ESTUARY AND PLUME PROPOSALS

ProjectID: 199801400

Survival and Growth of Juvenile Salmonids in the Columbia River Plume
Sponsor: NMFS
Province: Columbia Estuary
Subbasin: Columbia Estuary
FY03 Request: $2,092,855
5YR Estimate: $10,359,054
Short Description: Evaluate the role of the Columbia River plume in survival of juvenile salmon through long-term observations, fine-scale process studies, retrospective assessments, and modeling to assess management of flow to improve habitat opportunity.
Response Needed? Yes

Requests for clarification by Objective and Task:

General comment: **Objective 1. (page 14) What is the value of the additional February cruise? Any inference concerning Columbia River salmon would again involve inferences about the residence of Columbia River salmon through the preceding months. We are uncertain that this assumption merits the investment in an additional cruise unless more justification or other objectives can be provided.**

Response: Conditions at the time of entry, during the first summer growing season, and during the first winter period (Beamish et al. 2001) are thought to influence juvenile survival. Recent modeling efforts to characterize the relationship between climate and oceanographic conditions with smolt-to-adult return rates identified winter conditions (as measured by sea surface temperatures) prior to ocean entry and the first year after ocean entry as significant model parameters (Logerwell et al. 2002). Because the Columbia River plume affects the coastal environment throughout the year, evaluating conditions juvenile salmon encounter during the winter would provide additional information during a period that evidence suggest affects survival.

The panel rightly considers whether information of Columbia River basin juvenile salmon residing in the coastal region during this period is available. To our knowledge this information does not exist. However, juvenile salmon from the Columbia basin are confirmed to be present May, June, and late September/early October (information on genetic stock composition made to the panel during the review) in the coastal region influenced by the plume. Moreover, coded-wire-tag recoveries of subadult and adult salmon suggest Columbia River basin salmon also reside in coastal marine waters of Oregon and Washington. All available evidence suggests Columbia River basin juvenile salmon will also be present in the sampling region in February. Confirmation of the presence of juvenile salmon during the winter period can only be confirmed by direct measurement. We suggest that an exploratory survey be funded for one February cruise during the 3-year funding period to develop information that the panel can use to assess if further funding during this period is warranted.

We note here that we made an error in estimating costs for ship time for the four surveys proposed per year. We calculated a ship time cost for 3 cruises (10 days each/cruise) and not 4 cruises in our submitted budget estimate. Currently in our budget estimates, the February cruise is not budgeted. See cost estimate below for the additional cruise if recommended.

General comment: **Task 1.b. (page 15) As in our last review of this program, we certainly support the predation aspect of this study and are uncertain about how predator population sizes will be estimated. No results of past predation sampling was included in this proposal, what progress has been made and have population sizes been estimated? How transient are these predators and variable is their population size?**

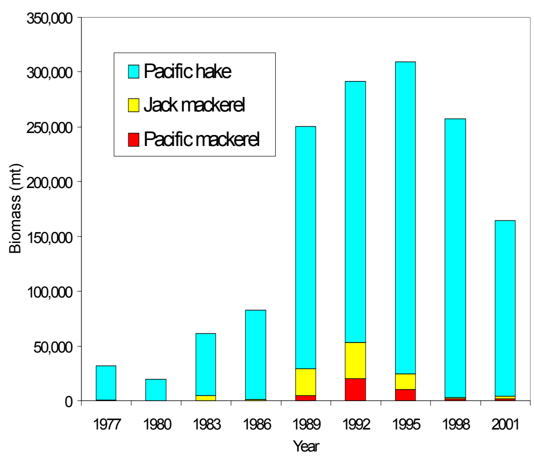
Response: Progress in the predator portion of the study are reported in 'Emmett, R. L., P. J. Bentley, and G. K. Krutzikowsky. 2001. Ecology of Marine Predatory and Prey Fishes off the Columbia River, 1998 and 1999. NOAA Tech. Memo., NMFS-NWFSC-51, 108 p.

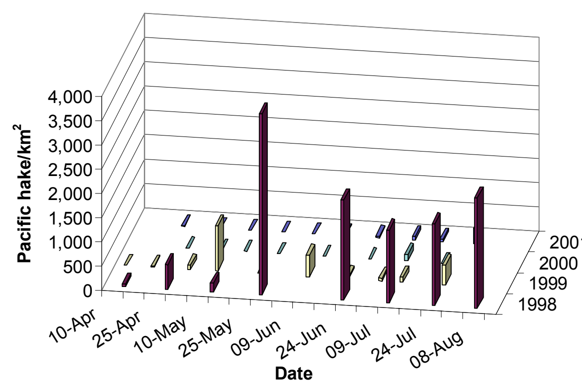
Information from the predator portion of the study was included in the proposal. Findings were captured in the last bullet on page 12 of the proposal under "Findings to Date: Fisheries" and in Figure 7a & b. Generally, an increase in the abundance of forage fish species and a decline in the abundance of piscine predators were observed in the coastal area surrounding the mouth of the Columbia River, i.e. in the plume region during the study period to date.

With respect to estimating predator population size, we are evaluating the use of the method proposed by Beamish (Beamish, R. J., D. McCaughran, J. R. King, R. M. Sweeting, and G. A. McFarlane. 2000. Estimating the abundance of juvenile coho salmon in the Strait of Georgia by means of surface trawls. N. Amer. J. Fish. Manag. 20:369-375) to estimate "effective" piscine predator population size around the Columbia River during the smolt migration. Undoubtedly only a portion of the hake population inferred from the large scale NMFS triennial surveys is probably interacting with the salmonid population and our data are only appropriate for the Columbia River region. Population (biomass) estimates of hake by region and total are available from the NMFS triennial surveys since 1977. We will compare our biomass estimates for off the Columbia River with NMFS triennial biomass estimates for the Columbia Region for 1998 and 2001, years where our data sets overlap to confirm the estimates.

We have already standardized all our catch data by area swept (km squared). Conversion to standardize these data to volume swept will be needed to make population estimates. We have estimates of the mouth area of the net from gear acoustic measurement equipment. These data indicate the mouth area to be 360 m squared while the net is fishing. Multiplying this area by length of tow - using GPS measurements (beginning and end of tow), provides us with the total volume swept by each tow. From these data and the estimated total volume of water in our survey area (we will use only the top 20 m) we can make minimum estimates for the abundance of piscine predator and forage fish species off the Columbia River. These estimates will be a minimum because they are assuming a net efficiency of 1 (all fish are captured by the net). Means and variances will be calculated by year and survey.

How transient and variable is the predator population? See figures below of the hake abundance by year and date. As this figure shows, the annual fluctuations (derived from the trienniel survey) appear to be greater than within year variations (this predator study). Since 1999 we have seen a dramatic decline in hake abundance. Using the volume swept method (Beamish et al. 2000) we will make estimates of the abundance of hake (or other species) by year and by each survey (each 2 night survey has the 12 trawls).





<u>General comment:</u> **Task 1.c. (page 16) The objective of this added task is justified but the methods not adequately described. There is no description of salmon sampling efforts and reference to only "occasionally" sampling zooplankton. How will this information be incorporated into other sampling designs if there is not a specific sampling effort in support of this objective?**

This task integrates strip-transect surveys of seabirds directly with the mesoscale fishery/oceanographic surveys off the Oregon/Washington coast and in the Columbia River plume identified in Task 1a. When the project is conducting the mesoscale surveys, a portion of the mesoscale survey will be dedicated to seabird observations in support of assessing the physical and biological conditions of the nearshore ocean environment that encompasses the plume. Therefore, the salmon and zooplankton sampling referred to in Task 1c follows the temporal and spatial sampling protocol specified for salmon and zooplankton in Task 1a, with the addition of some specifically requested stations in the vicinity of dense aggregations of foraging seabirds. In this regard, the seabirds can help focus sampling at oceanographic features that are important to juvenile salmonids and their prey.

As mentioned above, the seabird surveys are part of the mesoscale fishery/oceanographic surveys proposed in Task 1a. Success of the top-trophic component of the research therefore hinges directly on the support of fishery/oceanographic mesoscale surveys of the Columbia River plume and surrounding coastal system.

General comment: **Task 1.d. (page 16) How consistently can the "ocean entry mark" be determined on otoliths (by species) and have studies been conducted to verify that the "mark" does relate to ocean entry. Other proposals reviewed referred to chemical analyses used to determine when the fish enter the marine environment.**

Response: We have estimated ocean growth of juveniles by using the ocean entry mark on scales and back-calculating growth in length and weight. Growth rates (determined using the ocean entry mark) have been compared to ocean growth of coded-wire-tagged juveniles (known likely entry date and size). The relative differences in growth between years and areas are comparable using both methods. This suggests that the ocean entry mark provide a reasonable estimate from which ocean–related growth can be measured. We are further along with this effort with coho salmon than with chinook salmon.

We are aware of the proposed work to utilize otolith Sr/Ca ratios in otolith transects to determine migration along the salinity gradient associated with transitions from fresh to marine waters. It is an effort we are supporting to provide a means to directly quantify the point of ocean entry (it is part of the project to assess estuarine habitat utilization by juvenile salmon, funded by the U.S. Army Corps of Engineers, and is proposed in the BPA proposal 3001 under review). Recent results from the Salmon River, Oregon showed that chinook salmon exhibited a dramatic increase in otolith Sr/Ca ratios after entering the estuarine/marine environment. These results show that measurable physical criteria in otoliths can be used to track migration of juvenile salmonids between freshwater and marine habitats. Given the need (identified below) to help identify point of ocean entry to time of capture and to provide some measure of residence period, we will begin to utilize the methodology on subsets of otolith samples already archived and on samples obtained during this proposal period. Because the application of the methodology is limited in how many samples can be processed, (efforts to increase sample numbers are needed) we will pursue this effort independently on a subset of archived and collected samples.

General comment: **Task 1.d. (page 17) Given the extensive comments presented by the ISRP in their last review, this review committee was surprised that a more thorough description of these methods were not included in this proposal! Many of the past comments continue to seem valid and require real clarification and not debate. We have read the past comments and considered what any misunderstanding may be … but we should not have to "interpret" this aspect of the proposal. Estimation of growth and survival is probably the critical task in this large proposal. If it cannot be done, then it would clearly limits the value of this investment. The issue seems to be that you can measure growth rate and size of individuals sampled but how can growth and survival between sampling periods be**

<u>inferred if you do not know the residence time of the individual (or its population) in the plume?</u> If the intention is to compare size of fish between sampling periods, how can this issue be addressed and how can survival be differentiated from dispersal?

<u>Response:</u> We recognize that any study of growth and survival of juvenile salmonids in the ocean has to take account of dispersal, migrations, and population mixing and agree with the panel's concern. Juvenile salmonids are highly mobile, and their movements may vary in response to changes in the physical ocean environment (temperature, currents, etc.), in response to feeding conditions, and in response to genetically controlled migrational behaviors.

We believe part of the problem originated in mis-stating in the proposal the means by which we will assess the role of the plume on growth (and as a corollary, impact on survival). The proposal infers that the principle comparison for growth will be between the sampling periods of May and June compared to September. The panel questions the value of this comparison. We concur for the reasons raised.

The principle comparison of juvenile salmon growth will be **within** a sampling period, **not between** sampling periods, in the following manner. Juveniles will be categorized as being influenced by the plume in two ways. We are comparing growth and condition of juveniles captured at stations that exhibit surface salinity (at 1 meter depth) of less than 31 ‰ compared to growth of juveniles at stations that exhibit salinity greater than 31 ‰ for each month sampled. The other approach will be to define geographic boundary conditions for juvenile more likely to be influenced by the plume for any sampling period. We have used the definition of the marine coastal environment north of Cape Meares, OR and south of Grays Harbor as the zone most influenced by the Columbia River plume (this approach was presented to the panel in the ISRP review). Juveniles, during a sampling period (May, June, or September) will be aggregated as being in the Columbia River plume zone or outside of the zone, north or south of the plume. Comparison of various measures of growth and health will be used in one-way and multi-factorial ANOVA assessments. Period of capture (May, June, September) and hatchery/wild (with or without an adipose clip) origination will be cofactors in the evaluations. Residence time in the ocean will be inferred for the population groups (as defined above) using coded-wire tagged fish, ocean entry mark, and Sr/Ca ratios on otoliths.

Although we will not know the duration of residence of individual juvenile salmon in the plume environment explicitly using either approach, Columbia River basin fish enter and migrate through the plume environment before dispersing on to other regions. It appears valid to assume that a group of fish primarily of Columbia River basin stock, caught in the plume environment, and has been in the ocean for a period of time is more likely to have been resident in the plume than not. Recall that 90 % of the juveniles captured in May and June originate from the Columbia River basin. This issue will be more problematic in the September cruise than the May or June cruise thus month will be a factor in the analysis, but not the primary factor.

We recognize the need to resolve the uncertainty of residence in the coastal habitats we sample. The evidence we have collected and have in hand (including historical information from Pearcy and Fisher) suggest that the influence of the residence uncertainty on relationships between salmon and the plume habitat are not great. However, resolving this uncertainty will be critical and we are attempting to address it. We are, under separate funding, currently developing microsatellite DNA baselines for Columbia River Basin stocks of chinook salmon. Microsatellite loci provide a greater ability to resolve and identify the stock origins of ocean-caught juvenile salmon (Beacham et al. 2001) and have been used to identify the stock origins of individual chinook salmon in California's Sacramento River (Banks et al. 2001). We will apply the Columbia River Basin microsatellite data in our estuarine studies this year and plan to shift our mixed-stock analyses of ocean juvenile salmon from allozymes to microsatellites during this proposal period. We have preserved our samples from the past four years of ocean sampling for re-analysis with the DNA markers once adequate baseline data become available.

Finally, we are also submitting a proposal to the Columbia River Systemwide Province RFP that will expand the development and application of an accoustic tag and sensor array currently being developed by NMFS for the U.S. Army Corps of Engineers for the Columbia River estuary. The tag is being miniaturized to allow the full size range of juvenile chinook and coho to be tagged. The proposal objective will be to assess residence time of juvenile salmon in the plume and surrounding coastal environment of the Pacific Northwest.

Banks, M.A., C.A. Greig, M. Bartron, V.K. Rashbrook, and D. Hedgecock. Molecular and statistical power for identification of California's Central Valley spring run chinook: Completion report for Category III Agreement No. 9054 Molecular Genetic Study of Central Valley Stocks Focusing on Spring-run Chinook Salmon. 2001. Bodega Marine Laboratory/ University of California at Davis. Bodega Bay.

Beacham, T.D., J.R. Candy, K.J. Supernault, T. Ming, B. Deagle, A. Schulze, D. Tuck, K.H. Kaukinen, J.R. Irvine, K.M. Miller, and R.E. Withler. 2001. Evaluation and Application of Microsatellite and Major Histocompatibility Complex Variation for Stock Identification of Coho Salmon in British Columbia. Transactions of the American Fisheries Society. 130:1116-1149.

General comment: Part of this answer may relate to Task (1.e.). Our question concerning the IGF-I hormone is how sensitive the assay is in providing "a good index of recent growth rate in salmonids"?

Response: In laboratory experiments, IGF-I levels of 1^+ coho salmon responded to changes in feeding level within a period of 2 – 4 weeks (Larsen et al 2001). Subsequent work showed that IGF-I levels in coho salmon subjected to a fast took 3 – 4 days to show a significant decline (Pierce et al. unpublished). Further experiments have demonstrated a significant, strongly positive (r^2>0.5) relation between plasma IGF-I levels and growth in length over two week periods (n=5, July – September) (Beckman et al. unpublished). This substantiates previously published work suggesting a relation between IGF-I and growth (Beckman et al. 1998, 1999, 2001, Pierce et al. 2001). Current data suggests that plasma IGF-I levels provide a good indication of relative growth rate of juvenile salmonids and responds accordingly over a period of roughly a week.

Beckman, B.R., Shearer, K.D., Cooper, K.A., and W.W. Dickhoff. 2001. Relationship of insulin-like growth factor-I and insulin to size and adiposity of under-yearling chinook salmon. Comparative Biochemistry and Physiology 129A:585-593.

Beckman, B.R., Dickhoff, W.W., Zaugg, W.S., Sharpe, C., Hirtzel, S., Schrock, R., Larsen, D.A., Ewing, R.D., Palmisano, A., Schreck, C.B., and C.V.W. Mahnken. 1999. Growth, smoltification, and smolt-to-adult return of spring chinook salmon (*Oncorhynchus tshawytscha*) from hatcheries on the Deschutes River, Oregon. Transactions of the American Fisheries Society 128:1125-1150.

Beckman, B.R., Larsen, D.A., Lee-Pawlak, B., Moriyama, S., and W.W. Dickhoff. 1998. Insulin-like growth factor-I and environmental modulation of growth during smoltification of spring chinook salmon, (*Oncorhynchus tshawytscha*). General and Comparative Endocrinology 109:325-335.

Larsen, D. A., Beckman, B. R., and W. W. Dickhoff. 2001. The effect of low temperature and fasting during winter on metabolic stores and endocrine physiology (insulin, insulin-like growth factor-I, and thyroxine) of coho salmon, *Oncorhynchus kisutch*. General and Comparative Endocrinology 123:308-323.

Pierce, A.L., Beckman, B.R., Swanson, P., Shearer, K., Larsen, D.A., and W.W. Dickhoff. 2001. Effects of ration on somatotropic hormones and growth in coho salmon. Comparative Biochemistry and Physiology 128B:255-264.

General comment: Task 1.f. (page 17) Why are only two months proposed for sampling, would not the July sample be important in examining duration of use of the plume and changes in stocks during this summer period?

Response: In the proposal, we propose 4 sampling periods (during the months of May, June, Sept, and February). We concur that a late July or early August sampling would be beneficial. Sampling in July would be during a smaller and warmer plume conditions and we would collect more 0-age chinook coming out of the Columbia River. The cost associated with the additional sampling would approximate $75K (ship time and sample processing). In the first question posed above by the panel, there is concern regarding the February cruise and its appropriateness. We believe, for the reasons outlined above, that a February cruise would be beneficial. However substitution of a late July or early August cruise is feasible. However, as stated previously, we budgeted for 30 days at sea, not 40 days, in our original proposal. Depending on the agreements with the panel, we can maintain the February cruise and add a July cruise for a cost of approximately $150K. In order to support either a February or July cruise, an additional $75K would be needed. The budget portion of the proposal will be amended to reflect the costs for an additional cruise.

General comment: **Task 1.g. (page 18) Is there a source or base sample of these fish and pathogens in the Columbia River? Without that sample we are uncertain what the fish sampled from the plume would be compared against. How will survival actually be assessed by this sampling?**

Response: We are aware of the importance of the base information needed for comparison. We are sampling outmigrating salmonids (yearling and subyearling chinook salmon and coho salmon) for pathogen analyses in the lower Columbia River estuary as part of an independent NMFS funded examination of the distribution of salmonid and non-salmonids fishes in the lower estuary. Juvenile salmon are sampled every two weeks by purse or beach seine beginning in April and continuing into September. This sampling design is followed to maximize the sampling of a variety of salmon stocks as they migrate out of the estuary. These studies began in 2001 and we expect them to continue through the time period that would be covered by the proposed BPA project. We would also work collaboratively with other Columbia River projects to obtain pathogen data from salmon taken for other objectives at different locations in the Columbia River estuary (e.g. Project ID: 30001; Historic habitat opportunities and food-web linkages of juvenile salmon in the Columbia River estuary: Implications for managing flows and restoration; and a U.S Army Corps of Engineer sponsored study that evaluates current and historic use of lower Columbia River and estuary habitats). In addition, state, federal, and tribal hatcheries monitor hatchery stocks for pathogens pre-release. Each hatchery has a pathogen history and most agencies maintain pathogen databases. If needed, this information is available.

With the information provided by allozyme frequency analyses, the effects of pathogens on marine survival can be assessed. Genetic mixed stock analysis using allozymes has been, and will be used, (as outlined in the proposal) to describe stock composition of coho, yearling chinook and subyearling chinook salmon spatially (the zones defined by salinity or geographic plume boundaries described above) and temporally (between months). Spatial and temporal differences in infection prevalence and intensity between groups of juvenile salmon can provide information on pathogen-influenced mortalities when stock composition of groups is similar. For example, if the genetic stock composition of yearling chinook salmon reveal that samples obtained in May and June are largely the same, then comparison of infection between months in these juvenile salmon is valid means to explore the potential impacts of a pathogen as a contributing factor affecting survival of juveniles.

This approach has already provided us with evidence of potential differential mortality of juvenile salmon due to pathogens. Appendix Figure 6 of the proposal shows a decline in coho salmon infected with *Renibacterium salmoninarum* between May and June and a decline in coho salmon infected with *Nanophyetus salmincola* between June and September of 2000. Stock composition (assessed using the distribution of allozyme genotypes in the ocean samples and the frequencies of these genotypes in individual stocks) is largely unchanged during the sampling period (May through September) suggesting selective loss of infected individuals from the population. Fish are not able to clear these infections so differential mortality remains as the most likely cause for the greater disappearance of infected fish. Other data (not shown in the proposal) includes a lower condition of yearling chinook salmon infected with *R. salmoninarum* than uninfected salmon.

General comment: **Task 1.h. (page 18) Clarify the intent of "We usually only enumerate those taxa from the 1-m, bongo, and neuston nets that are part of the salmon diets." If this were true, how would selectivity be assessed?**

Response: Yes this was not worded correctly. We plan to enumerate those taxa >3 mm that salmon have been shown to consume (Brodeur 1991, Schabetsberger et al. MS). This should have been more explicitly stated. Because of the mesh size of our sampling gear, we catch substantial numbers of small zooplankton, such as copepods, that are not within the size range of prey that juvenile coho and chinook salmon normally consume. Thus, in any selectivity calculations comparing prey fields in sampling nets to prey consumed in salmon diets, copepods would always show very high negative selective values and all other taxa would be positively selected, biasing and reducing the resolving power of the analysis. Thus, we limit our sorting to those taxa of sufficient size that are in the visual perceptive range of salmon. Even above this threshold, there are apparently taxa (mainly ones with a lot of pigment) that are positively selected relative to their abundance in the field (Schabetsberger et al. MS). Having information on smaller copepods would be useful if we want to examine selectivity of chum, pink or sockeye salmon that feed on a smaller size spectrum of prey.

Brodeur, R.D. 1991. Ontogenetic variations in size and type of prey consumed by juvenile coho, *Oncorhynchus kisutch*, and chinook, *O. tshawytscha*, salmon. *Env. Biol. Fishes* 30:303-315.

Schabetsberger, R., C.A. Morgan, R.D. Brodeur, C.L. Potts, and W.T. Peterson. MS. Diel feeding chronology, prey selectivity, and daily ration of juvenile chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Columbia River plume. *Fish. Oceanogr.* (submitted)

General comment: **Task 2.a. (page 19) It is not evident how samples collected during the plume front studies relate to the other collections … are these in addition to the monthly samples collected under Task 1? Also, sampling of a front using the Nordic 264 net would seem inconsistent with the size of the net versus the scale of the front. What are concerns associated with using this net to sample the fronts?**

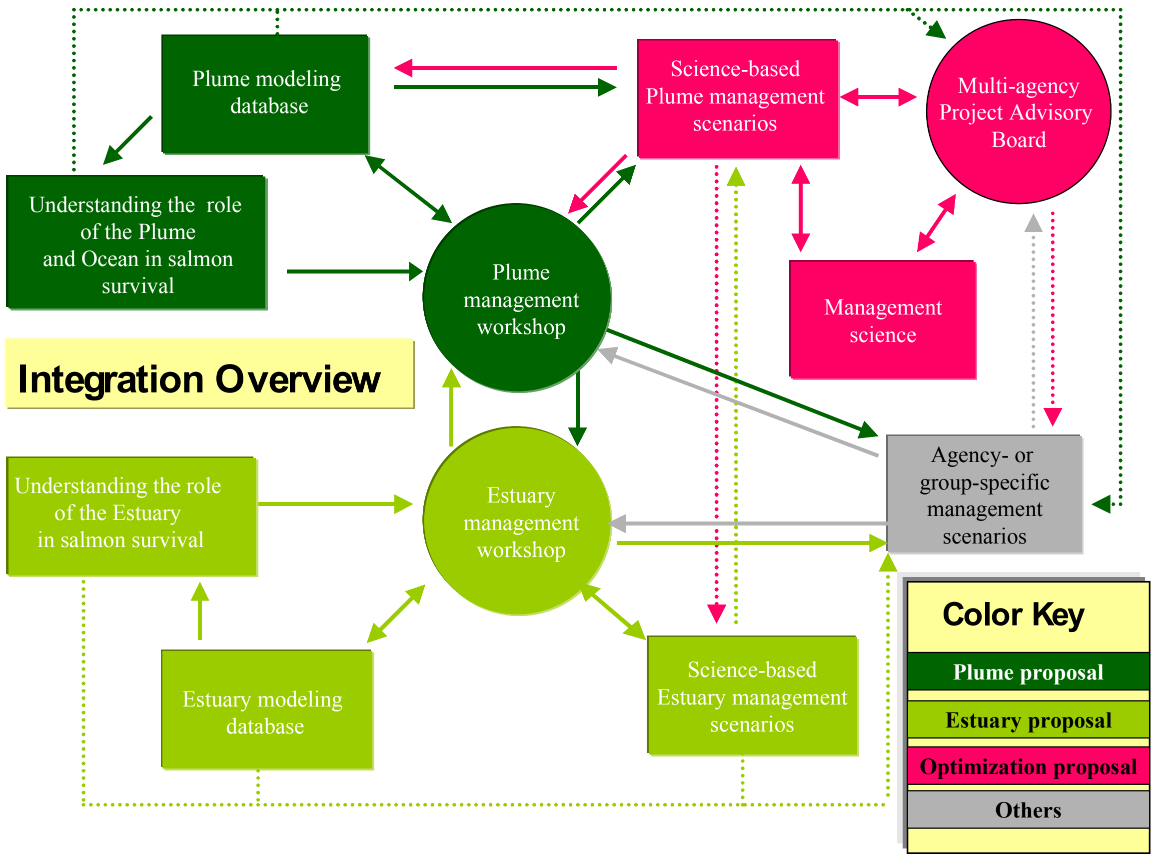
Response: These are specific fine-scale samples collected right off the mouth of the Columbia near the peak of the coho and yearling chinook outmigration. They are in addition to, and generally would follow, collection of the broad-scale mesoscale survey information. The fine scale process studies underway and proposed for continuation are intended to provide information about a critical bio/physical feature (convergent zone) that is created by the Columbia River plume interacting with the nearshore ocean. The larger survey area (identified in Objective 1) is intended to provide information about the coastal ecosystem (which the plume is part of) and salmon. The larger survey will allow us to evaluate fine scale characteristics of the plume environment in the appropriate context (as proposed in Objective 2). It is likely the size and distribution of the plume in the coastal environment as well as fine scale features (fronts and eddies) collectively influence the success of salmon.

The fronts we are sampling occur regularly, are relatively large, and easily visible from the sampling vessel and helicopter. When we fish the surface trawl, we sample directly "on" the front during the entire ½ hour sampling period (i.e., along the visible convergent line of the front). The mouth width of the surface trawl is only slightly larger than this dynamic frontal zone when it is fishing and thus would not be sampling very much non-frontal water.

General comment: **Most of the remainder of the proposal addresses the extensive analysis and modeling component of the study. The modeling work, however, overlaps extensively with two other proposals (30001 Historic Habitat…, and 30002 Optimization of FCRPS impacts …) and lead to confusion concerning tasks and deliverables. Our understanding of the relation with proposal 30001 is that the numerical modeling tasks in project #199801400 will apply the results from that proposal. However, the relationship with proposal #30002 is certainly less clear (although tables of these interrelationships are noted in the other proposals). To clarify the role of analyses and modeling (by model type and objective), the ISRP requests that the proponents clearly differentiate activities as estimation, simulation, and validation of the models developed; and who the responsible investigators are for each task. A single summary table or flow chart may be adequate. Proposal #30002 indicates that all numerical modeling will be included in project #199801400 and during the briefings it was indicated that any validation work would also be included in that project. We are then uncertain of the necessity of a separate proposal (#30002) unless it is solely focused on definition of possible management scenarios.**

Response: We understand the confusion, as we are proposing a highly integrated effort building on our past findings and ongoing and proposed studies, across multiple regions and involving various research teams.

In particular, this is one of the three linked proposals submitted to the RFP: 199801400 (this proposal, "*Plume*"), 30001 ("*Estuary*"), and 30002 ("*Optimization*"). Together, these proposals address recovery of the Columbia River estuary and plume as vital habitat for juvenile salmonids. We believe that FCRPS management strategies must be based on a sound understanding of the importance of the estuary and plume to salmonids, the impacts of the FCRPS on the physical and biological processes of these environments, and the constraints placed on future FCRPS management by climate. Each proposal addresses different aspects of these problems, and coordination across the three proposals is vital to provide sufficient knowledge towards effective future management options.



The flow chart above provides an overview of the individual roles and coordination across the three proposals submitted under the CR estuary province. Colors distinguish among the three efforts.

Our approach builds on the premise that we can develop understanding of the relationships between juvenile salmon and the habitats they occupy. To establish these relationships, we will rely extensively on ‘modeling databases’, containing detailed space-time descriptions of the physical habitat obtained through numerical modeling. We will use ‘understanding of fish-habitat relationships’ and ‘modeling databases’ and ‘FCRPS management scenarios’ as input to workshops and other forums (e.g., a multi-agency advisory board, in the case of Optimization) that are integral to our evaluation of the potential impact of management scenarios on salmon survival. Separate workshops are planned for the estuary and the plume, although we expect (and will encourage) overlaps.

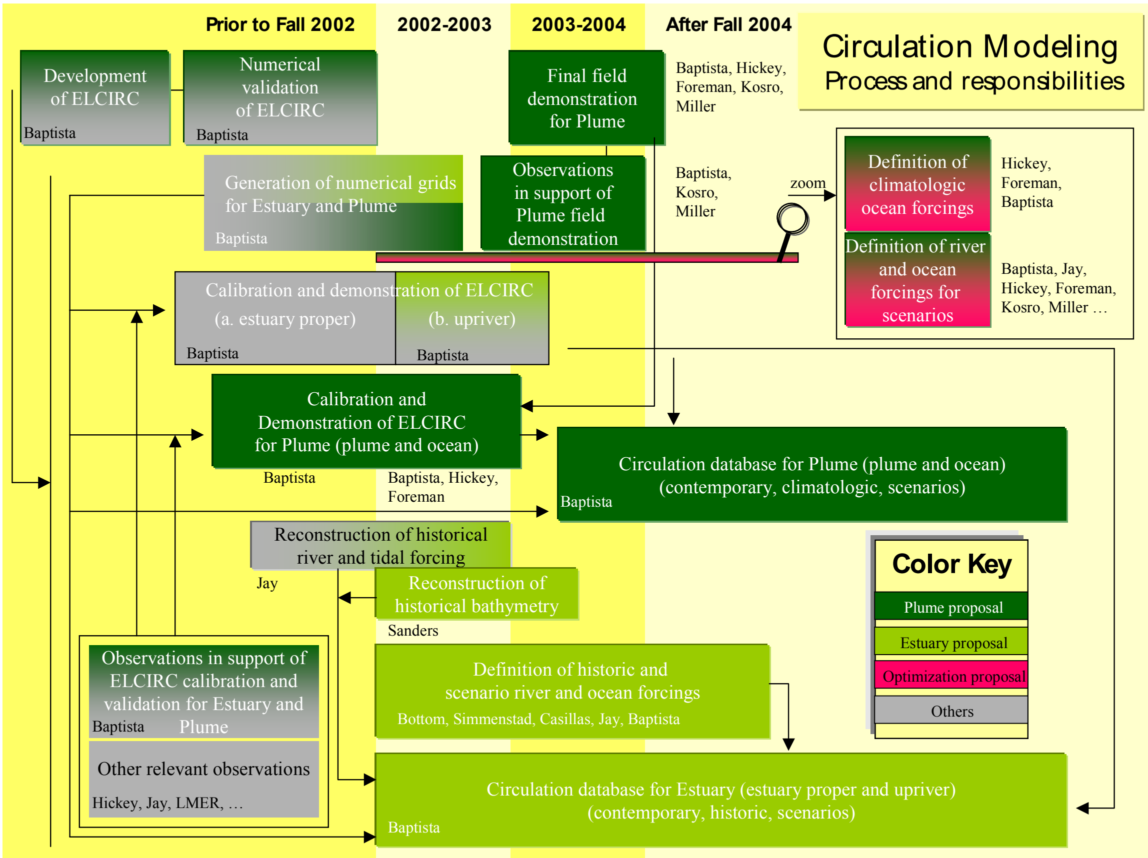
The Plume and Estuary efforts are focused on different habitats (‘plume and ocean’ and ‘estuary and upriver’, respectively), but each contains similar building blocks for the respective habitat. Building blocks common to these two proposals are (a) the ‘modeling database’, (b) the development of ‘understanding of the role of habitat on salmon survival’, and (c) the evaluation of the impact of FCRPS management scenarios, which includes the organization of management workshops with broad participation of Columbia River stakeholders.

The Plume proposal will rely on the Optimization proposal to assist in the development of science-based management scenarios for the plume. Although a parallel effort to address management scenarios in the estuarine environment is self-contained within the Estuary proposal, we felt the need to separate the definition of the scenarios out in the Plume study. This is in part because we still feel the need to better define empirically the role of the plume to juvenile salmon, while we consider that we are farther along in this effort in the estuarine environment. This separation also allows for a critical mass of respected coastal scientists, mostly from Pacific Northwest universities, to participate in development of management scenarios. This participation is important to provide a systematic connection between proposed future scenarios and the climate and coastal forcing that in large part control estuary and plume habitat. *Optimization* will also help structure the scenarios so that similarities to and departures from previous management practices are evident to FCRPS managers. Especially if the Management Workshops (Objective 5 of *NMFS-Plume*) are delayed (see below), the development by *Optimization* of management scenarios in 2004-2005 will provide vital early input to FCRPS managers and feedback to the field programs undertaken by all three linked proposals.

We will open to this group of scientists our modeling database and associated metrics of habitat opportunity, and we will conduct simulations for some of the top-ranked climatologic and management scenarios that they will develop with the guidance of a multi-agency advisory board. In addition to providing scenarios for simulation, we anticipate that Optimization will contribute to our efforts by proposing additional metrics of habitat opportunity, and by enhancing our physical characterization of the plume and ocean in their response to climatologic and FCRPS forcings.

Many of the scientists in Optimization will also participate in the Plume effort, but typically in roles limited in scope and time, and often centered on specific modeling tasks including data collection for a field demonstration of the model in 2004. An exception is Dr. Baptista, who will be the lead physical modeler in Plume and Estuary, and whose participation in Optimization will be focused on inter-coordination across the Plume and Optimization efforts.

Because modeling of physical circulation (and associated generation of metrics of habitat opportunity) is so integral to all three efforts, the following flow chart attempts to clarify allocation of efforts among proposals, and a timeline for selected key tasks:

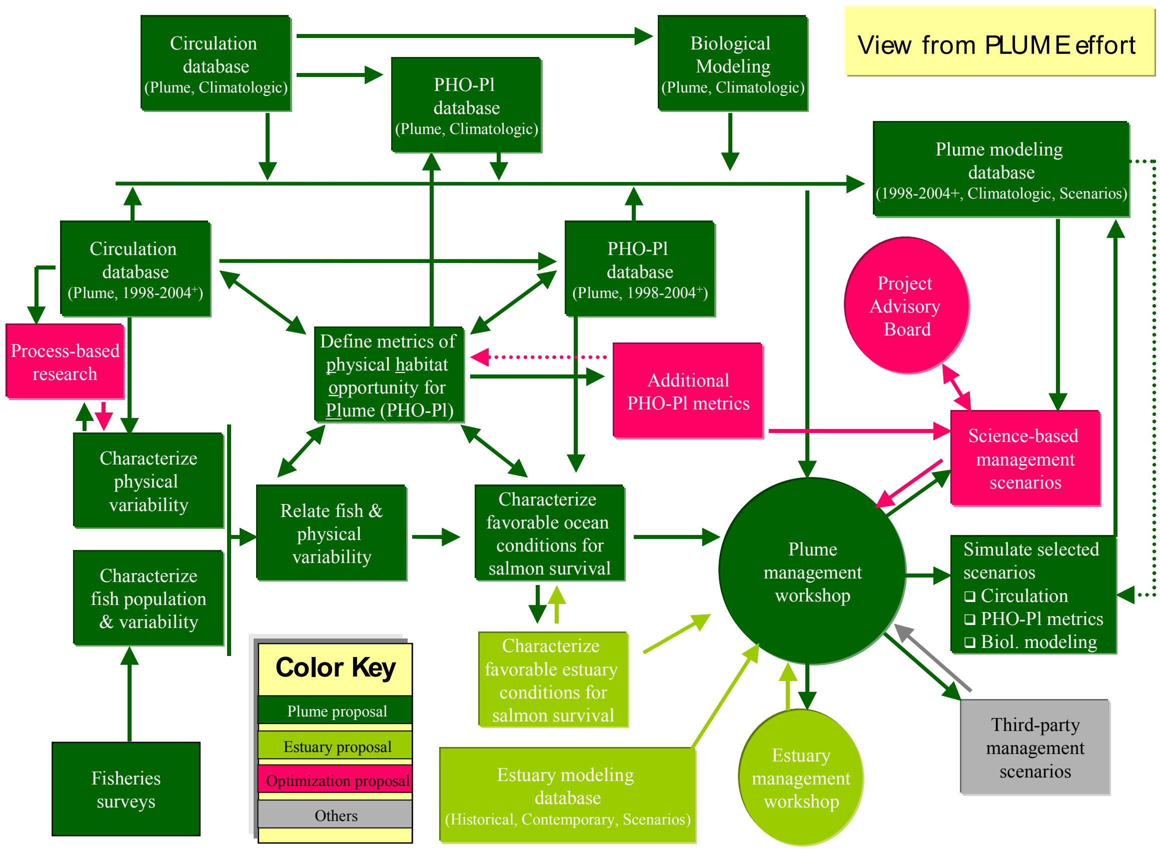


We note that:

- All modeling tasks will be conducted by either the Plume or the Estuary efforts, in each case with focus on the respective target habitat. No modeling tasks are included in Optimization, which will rely on the modeling databases generated by Plume and Estuary. However, Optimization will influence the Plume modeling database by helping define river and ocean forcings for both the contextual climatology and specific science-based FCRPS management scenarios.
- There are some commonalities between the modeling for the two target habitats ('plume and ocean' and 'estuary and upriver', respectively), including the same computational code (ELCIRC), partially shared computational grids, and shared forcing types. However, each habitat requires separate modeling treatments at various levels, some of which are identified below.
- Model calibration (including 'parameter estimation', i.e., quantification of the limited number of empirical coefficients required by circulation models) and model validation (independent certification that calibration has broad validity) require specific efforts for specific habitats. These efforts are in various stages of maturity (partially illustrated by their location in the time axis of the flow chart).
- We anticipate that a validated model for the estuary and parts of the upriver will be available at the beginning of the Estuary project. An equivalent plume modeling capability is expected to be available at the beginning of year 2, and will be the subject of an extensive field demonstration in 2004. Modeling databases will begin being built in

year 1 for both projects, but will become a focus for the Plume project only in year 2 and beyond. As model robustness increases over time, databases will be upgraded as appropriate and feasible.

- Estuary and Plume require drastically different spatial refinements in different areas of the computational domain of the models. Cost dictates, therefore, that different computational grids will likely be used for each effort (and we may even use more than one grid within each effort).
- Estuary and Plume will only partially overlap in periods/conditions of simulation, with most of the overlap for contemporary simulations. Indeed, we anticipate that historical simulations for the estuary and upriver will cover very different conditions than the climatologic simulations for the plume and ocean, and we anticipate only a modest overlap on the conditions for management scenarios under both efforts. Coupled with likely differences in computational grids, we anticipate that the building of the Estuary and Plume databases will constitute two different tasks. However, we have deliberately positioned our efforts to optimize synergies and retain commonalities of approaches wherever appropriate.
- The enormous complexity of the modeling of the near-field plume environment recommends that a targeted field demonstration be conducted specifically for that environment. Baptista, Hickey, Foreman, Kosro and Miller will join efforts for that field demonstration, which will bring together three leading Pacific Northwest modelers and specialized observation technologies. Prior to the field demonstration, Baptista, Hickey, Foreman will also join efforts in model calibration/validation for the plume and ocean, based on contemporary and historical data sets available to them.
- Although our field design is self-contained, we will actively seek and encourage synergies with other relevant field efforts. Obvious opportunities for synergy exist relative to the multi-year surveys proposed by Optimization researchers (Jay and Miller), to field efforts proposed or in preparation for submission to National Science Foundation programs such as *Major Research Instrumentation* and *Buoyancy Initiative*, and to on-going GLOBEC programs. These links are not shown in the flow chart by lack of space.
- Biological modeling (not shown in the diagram above) is an inherent component of the Plume effort, as is the definition of physical habitat opportunity metrics. There is no equivalent biological modeling in the Estuary effort, but that effort has an equivalent component of definition of habitat opportunity metrics. The integration of biological modeling and definition of habitat opportunity metrics in the Plume effort is shown in the flow chart below.



General comment: **The budget for ship time is not well described (i.e., activities by vessel and costs) but ISRP notes that other or supplemental sources of funding for ship-time and other vessel alternatives such as fishing boats may be available. There is precedent for this in ground fishing research being done by NMFS at the NWFSC. Further, the size of this proposal makes it difficult to assess costs by activity and the relative priority of various tasks. Given the increasing competition for resources in this Province, it would be appropriate to rank the value of the various activities or provide a strong justification if this should not be done.**

Response: Ship time is included in Objective 1, Tasks 1.a and Task 1.b, and Objective 2. Ship time costs to accomplish Tasks 1.1 and Objective 2 (large scale and fine scale surveys are conducted during each 10 day cruise) is proposed at $140K per year (includes three10-day cruises per year). Ship time to accomplish Task 1.b is $80K per year (includes ten 3-day cruises every two weeks from Mid April to July). Ship time is separated for these tasks because of the need to specifically conduct night-time sampling for assessment of piscine predator and forage fish populations (Task 1.b). Many of these fish move to the surface at night whereas salmon appear to show a preference for surface activity during daylight hours. Night and day operations on the same vessel would require a much larger ship that can staff two crews (both for ship operations and scientific sampling).

We presently contract commercial fishing vessels (which are flexible in their ability and less costly for the type of dedicated operations we seek) to conduct this research because NOAA/NMFS vessels are unavailable. If we are able to get NOAA ship time in the future to conduct these collections, our budget would be reduced accordingly. We have requested, and continue to, NOAA vessels for these studies, but competition amongst NOAA Line Offices and other outside users (e.g. National Geographic, NSF) is high. The needs by a variety of users are great and far exceed the time available for NOAA ships.

It is difficult to rank the proposed acitivities, as we are using an ecosystem approach to evaluate the role of the Columbia River plume to juvenile salmon. The information gained will be used to assist management in affecting the recovery of juvenile salmon by incorporating habitat assessing tools. However, if we were to suggest a stepwise approach, Objectives 1, 2, and 3 provide the basic information, understanding, and potential to evaluate management actions. These should be fully supported. Objective 4 would provide the opportunity to identify the limitations of our understanding and the principle factors affecting growth and distribution of salmon in the coastal environment encompassing the Columbia River plume, but could be deferred 1-2 years as we develop the basic information. Similarly, the development, simulation and analysis of management scenarios (Objective 5), although the ultimate goal, could be deferred 1-2 years.

The development of functional future management strategies is our ultimate goal, and the timetable of the Biological Opinion dictates that development of the science-based management options begin in the near future, so that new management regimes can be implemented within a decade. However, the development, simulation and analysis of management scenarios contained in Plume (Objective 5) could be deferred for 1-2 years, in particular if the Optimization proposal begins addressing scenario development during that period.