued and continuing development of the models for circulation and plankton dynamics due to support from the Oil Spill Recovery Institute and from the AOOS and PWSOOS programs, with contributions from EVOSTC. The point of this long list is to highlight the fact that all of the models are the same type; the foundation of each is a system of evolution equations. This foundation is the source of some internal and necessary structure. That structure is a natural guide to use in formulating projects involving these models and the natural guide for managing, administering, or working on such projects. This Appendix starts with the structure and then commences to paint the picture of the pink salmon fry survival model on and over this structure. The painting is not abstract; the painting proceeds in chronological order through a real history. The bottom line is the hope that future encounters with this or related models will be a lot more obvious with this Appendix than without it.

A second reason for this Appendix is its role in a full and effective response to the many thoughtful and useful comments and requests received. Many of the requests are understood by us to be looking not only at the issue at hand but looking past that issue and into the body of this work—what it was, what it did or still does or could do and to what end. The sense of the collaboration was that a significant fraction of those interested enough to ask could not be properly answered without the inclusion of something like this Appendix in this revised proposal. With that, we turn to the common structure.

The models share the following three-component structure:

M-1. For the subject environmental or ecological subsystem, an approximating representation in the form of a system of evolution equations; (Patrick et al., 2006, v1 chs 3, 4)
M-2. A numerical analysis of the equations and an approximating numerical solution;
M-3. A computer program which implements the numerical solution.

The term "evolution equations" denotes a class of differential equations in which the equations have a specific form. Let t denote time, and let u be a time-varying function of a scalar variable x, with values denoted by $u(x,t)$. The function u is described by an evolution equation if the defining equation can be put in the form

$$\frac{\partial u}{\partial t} = G(u,t) \qquad \text{along with initial and boundary conditions} \tag{A1.1}$$

where G is a time-varying differential operator which acts on u only by $\frac{\partial}{\partial x}$ (any order). In particular, $\frac{\partial}{\partial t}$ appears only on the left side of the equation and only first order. If u is multivariate, $u = (u_1, u_2, \ldots, u_m)$, then there is a system of m evolution equations and a set of m operators G_i, $i = 1, \ldots, m$, with $\frac{\partial u_i}{\partial t} = G_i(u,t)$. Similarly, we can have $x = (x_1, x_2, \ldots, x_n)$

and the corresponding n partial derivatives $\frac{\partial}{\partial x_j}$, $j = 1, 2, \ldots, n$. For the special case of u depending only on t or that of G being a time varying function of u (i.e., not an operator, no derivatives of u), then (A1.1) reduces to a first order ordinary differential equation.

For M-1 to be more than a conjecture, we need M-2 and M-3 and we also need the following:

A-1. A source of either historical or realtime real-world data for initial conditions and forcing conditions, data which satisfies requirements regarding coverage of the relevant domain (i.e., time interval or time plus spatial region) and sampling frequency; (Patrick et al., 2006, v1 chs 2, 6; v2) (Willette et al., 2001)

A-2. Procedures whereby modeled states of the system (past, present, or future) are compared with corresponding observed states; (Patrick et al., 2006, v1 ch 2) (Willette et al., 2001; Willette et al., 2000)

A-3. If the time interval of interest is longer than the interval during which the model with A-1 and A-2 alone satisfies accuracy requirements, procedures for observation-based adjustments that reduce the difference between computed and observed states (i.e., data assimilation).

While the capability to numerically reproduce or track the evolution of the state of the real-world system is essential if M-1 is to have scientific and application relevance, in the case of knowledge-directed objectives, objectives whose statements use words such as "explanations" and "understanding," this capability alone is only marginally more enlightening than the observed data it seeks to reproduce. The path to objectives of this type is through two further common items:

Q-1. Qualitative analyses of the evolution equations of M-1; (Patrick et al., 2006, v1 chs 5, 6)

Q-2. Collections and accounts of the results of the analyses. (Willette et al., 2001)

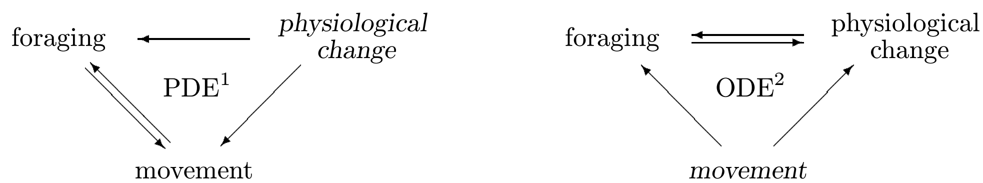
In principle, all that is needed for Q-1 and Q-2 is a completed M-1. However, the history of the psf model development consistently shows that serious advances in Q-1 and Q-2 occur only in response to unanticipated, unexplained results from numerical simulations of real-world scenarios, i.e., questions that **follow from** the activities in A-1 through A-3.

The pursuit of an effective, applicable, economically viable, evolution equation representation of the ecological subsystem associated with pink salmon fry in PWS (more briefly, *pink salmon fry survival model*; more briefly still, *psf model*) is now in its thirteenth year. By the end of 2003, seven of the eight common features above had been realized. Because of support during 2005 and 2006, the realization of an informal version of data assimilation, the remaining item, is at hand. Project managers should find the foregoing description useful because the order used for the presentation is the "natural" order to use in constructing a project plan for model development.

The most current draft of the nearly complete two-volume book on the psf model addresses the topic of M-1 in Chapters 3 and 4 of Volume 1 (Patrick et al., 2006). That treatment begins with the most general and most current formulation (developed in 2003) and then describes the representation of 1998 as an approximation of the more general form. Because the 1998 version is the basis for the existing implementation (i.e., M-2 to A-3) and because the interest here is both programmatic and technical, the presentation below is chronological, moving from origins to 1998 approximation to later refinements and up to today.

Developmental history and milestones

The diagram in (A1.2) shows the three mechanisms by which the spatial distribution (i.e., density function) of a trophic group's biomass is changed: 1) foraging, i.e., consumption, changes labels—mass that before consumption carried the label of a prey trophic group is designated "gut content" of a predator trophic group after consumption; 2) assimilation and metabolic processes determine the fraction of the consumed mass that ends up with the label of the predator's trophic group; 3) a trophic group may simply change its location or alter its spatial distribution or both. Stating the three processes mathematically and similarly stating the three interdependences is what M-1 above is all about. From 1989 through 1998, the model development pursued in parallel the two 2-component problems in (A1.2): *a*) the representation of foraging and movement and their interdependence (double arrows in left diagram); *b*) the representation of foraging and physiological change as a closed-loop system (double arrows in right diagram).



(A1.2)

1989–1992 Mason and Patrick wrote the first version of what later would become the psf model (Mason and Patrick, 1993). Aware of the simplicity of the pelagic ecosystem of Lake Michigan and with an interest in the debate-of-the-day regarding ecology as a science (Peters, 1991; Guilizzoni, 1996; Egler, 1977; Egler, 1986), they set about exhibiting a mathematical representation of the system dynamics. The real pelagic system was approximated by a tropic web $\mathcal{T}$ with four trophic groups spanning three trophic levels. The **state** of this system at time t is, by construction, the instantaneous values of the four, time-varying population density functions $u_f(x,t)$, f in $\mathcal{T}$. For this initial study, all densities save that for the group in the middle (alewife) were assumed known for all space and time (i.e., forcing), as were all relevant environmental variables. The evolution of the unknown density u_f, $f =$ alewife, was described by the diffusion-taxis equation (A1.3) with D_f and χ_f constants, with zero-flux boundary conditions, and applied to scenarios with short time intervals such that physiological changes are negligible (i.e., fixed and forcing) and predation losses can be ignored (i.e., $\Re_f = 0$).

$$\frac{\partial u_f}{\partial t} \;=\; D_f \,\mathrm{div}\,\mathrm{grad}\, u_f \;+\; \chi_f \,\mathrm{div}\Big(u_f \,\mathrm{grad}\, \lambda^f\big(x,t\big)\Big) \;-\; \Re_f\big(x,t\big) \tag{A1.3}$$

The focus of the work was the "loss function" $\lambda^f(x,t)$, a function which for each time t examines the foraging rate at x together with a suitably defined predation risk at x and outputs a measure of the "unfavorableness" of position x relative to alternative nearby sites. By construction, individual movement is "downhill," from larger to smaller values of $\lambda^f(x,t)$. The evolution equation (A1.3) was not solved numerically, instead, the quasi-stationarity $\frac{\partial u_f}{\partial t} = 0$ observed for most time was assumed to hold for all time.

1 In the 1998 approximation, this component is represented by partial differential equations (PDE).
2 In the 1998 approximation, this component is represented by ordinary differential equations (ODE).

1994–1996 EVOSTC / SEA

1. Finite element, hybrid method solution for systems of equations of type (A1.3).

Investigators: Prof. R. H. Nochetto, U.MD.; S. P. Rao, Santa Monica.

Scope: constant diffusivity D_f; constant taxis coefficient χ_f; any loss function λ^f; any reaction function $\Re_f$; any number of trophic groups (i.e., number of equations).

Completion: Mixed-method, 1D solution, coded in C, tested and operational in 1995. Migration to 2D and 3D explored but abandoned due to insufficient resources. A smaller, faster hybrid solver for (A1.3) was completed in mid-1996, coded in IDL, and made the solver in the new Combined Code by winter.

Documentation: (Nochetto, 1993; Nochetto and Rao, 1996; Nochetto and Rao, 1997)

2. Closed-loop representation of individual foraging-physiology in (A1.2).

Investigators: E. V. Patrick, D. M. Mason.

Scope: integration of foraging, gastric evacuation, and bioenergetics;

State variables: mass a_j of prey type j, $j = 1, \ldots, n$, in gut [or total mass $a = \sum_j a_j$]; energy b in fast-access buffer; whole body (wet) mass m; fork length ℓ.

Representation: $n + 3$ [or 4] ODEs, solved numerically within model code.

Features in 1996: autoselection of particle or ram feeding mode (by optimum mass flux); foraging includes submodels for *schooling* and *capture probability*. two feedback variables b and $a = \sum_j a_j$ enable accurate reproduction of published reports regarding fry feeding behavior (Godin, 1981a; Godin, 1981b; Godin, 1990) as well as non-continuous, episodic feeding of adults.

Completion: tested, coded in IDL, operational in 1995, in Combined Model in 1996.

Documentation: VOL 1 CH 5 "Foraging and physiological change" (Patrick et al., 2006).

1997 EVOSTC / SEA

Investigators: E. V. Patrick, T. M. Willette, R. T. Cooney, J. R. Allen, D. M. Mason

3. Model simulations exhibited the instability in Figure A1-1. The lower curve is the change from the upper curve due to a doubling of the number of predators. This raised three questions: Is the model flawed? If not, where is there evidence of survival rates as low as is indicated? If such a record exists, what are the "mechanics" of this "sensitivity" and of the "crash" or "bloom" alternative outcomes?

The historical record for annual mean survival for individual hatcheries has never exhibited a return as low as Figure A1-1 indicates is possible. However, Coded Wire Tag records of survival (Figure A1-2) do.

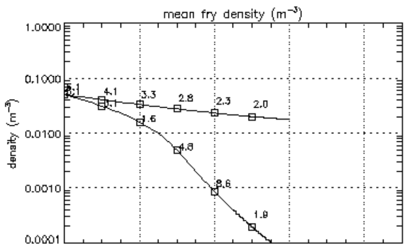
A qualitative analysis was undertaken to determine the origins and properties of the instability in Figure A1-1, and the Crash-Bloom Lemma (Patrick et al., 2006, VOL 1 CH 6), (Patrick, 1997) is the formal statement of the results. The lemma and Fig A1-1 describe a simplified predator-prey scenario in which the predator is satiated (less than 24 hours to fill gut), a situation also called "predator swamping" by hatchery managers. Although relatively simple in form, the lemma is a source of many excellent lessons about ecosystems and mathematics.

1998 EVOSTC / SEA

Investigators: E. V. Patrick, T. M. Willette, R. T. Cooney, J. R. Allen

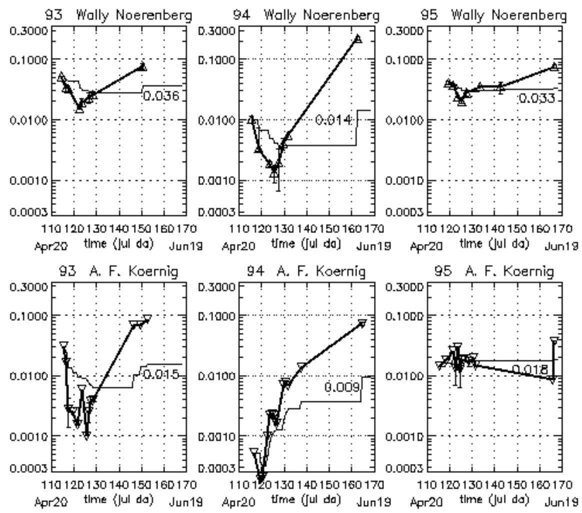
4. Coded Wire Tags (CWT) had a critical role in the development of the psf model.

- The “signals” in survival data were strong and their reproduction was absolutely essential.
- The structure of tagged groups was used to define model subgroups.
- CWT survival data shares the spotlight with the inability of contemporary sensors to track the surface adhering pink salmon fry and their inability to monitor the movement and distribution of adult fish relative to the nearshore as the reason for changing the implementation plan from transversal to parallel relative to the migration path;
- Implementation included comparisons between field observed and simulated physiology data collected or computed at times spanning the migration period. (Willette et al., 2001; Willette et al., 2000)



x-axis: time since release (das.)
y-axis: fry density (m^{-3})

Figure A1-1 Fry evolution under identical scenarios except predator density for lower curve is twice that for upper curve.



x-axis: Julian date of group’s release

Figure A1-2

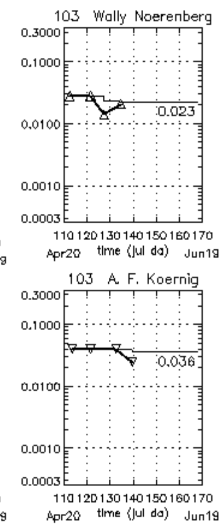


Figure A1-3
thermally marked

CWT survival records total marine survival of a group. The *relative pattern* is a PWS fingerprint if the survival for all groups once outside PWS is relatively uniform. In 1998, this was assumed to be the case. At the PWSFRAP workshop in March 2004, Prof. Lew Haldorson reported that his findings from his GLOBEC studies in the PWS-GOA transition region were consistent with the 1998 assumption.

1999

5. The 1998 version of the model had performed reasonably well, but it had been unable to reproduce the dominant feature in the WHN 1994 survival, a strong mid-release minimum.

The construction of the model had been parsimonious in the sense of what processes were included. The foraging model had been left non-discriminating, that is, the attack probabilities for all prey encountered were the same. The appropriateness of an optimizing foraging model was left open and none had been implemented. It was known that the WHN 1994 survival pattern could not be generated by a linear process. An optimum mass flux submodel was added to the psf model in early 1999; almost immediately thereafter the model successfully reproduced the survival pattern of WHN 1994.

2000–2004

6. Success in 1999 created two new problems for 2000. First, despite repeated examinations of all the simulation outputs, no one could identify from inspection how the modeled physiological system, in conjunction with the several time-varying forcing conditions, had reproduced the WHN 1994 survival data. In addition, there was the pending high costs of independent production of a peer reviewed, publishable paper on the psf model. The obvious second problem was the fact that the paper could not be written without a second independent investment in the research required to solve the first problem.

This marked the beginning of efforts to integrate these activities into the economy. The mystery was solved regarding the mechanisms responsible for the WHN 1994 data, the paper was written and accepted (Willette et al., 2001), and private investment covered the costs. The dilemma of cost recovery was addressed by rolling the half-year effort into a further effort, the production of the book cited herein and made available for review. The WHN 1994 question was non-trivail; its solution is split across chapters 5 and 6 of the book.

Summary of development and findings in 2005 and fundamental factors

The foregoing makes clear that the in-sound resource in 2005 are very different from the resources in 1998. The year began with the view on the alignment between problem and new resources that was blurry and undifferentiated. The year ends with much sharper focus and significant progress with project resources as well as with project structure. It is hoped that this is conveyed by Table 1. The structure of the table is a result in itself; that structure mirrors the project structure which is behind the details described herein.

During 2005, the goal was undifferentiated—establish collaborative awareness of the resources available now relative to the seven components. The entries "05" and "05, 06" mark progress. The entries "06" identify tasks to commence October 2005. The relative projected progress is misleading; it reflects not just priority and level of effort but also past relationships and previously established progress. At the end of 2005, the perspective on priority is as follows: 1) "I.V. & Markings," "Data Assimilation," "Economics," "Model (in itself)"; 2) "Routes & Pathways," "Ocean Survival"; and 3) "Forcing & Boundary Conditions."

The position here is that projections will be meaningful and useful only when there is a solution to the problem of data assimilation during fry outmigration. From Figure A1-2, one could assume that the CWT signatures would be evident in the fry population *prior to* departure from PWS. Unfortunately, the very limited number of tags used kills that idea. However, thanks to CWT, we learned just how far we can go with knowledge of relative values for observables (e.g., escapement). The conversion to thermal marking (Hagen et al., 1995; Munk et al., 1993) gives us one step forward and one step back. 100% marking solves the problem of sample size with CWT. However, Figure A1-3 shows that the resolution now available with otolith marks is very limited and possibly further degraded by new release techniques. At PWSRAP workshops, both VFDA and PWSAC are consistently optimistic regarding more marks. There is another advance. The summer monitoring of outmigrating fry by ADF&G, now with 100% marked fish, is a new resource for data assimilation that we have begun to study in 2005 and will be examining in depth in 2006. This problem of data assimilation in PWS in 2005 is reminiscent of the problem of evolution equation models for PWS in 1993. We repeat here what we said in 1993: This problem is solvable.

III. SCHEDULE C. Consolidated view of FY05 accomplishments and FY06 project tasks

Common and PWS-Custom Components of a Model-based Application Development Program

Table 1

(see Sec VI p9-10)

	MODEL eqns numerics code, hrdwr	INITIAL VALUES & MARKINGS	FORCING & BNDRY CONDTNS	DATA ASSIMILTN	ROUTES & PATHWAYS	OCEAN SURVIVAL	ECONOMICS open source	 cost recovery
Stages & Tasks for Model-based Dev.	K. Adams	VFDA	PWSOOS	ADFG CDV	PWSOOS	ADFG CDV	EcoTrust	EcoTrust
(see Sec III-C p7)	R. Mullins	PWSAC	AOOS	UAF Juneau	AOOS	ADFG Soldtn	Mar Adv Prg	Mar Adv Prg
information / expertise	PWSFRAP	ADFG CDV	PWSSC	ADFG Soldtn	ADFG CDV		CRWP	CRWP
and	COLLABORATION	UAF Juneau	OSRI	U. Maine	ADFG Soldtn		EPC	EPC
owners / maintainers	V, Patrick	P. Hagen	VFDA	JPL	OSRI		Simon Fraser	Simon Fraser
[06] = begin - partial completion	T. Cooney		PWSAC		PWSSC		PWSFRAP	PWSFRAP
<06> = as needed, context dependent	S. Moffitt		U. Maine		U. Maine			
	M. Willette		JPL		JPL			
INPUTS & CONSTRUCTION	adv comm							
design								
init. contact -- agree to contin	**05**	**05**	**05**	**05**	**05**		**05**	**05**
exploratory & info exchange	**05**	06	**05 , 06**	**05**	06		**05**	06
testing -- issue resolution	06	<06>	<06>	<06>	<06>	**05**		
hardening	06	06	06	06	06	06	06	06
agreement	06	06	[06]	06	[06]		06	06
Request for Comments (RFC)	[06]			[06]			[06]	[06]
implement								
feasibility -- tech & finance	[06]	[06]	[06]	[06]	[06]		[06]	[06]
establish financing								
agreement to commence								
schedule hardening								
start								
manage								
eval -- technical								
eval -- fiancial								
continue / stop								
OUTPUTS	(during development, pre-implement.)							
this proposal	**05**	**05**	**05**	**05**	**05**	**05**	**05**	n/a
extranet & reports	**05 , 06**	06	06	06	**05 , 06**		**05 , 06**	n/a
collaboration server, intranet	**05 , 06**	**05 , 06**	**05 , 06**	**05 , 06**	**05 , 06**	**05 , 06**	**05 , 06**	n/a
technical library	**05 , 06**	**05 , 06**	**05 , 06**	**05 , 06**	06	**05**	**05 , 06**	06
data library	**05 , 06**	**05 , 06**	06	**05 , 06**	[06]		06	06
publishing	00-03	(hatched)	(hatched)	(hatched)	(hatched)	(hatched)	(hatched)	**05 , 06**
curriculum	**05 , 06**	[06]	[06]	[06]	[06]		**05 , 06**	**05 , 06**
COLLABORATION								
size & scope of active involvement	6	3	3	5	1	3	3	3
teleconferences	total: over 30	4 or more collab/confer		min 2 teleconf per implement component in 2005				
on-site workshops								
PWSFRAP Cordova, Oct 24-27, 2004	spkr V. Patrick		spkr T. Cooney		invited spkr Carl Schoch	spkr Mark Willette	guest speaker Astrid Scholz, EcoTrust	
AOOS - PWSOOS Conference Cordova, June 15-18	invited speaker, session lead T. Cooney	 R. Mullins						
Economic sector interviews (participants unaffiliated)	1 economist 2 organizer	conserv org native interests	3 snr. comm fisherman 4 snr. comm fisherman		5 hatchery founder, ex. dir 6 elected official, city gov		7 snr. mangr	processor
TECH LIBRARIES	Sci Plan *Oct 2004* psf book Int - full text Ext - samples *Dec 2004* psf curriculum modules *in progress*	thermal mark 5 doc/pubs *Dec 2004* AK Salmon Hatchery Annual Rprt AFK 1997-2004 CCH 1997-2004 SGH 1997-2004 WNH 1997-2004 *Jan 2005*	PWSOOS / AOOS Conf Jun 2005 transcripts *Sep 2005*		LIDAR 2 tech docs pws surv 01 pws surv 02 *Dec 2004* PWSOOS / AOOS Conf Jun 2005 transcripts *Sep 2005*	mark recapture 1 item natural mort 1 item		
DATA LIBRARIES	psf model simulations'99 graphic dsply animations online *Aug 2005*	CWT codes, srvvl RY1976-1987 RY1988-1996 complete *Aug 1997* Thermal Mrk codes,srvvl 1997 - 2004 complete *Jan 2005*	PWSSC/OSRI R. Thorne zooplankton acous. survey agreemnt w/ PI access TBD *Dec 2004* VFDA/PWSAC Wells / Reggiar zoopl. & T, S (hatch. watch) agreemnt w/ Di *Oct 2004*	ADFG summer fry surveys 1997 - 2003 complete *Mar 2005* GLOBEC summer fry surveys 1998 - 2001 ?? agreemnt w/ PI *Dec 2004* access TBD				

References

Egler, F. E. (1977). *The Nature of Vegetation: Its Management and Mismanagement.* Aton Forest Publishers, Norfolk, CT, in cooperation with Connecticut Conservation Association, Bridgewater, CT. 562p. The oft-cited source of Egler's (in)famous one-line characterization, "Ecosystems are not only more complex than we think, but more complex than we [can] think.

Egler, F. E. (1986). Commentary: "Physics envy" in ecology. *Bulletin of the Ecological Society of America*, 67(3):233–235.

Godin, J.-G. J. (1981a). Daily patters of feeding behavior, daily rations, and diets of juvenile pink salmon (*oncorhynchus gorbuscha*) in two marine bays of british columbia. *Can. J. Fish. Aquat. Sci.*, 38:10–15.

Godin, J.-G. J. (1981b). Effect of hunger on the daily pattern of feeding rates in juvenile pink salmon, *oncorhynchus gorbuscha* walbaum. *J. Fish Biol.*, 19:63–71.

Godin, J.-G. J. (1990). Diet selection under the risk of predation. In Hughes, R. N., editor, *Behavioural mechanisms of food selection*, volume G20 of *Nato ASI Series*, pages 739–769, New York. Springer Verlag.

Guilizzoni, P. (1996). Robert Henry Peters (August 2, 1946 – June 26, 1996). *Memorie dell'Istituto Italiano di Idrobiologia*, 55:1–4. Renamed *Journal of Limnology* in 1999. article URL: www.iii.to.cnr.it/pubblicaz/mem55/mem55_01.pdf.

A line from Guilizzoni's recollections followed by a quote (slant type) said to come from a Peter's letter:

...I also recall your doubts, your desire to transform ecology into a quantitative science like other scientific disciplines.

...

I think the "Critique" is part of a movement that is unsatisfied with hand-waving and impotency, with the feeling that we know very little. I hope it will encourage people to produce real, albeit simple predictions, because once one gets the taste for useful, informative science, the pallid imitations offered by classical ecology are not satisfying.

Hagen, P., Munk, K., Van Alen, B., and White, B. (1995). Thermal mark technology for in-season fisheries management: A case study. *Alaska Fishery Research Bulletin*, 2(2):143–155.

Mason, D. M. and Patrick, E. V. (1993). A model for the space-time dependence of feeding for pelagic fish populations. *Trans. Amer. Fish. Soc.*, 122:884–901.

Munk, K. M., Smoker, W. W., Beard, D. R., and Mattson, R. W. (1993). A hatchery water-heating system and its application to 100% thermal marking of incubating salmon. *The Progressive Fish-Culturist*, 55:284–288.

Nochetto, R. H. (1993). Finite element methods. Proposal, U. Maryland, College Park, MD. Proposal online at www.pwsfrap.org/pwsfrap/Publications/rhn1993_proposal.pdf.

Nochetto, R. H. and Rao, S. P. (1996). Finite element simulation of a taxis model for population interactions in 1D. In Cooney, R. T., editor, *Sound Ecosystem Assessment*

(SEA) - An Integrated Science Plan for the Restoration of Injured Species in Prince William Sound, appears as Appendix 7 of Ch 7 of the 1995 Annual Report for the *SEA* Program, Ch 7 is the report for the Information Systems and Model Development Project. *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska. Article online at www.pwsfrap.org/pwsfrap/Publications/rhn1996_FiniteElSimTxsMdl.pdf.

Nochetto, R. H. and Rao, S. P. (1997). Progress report 1 (1996). In Cooney, R. T., editor, *Sound Ecosystem Assessment (SEA) - An Integrated Science Plan for the Restoration of Injured Species in Prince William Sound*, appears as Appendix 4 of Ch 7 of the 1996 Annual Report for the *SEA* Program, Ch 7 is the report for the Information Systems and Model Development Project. *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska. Report online www.pwsfrap.org/pwsfrap/Publications/sri+rhn1996_ProgressReport1.pdf.

Patrick, E. V. (1997). Lower bounds for survival of juvenile pink salmon during migration as fry through Prince William Sound, AK. Technical note, ISMD Project, SEA Program, PWSFRAP, Cordova, AK 99574. Online at www.pwsfrap.org/pwsfrap/Publications/LowBnds_crashbloom.pdf.

Patrick, E. V., Mason, D. M., Willette, T. M., Cooney, R. T., Nochetto, R. H., Allen, J. R., Rao, S. P., and Kulkarni, R. (2006). *An Evolution Equation Representation of the Marine Ecosystem Associated with Juvenile Pink Salmon*, volume 1 and 2. CFIMS Press, P.O. Box 122, Savage, Maryland 20763, 1st edition. Sample chapters from pre-publication version online at www.cfims.org.

Peters, R. H. (1991). *A Critique for Ecology*. Cambridge University Press, Cambridge, paperback edition. 384p.

Willette, T. M., Cooney, R. T., Patrick, V., Mason, D. M., Thomas, G. L., and Scheel, D. L. (2000). Ecological processes influencing mortality of juvenile pink salmon (*Oncorhynchus gorbuscha*) in Prince William Sound, Alaska (extended abstract). In Beamish, R., Ishida, Y., Karpenko, V., Livingston, P., and Myers, K., editors, *Workshop on Factors Affecting Production of Juvenile Salmon: Comparative Studies on Juvenile Salmon Ecology between East and West North Pacific Ocean*, Technical Report 2, page 14, Tokyo, Japan. North Pacific Anadromous Fish Commission, Vancouver, BC, Canada V6C 3B2. Presentation graphics online at www.pwsfrap.org/pwsfrap/Presentations/.

Willette, T. M., Cooney, R. T., Patrick, V., Mason, D. M., Thomas, G. L., and Scheel, D. L. (2001). Ecological processes influencing mortality of juvenile pink salmon (*Oncorhynchus gorbuscha*) in Prince William Sound, Alaska. *Fisheries Oceanography*, 10(Suppl. 1):14–41.

2006 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2006 - September 30, 2007

Budget Category:	Authorized FY 2005	Proposed FY 2006						
Personnel	$37.7	$37.8						
Travel	$9.9	$6.2						
Contractual	$31.9	$37.3						
Commodities	$0.3	$0.3						
Equipment	$0.0	$11.6	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$79.8	$93.2				Estimated FY 2007		
Indirect	$6.2	$6.2						
Project Total	$86.0	$99.4				$150.0		
Trustee Agency GA (9% of Project Total)	$7.7	$9.0						
Total Cost	$93.7	$108.4						
Full-time Equivalents (FTE)		1.0						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$18.0	$13.0						

Comments:

ADF@G in their FY05 companion proposal was funded by the EVOSTC for the PIT tag field research($18k). For FY06 ADF&G has agreed to provide a $13k in kind contribution for data and statistical analysis consisting of 1 man month for Steve Moffitt and 1 man month for a department biometrician.

Indirect rate: 5.8% (Includes office lease @ $4.3 {$360 x 12mo}; utilities @ $1.2 {$100 x 12mo}; liability insurance @$.07)

Trustee Agency GA (9% of Project Total) $9.0 (this amount is entered manually above as no row was available in the TC provided format.)

Co-PI's Adams and Mullins devote essentially full time to the project with the exception of approximately 4 months in summer when fisheries are conducted.
Mullins is retired and maintains project activity during summer months as required.

FY06

Prepared: 09/14/2005

Project Number: 060784-BAA
Project Title:Ongoing Synthesis and Modeling Activities Restoring Injured
Commercial Fishery Services
Name: Ken Adams and Ross Mullins

2006 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2006 - September 30, 2007

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2006
Ken Adams	Co-PI		2.5	4.8		12.0
Ross Mullins	Co-PI		2.5	4.8		12.0
Liz Senear	Tech/Admin		2.0	3.0		6.0
Ted Cooney (Retired)	Consult		0.4	6.4		2.6
Dick Thorne (OSRI/PWSSC)	Consult		0.4	6.4		2.6
Lew Haldorson (GLOBEC)	Consult		0.4	6.4		2.6
*EV Patrick UMD(PS model development)	See contractual		3.9			0.0
*Mark Willette (ADF&G Fisheries Researc	agency consult at no cost					0.0
*Steve Moffitt (ADF&G Fisheries Researcl	agency consult at no cost					0.0
						0.0
						0.0
						0.0
	Subtotal		12.1	31.8	0.0	
					Personnel Total	$37.8

Travel Costs:			Ticket	Round	Total	Daily	Proposed
Description			Price	Trips	Days	Per Diem	FY 2006
Ken Adams			0.28	1	4	0.10	0.68
Ross Mullins			0.28	1	4	0.10	0.68
FY06 Workshop: 4 participants travel:	Patrick	1@$1200	1.20	1	3	0.15	1.65
	Cooney	1@$1100	1.10	1	3	0.15	1.55
	Haldorsoı	1@$350	0.35	1	3	0.15	0.80
	Willette	1@$400	0.40	1	3	0.15	0.85
							0.00
							0.00
							0.00
							0.00
							0.00
							0.00
						Travel Total	$6.2

FY06

Prepared: 09/14/2005

Project Number: 060784-BAA
Project Title: Ongoing Synthesis and Modeling Activities Restoring Injured
Commercial Fishery Services
Name: Ken Adams and Ross Mullins

Contractual Costs:			Proposed
Description			FY 2006
Phone	$60.00	month x 12	0.72
Internet	$176.00	month x12	2.11
Photocopies	annual		0.20
Conference calls	annual		1.89
Cater for conference	annual		0.35
Subcontract E.Vincent Patrick.			32.00
Contractor will continue to maintain and develop the website for use by collaborators for continued development of the PS fry model and implementation plan. Contractor Patrick was the lead PI in the SEA pink salmon fry survival model development and agrees to continue working with project coordinators in all aspects of model development and implementation. Dr. Patrick agrees to relocate to Cordova and to continue work on the planning efforts and to move model code from the mainframe at the Univ of Maryland to a server that will be installed in the PWSFRAP office at Cordova. Startup and trouble-shooting of system will be conducted to prepare for model implementation. Dr Patrick's compensation results in a rate of 3.9 man months totaling $32k.			
		Contractual Total	$37.27

Commodities Costs:	Proposed
Description	FY 2006
Computer and office supplies	0.30
Commodities Total	$0.3

FY06

Project Number: 060784-BAA
Project Title: Ongoing Synthesis and Modeling Activities Restoring Injured
Commercial Fishery Services

2006 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2006 - September 30, 2007

Prepared: 09/14/2005

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2006
Computer server/ workstation for Cordova office to house model code	1	8.6	8.59
IDL language license for model code			3.00
			0.00
			0.00
			0.00
			0.00
			0.00
			0.00
			0.00
			0.00
Those purchases associated with replacement equipment should be indicated by placement of an R.			0.00
		New Equipment Total	$11.6

Existing Equipment Usage: Description	Number of Units	
Computer equipment purchased in FY02 and FY03 will continue to be utilized	1	

FY06

Prepared: 09/14/2005

Project Number: 060784-BAA
Project Title: Ongoing Synthesis and Modeling Activities Restoring Injured
Commercial Fishery Services
Name: Ken Adams and Ross Mullins
PWS Fisheries Research Applications and Planning group

BUDGET JUSTIFICATION

FY-06- **Ongoing Synthesis and Modeling Activities Restoring Injured Commercial Fishery Services** -Project Development Continuation**.** Project Number 060784-BAA

Total funding requested: $108,400.00

Personnel:
Co-PI's Adams and Mullins are each budgeted @ $30/hr for 2.5 man months for a total of 5.0 man months and a gross amount of $24.0 k annually. Senear the tech/admin office person is budgeted @ $20.hr for 2.0 man months for a total of $6.0 k annually. All personnel work essentially year round on the project with the exception of part time in the months of June, July, August and September when Adams is engaged in commercial fishing activity. Mullins is retired and devotes time to project activity also during summer months. FY06 will be a continuation from FY05 and will ensure maintaining the organization of an effective interdisciplinary project design team for the implementation of a multi-year observational and fry survival model prototype. This task requires a blending of disciplines and communication skills that rely on previous personal interrelationships and assets brought forth in a series of workshops held in Cordova from late FY02-FY05. The installation of a computer server/workstation platform at the Cordova office will be utilized to house the model with backup facility at the University of Md. The IDL language license will be acquired which is necessary for operating the model. Total for Adams, Mullins and Senear is $30.0k. There is no set hourly rate.

Richard Thorne is budgeted for compensation of $2.6k. Dr. Thorne is chief scientist with the Prince William Sound Science Center and will be devoting time helping to continue the design of the implementation plan anticipated for the FY07 season. Dr. Thorne is currently working on hydro-acoustic measurement of fish populations and conducts seasonal zooplankton assessments in selected areas of PWS. Total for Dr. Thorne $2.6k. There is no set hourly rate.

Ted Cooney is budgeted for compensation of $2.6k. Dr. Cooney is a retired researcher from the University of Alaska School of Fisheries. Dr. Cooney has extensive experience in PWS with observational studies and project design dating back to the early 1970's and will continue to contribute invaluable insights and time to the overall planning development process. Total for Dr. Cooney is $2.6k.
There is no set hourly rate.

E.V. Patrick will be compensated through a contract that will be signed between the PWS Fisheries Research Application and Planning group (PWSFRAP) and Dr. Patrick upon approval of this continued planning grant proposal. Dr. Patrick was the principal PI in the EVOSTC funded SEA project (1993-1999) in PWS that developed the Pink Salmon Survival Model (PSSM) and the Herring Advection Model. Dr. Patrick is presently at the University of Maryland. He has agreed to relocate to Cordova for the FY06 work with the Psmodel and will continue to provide his expertise consulting on the issues relating to model implementation anticipated for the future. Dr. Patrick will also continue to provide and maintain a virtual web presence for project planners to utilize for the posting of writing and editing assignments required during the continuing project development process. This web presence is an invaluable adjunct to the planning group for maintaining active communication and plan development. Dr. Patrick will be in charge of moving the model code from the mainframe computer at the Univ. of Md where it is currently housed, to a server to be installed in the PWSFRAP Cordova office. Dr. Patrick will be responsible for acquiring current licensing for the IDL software and will be conducting startup and trouble-shooting of the system in preparation for model implementation. Working closely in cooperation with Dr. Patrick is fundamental to the successful plan development and to the anticipated implementation of the PSSM in the future. (See contract amount of $32.0k under contractual section of this proposal budget.)

Mark Willette and Steve Moffitt are ADF&G researchers that will be devoting time to the planning process and will be the primary PI's for the fieldwork involving the PIT tag feasibility portion of the project. (The budget request for the FY05 PIT tag feasibility study was previously submitted and approved under trustee agency submission and will be conducted during this 05 summer season

The personnel costs of $37.8 will be expended on time relating to preparation for and conducting a planning workshop in Cordova, participation in relevant ocean observing programs, presentations and model visualization development and for compensation of time expended by planners. The planning team will meet frequently by teleconference for discussion and problem resolution. The PWSFRAP website <www.pwsfrap.org> will continue development and maintainance by Dr. Patrick. and this will provide a valuable interactive resource for the posting, editing and communication between the planners. Additionally, this website provides synthesis of resources from the SEA plan funded under the 1994 restoration plan. The site will continue to evolve as a comprehensive source of background of the SEA evolution as perceived by the PWSFRAP organizers. Under pass word access the web site provides an enhanced opportunity for the projects planners to interact with each other at times that are convenient and available for each planning team members' circumstance.
Total personnel budget request is $37.68.

Travel:
Each Co-PI is budgeted for $0.68 k for attending the EVOS/GEM annual symposium. This includes round trip travel, lodging and meals. Total for this is $1.36 k.
The remaining travel budget of $4.8 k is for bringing planners together at a three day workshop to be held in Cordova during FY06. This travel budget includes the cost of lodging and meals while attending the workshop.
Total travel requested is $6.2 k.

Contractual Costs:
Contractual costs consists of telephone @ $60 per month totaling $.72k
Internet (high speed)@ $176.00 per month totaling $2.11k
Photocopying is budgeted annually at $0.2k
Conference calls for meetings is budgeted annually @ $1.89k. Our experience shows that costs are on average .10 cents per minute per person and we anticipate several conference calls per month at approximately $130 each.
Catering for three day planning workshop is budgeted @ $.0.35k
Subcontract with Dr. E.V. Patrick includes his relocation to Cordova where he will work on model development and planning through the PWSFRAP office.. Dr. Patrick's background with the Univ. of Md will ensure that computer assets available through that institution will continue to be available to the project.. Subcontract cost is $32.0k.
Total contractual requested is $37.27k.

Commodities Cost:
The cost of office supplies, computer/printer/ disks/consumables is budgeted at $.3k annually.
Total commodities requested is $.3k.

New Equipment Purchases: PWSFRAP will purchase two computers in FY06. Computer #1 @ $2.91will be for a computer workstation for the use of Dr. Patrick at the Cordova office to assist with updating model code continued web site support. www.pwsfrap.org.

Computer # 2 @ $5.68 is a server for the PWSFRAP office into which the PS model code and IDL language license will reside. This server will provide in house computing capability and will be mandatory for model implementation anticipated in the future.
Computer pricing was obtained from various supplier sources through the internet.
Total new equipment requested is $11.6k

Indirect Rate: 5.8%
Indirect rate cost includes office lease @360 mo x 12 totaling $4.3k, Utilities @$100/mo x12 totals $1.2k. Liability and workman's compensation insurance for the project is $0.7k annually. The indirect costs are for maintenance of a small office where project business is conducted and office equipment is housed. This office serves as an important interface with the community and creates a local presence for the EVOSTC programs. The total for all indirect costs is $6.22k.

Trustee Agency GA (9% of project total) is $9.0k.

The total requested for all of the proposed budget items is: $108.4k.

ADF&G in kind contribution: ADF@G in their FY05 companion proposal was funded for the PIT tag field research($18k). For this FY06 submission ADF&G agrees to provide PWSFRAP a $13k in kind contribution for data and statistical analysis consisting of 1 man month for Steve Moffitt and 1 man month for a department biometrician.
Total other contributions: $13.0k

RESUMES

Co-Principal Investigators

Ken Adams
Commercial fishing
P.O. Box 1855
Cordova, AK 99574
(907) 424-5456
kadams@gci.net
www.pwsfrap..org.

Ross Mullins
Commercial fishing
P.O. Box 436
Cordova, AK 99574
(907) 424-3664
rmullins@gci.net
www.pwsfrap.org

Brief Summaries of Professional Histories

In late February of FY02 and continuing in FY03, Adams and Mullins were provided funding for a "pilot project" by the EVOSTC entitled "Fisheries Management Applications" (02636 and 03636). Adams and Mullins have acted as co-coordinators for this **Community Involvement Project.** The name adopted by the Co-PI's for their project is Prince William Sound Fisheries Research Applications and Planning group (PWSFRAP).

In FY03 PWSFRAP incorporated into the project a volunteer Science Advisory Panel that was comprised of Mr. Mark Willette, former SEA PI and ADF&G research biologist; Mr. Tim Joyce, a former ADF&G management biologist, hatchery operator, US Forest Service subsistence biologist and currently serving as mayor of Cordova; Dr. Richard Thorne, a scientist at the PWS Science Center working on zooplankton and acoustic bio-mass fishery issues. Dr. Tom Kline, a scientist with PWSSC working in the area of marine isotope linkages in the ecosystem, and Dr. Ted Cooney (retired) chief scientist of the SEA program with a long history of PWS science involvement and Dr. Vince Patrick, former SEA P.I. modeler and dedicated supporter of community involvement process.

PWSFRAP was funded in FY'04 for continuation of the needs identification and resolution project begun in FY '02 and '03. After extensive collaboration with advisors and financial support from the EVOS Trustee Council and the Oil Spill Recovery Institute, Adams and Mullins hosted a successful three day workshop in Cordova from March 16-18, '04 aimed at improving pink salmon forecasting accuracy in PWS. In FY '05, PWSFRAP collaborators working jointly with personnel from the Alaska Department of Fish and Game, began the planning process for implementation of the Pink Salmon Survival Model (PSSM) developed within the SEA program. The PSSM implementation holds considerable promise for assisting with resource forecasting, harvest and enhancement.

Ken Adams

Ken Adams has been a commercial fisherman for 25 years. During that time he has held permits and owned vessels in a number of the fisheries of PWS.
Adams obtained an MA degree in biology from San Francisco State College (1970) and a BA in Science from Trenton State College in Trenton, New Jersey (1967). In addition Adams has completed approximately 30 credit hours toward a PHD degree in biology at the University of California, Santa Barbara. He has taught science classes in high school (1974-1980) and at the PWS Community College in the mid ‘80's.

Adams has held seats on the Board of Directors of PWS Aquaculture Corp., Cordova District Fishermen United, and PWS Science Center. He is currently serving as a Board member of the American Seafood's community advisory board. During 1993 Adams was a participant in the four-month planning process that created the Sound Ecosystem science plan and served on the BOD of the PWSSC for nine years. Adams has actively followed the progress of the overall restoration plan with the goal of identifying results that can now contribute to securing and sustaining the recovery of commercial fishing.

Ross Mullins

Ross Mullins has resided in Cordova since 1963 where he has pursued an active career in the varied commercial fisheries of the PWS-Copper River area. He has been both the owner operator of various vessels and, during the time that the herring fisheries were viable, he was President of MSP Corporation, a processor of herring products for export to Japan.

Mr. Mullins has been active in the various fishery related organizations of the region. He has served on the BOD and Executive Committee of PWSAC for many years since that organizations inception. Mullins has been a member of the BOD of CDFU and the former Cordova Aquatic Marketing Association for many years. In the late 60's and early 70's Mullins created the "Marine Pollution Committee" of the Cordova District Fisherman's Union with the intent to alert the community to the dangers posed by the transportation of oil by super tanker through PWS. This group funded an effort to prevent the siteing of the oil terminus at Valdez and promoted transport of oil to the lower 48 via pipeline through Canada. Mullins is a member of the Copper River Salmon Producers Assn. Mullins served on the BOD of the Alaska Commercial Fishing and Agriculture Bank for 13 years. Mr. Mullins is the founder and chairman of the PWS Fishermen Plaintiff's Committee, an organization that serves to provide that serves to provide an interface for information to the local community relating to the Exxon Valdez oil spill litigation. Mullins was a participant in the planning process that created the Sound Ecosystem science plan. That plan was the foundation document for the SEA program. During the period since the close of the SEA program Mullins has remained involved in attempting to understand the results of the technical assets and resources acquired through the SEA program.

Mr. Mullins attended the University of New Hampshire, the University of Michigan, and obtained a BFA degree in photography from the San Francisco Art Institute.

Chief Project Collaborators

Robert “Ted” Cooney

Robert “Ted” Cooney is a Professor of Marine Science Emeritus at the University of Alaska Fairbanks where he served in the Institute of Marine Science for nearly 30 years. His major publications are in the areas of marine zooplankton, marine ecology and fisheries oceanography, most notably descriptions of the juvenile salmon ecosystem. His teaching experience centers around graduate level courses and seminars in biological oceanography. From 1994 to1998, Dr. Cooney served as Lead Scientist for the EVOS Trustee Council funded Sound Ecosystem Assessment (SEA) program. Most recently, Ted has been working with Alaska Department of Fish and Game, the Prince William Sound Science Center, the regional aquaculture corporations in Prince William Sound, and other university scientists on the problem of extending the scientific breakthroughs of SEA to practical fisheries applications. As an advisor to the Prince William Sound Fishery Research Applications Program (PWSFRAP), he has assisted with workshops on resource forecasting and pink salmon modeling. He presently serves on the science and technical committee of the Oil Spill Recovery Institute in Cordova.

Steve Moffitt

Steve Moffitt is the Area Research Project Leader for Commercial Fisheries Finfish Research with the Alaska Department of Fish and Game in Cordova. Steve has a B.S. in Wildlife Management from the University of Alaska Fairbanks (1989). His previous careers include work as a Land Surveyor and six years managing the family dairy farm in Palmer, Alaska. He started work with the Department of Fish and Game in Cordova as a college intern in 1988. Steve has been working full time in the Cordova office since 1989. His current research duties include preseason and inseason forecasting and biological escapement goal analysis

E. Vincent Patrick

Vince Patrick is currently a Research Associate at the Institute for Systems Research at the University of Maryland, College Park, MD. He first traveled to Cordova in November 1992. In September 1993, he returned to serve as a member of PWSFERPG and later as principal investigator for the Information Systems and Model Development Project for the SEA Program. Since 1999, Vince has been an independent investigator, organizer and occasional writer. In March 2000, he left Cordova and returned to Maryland. A continuing interest is the incompatibility of the commons and the corporation. To that end, he has studied contemporary banking and monetary systems: he had a math note acknowledged and posted by a popular online lecturer. He established CFIMS Press to resolve his own issues with traditional academic publishing versus contemporary economic realities. Vince has remained actively involved with long-time collaborators among the Cordova fishermen and with the senior project managers at the PWS Regional Citizens’ Advisory Council. Vince received a B.A. in Physics from Thiel College in Pennsylvania in 1967, and a M.A. and a Ph.D. from the University of Maryland in

1982 and 1987 respectively. Previous positions include Senior Engineer at AIMS, Inc. in Rockville, Maryland, and Physicist at the Center for Night Vision. In the fall of 05 Dr. Patrick will move from Maryland to Cordova, Alaska to oversee the transition of the Ps model code from the Univ. Md. to a server at the Cordova office of PWSFRAP and to work on the model code in preparation for future model implementation.

Richard Thorne

Dick Thorne received a M.S. in Biological Oceanography (zooplankton ecology) from the University of Washington in 1968 (at the same time Ted Cooney was working on his doctoral research) and a Ph.D. in Fisheries from the University of Washington in 1970. He remained at UW on the research faculty of the School of Fisheries, specializing in fisheries acoustics, eventually reaching the rank of Research Professor. In 1989, he left for BioSonics, Inc., in Seattle, where he became Vice President and Director of Technical Services. He worked primarily on Columbia River downstream salmon migration issues at hydroelectric dams. In January 2000 Dick came to Cordova at the urging of PWSSC President, Gary Thomas, a long-time friend and colleague. He has three main projects at the Science Center: Zooplankton Monitoring, Herring and Pollock Monitoring, and Stellar sea lions.

Mark Willette

Mark Willette is currently the Research Project Leader for the ADF&G Commercial Fisheries Division in Upper Cook Inlet with research interests in preseason and inseason forecasting of salmon returns, and studies examining productivity of salmon stocks. He is currently working on research projects examining effects of oceanographic conditions of run timing and catchability of adult sockeye salmon and ecology and energetics of juvenile sockeye salmon. He was previously the principal investigator for EVOS Damage Assessment and SEA studies on juvenile pink salmon in Prince William Sound.

Project Consultants

Milo Adkison

Milo Adkison is an Associate Professor at the Juneau Center, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks. He earned a doctorate in fisheries from the University of Washington in 1994. He has also worked for the Biological Resources Division of USGS and as crew on a Bristol Bay gillnetter. He specializes in the quantitative aspects of management of Pacific salmon fisheries. Some of his current projects include: forecasting SE AK pink and chum salmon returns, estimating abundance and escapement for Yukon and Kuskokwim chum, identifying the determinants of early marine survival in SE AK Coho, improving the Chinook Technical Committee model, setting escapement goals when climate is changing productivity;, and adjusting sockeye escapement goals to account for nutrients in carcasses.

Lewis Haldorson

Lew Haldorson received his Ph.D. (1978) and M.A.(1973) from University of California Santa Barbara and B.S.(1963) from University of Minnesota. His primary interests are teaching and research in biology of marine fishes. Research interests include ecological relationships and population dynamics of nearshore fish populations with an emphasis on Arctic and SubArctic rocky reef communities. Other research is focused on the early life histories of marine fishes, with emphasis on larval ecological relationships. Apparently, most of the variation in year class strength of marine fish species results from differential mortality during egg and larval stages. Studies are being conducted to determine the effects of prey availability on growth and survival of selected marine larval fishes. Lew has been a principal investigator of GLOBEC's multi year study of the Gulf of Alaska's coastal shelf in the vicinity of PWS. Their focus has been on climate change and response of key species such as pink salmon.

Alex Wertheimer

Alex Wertheimer is a Research Fisheries Biologist with NOAA Fisheries, National Marine Fisheries Service Auke Bay Laboratory. He has been involved with research on Alaska salmon for over 30 years, during which time he has focused on enhancement technologies and strategies; marine ecology of Pacific salmon during their early ocean residency; straying rates of salmon; status reviews of Alaska salmon; the effects of hydrocarbon contamination on early-life stages of salmon; and ecological and genetic interactions of wild and hatchery salmon.