July 28, 2005.

CIE Review of Salmon Programs of the Auke Bay Laboratory, Alaska Fisheries Science Center

By

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Executive Summary

In July 2005, a panel appointed by the Center of Independent Experts, University of Miami, reviewed the salmon programs of the Auke Bay Laboratory (ABL) of the Alaska Fisheries Science Center (AFSC). The review consisted of a 3-day site visit and review of materials and publications from the Laboratory. My review dealt mainly with the ocean-salmon and population dynamics components of the program, and I made only a few comments on those elements that were focussed on genetics.

In general, I found that the salmon program is guided by some very experienced individuals and has had an excellent record of producing long-term data series from monitoring and survey work. Process or mechanism-oriented work has been conducted on a more limited scale. I provided a variety of comments on specific program elements but there are two major issues that the program would benefit from explicitly addressing:

(1) To meet AFSC's new focus on habitat and ecosystem-based research, ABL's marine salmon programs need to begin to find ways to link their findings on juvenile salmon in the surface waters to the rest of the marine ecosystem. A framework for doing this is likely ecosystem-based modelling. The goal is not to create a definitive working model for the whole ecosystem, but to use model development as a tool for developing testable hypotheses and identifying research needs and priorities.

(2) To raise the scientific profile of ABL's salmon program, more emphasis should be placed on the publication of research results in the highest quality journals. This should result in an evolution from the past tradition of case-history or descriptive studies to more insightful and innovative studies of mechanisms and processes. This does not lessen the importance of ABL's baseline studies since they provide the platform for this evolution. There appears to be considerable untapped potential in ABL's long-term salmon databases that should be explored, perhaps with outside collaborators.

ABL may wish to consider a recruitment plan that would assist the program in both addressing these issues, and allowing for mentorship with the experienced staff at the laboratory, especially with respect to some of the longer term studies.

Introduction

In early 2005, the Center for Independent Expertise of the University of Miami contracted Dr Mike Bradford, of Vancouver, British Columbia to participate in a review of the salmon programs of the Auke Bay Laboratory (ABL) of the Alaska Fisheries Science Center (AFSC), National Marine Fisheries Service (NMFS). Activities included reviewing background literature that was sent by ABL prior to the meeting and some of the laboratories publications, participating in the panel review from July 11-14, 2005 in Juneau, Alaska, and the preparation and submission of this report.

Part of the discussion at the ABL meeting concerned the original Terms of Reference (TOR) from CIE for the review, with some modifications to it based on the discussions during the meeting, and the consideration of 10 questions prepared by ABL staff that they wished the Panel to consider. In the preparation of this report, I focused largely on the 10 questions, as these directly related to the material presented at the meeting. The full text of the questions is not provided in my report, but is found in Appendix A. I also provide some responses to the specific questions identified in the TOR (the complete TOR is found in Appendix B). A list of documents that made up the background material is contained in Appendix C.

TOR #1: *The AFSC's primary research mission is to generate the best scientific data available for understanding, managing, and conserving living marine resources in Alaskan waters and the environmental quality essential for their existence. Primary species of interest are groundfish, crab, and marine mammal populations. Salmon are an important secondary species due to research responsibilities derived from international agreements. In addition, AFSC salmon programs receive direct funding from Congressional PPAs and NOAA research initiatives pertaining to ESA-related issues, the ecological role of salmon in the marine environment, and enhancement technology and impacts. The review panel should provide input on recommended directions in AFSC salmon related research in Alaska, and identifying appropriate levels of research directed at salmon management questions and at Alaskan ecosystem and habitat issues.*

(See Parts A-E under TOR #1 in Appendix B – Statement of Work)

TOR #2: *Three years ago, the NPAFC initiated BASIS (Bering-Aleutian Salmon International Survey), a yearly, basin-scale survey of the Bering Sea's pelagic ecosystem using survey vessels from Russia, Japan, and the USA. This international research program was developed by ABL scientists who continue to maintain a strong leadership role in this program. Although BASIS studies ostensibly address salmonid issues in the Bering Sea, research on forage fishes and the Bering Sea ecosystem have been key components of the national BASIS research programs. The review panel*

should provide input to the AFSC on the utility of BASIS research programs.

(See Parts A and B under TOR #2 in Appendix B – Statement of Work)

BASIS Studies.

ToR 1-D. The North Pacific Anadromous Fish Commission (NPAFC), a five nation International Convention focused principally on salmon resources of the North Pacific Ocean, encourages coordinated and cooperative research by member parties in both Convention Area waters and adjacent territorial seas. As the NPAFC Science Plan calls for research focused on early marine life of salmon, how can ABL research on juvenile salmon best provide a better understanding of the role salmon play in various components of the North Pacific ecosystem?

ToR 2-A. What is the potential for BASIS surveys to address current Bering Sea non-salmonid management and ecosystem research needs: what key management and scientific questions/hypotheses could be addressed by BASIS, either in its current form or through an augmented program?

ToR 2-B. How can the AFSC best utilize BASIS as part of its research mission in Alaska?

The BASIS program is an impressive collaborative effort to describe the Bering Sea and Bristol Bay epipelagic ecosystem, with emphasis on the relation between ocean conditions and salmon survival during their first year at sea. The program has done a thorough job of capturing the current state of the ecosystem for salmon and their prey, and has already yielded intriguing new insights, particularly those that relate to changes in climate.

The program is attempting to survey a vast area (both in terms of time and space), and the collaborators have chosen to focus on the fall period each year, but cover a large an area as possible, as evidenced by the expansion into the Norton Sound region in the most recent years. This choice allows for certain types of inferences from the data collected, and would be different from those that might be generated from a study design that focussed on a smaller area, but had multiple surveys permitting more temporal coverage of the early ocean life of juvenile salmon.

The goal of the BASIS program is to "understand the mechanisms underlying the effects of environmental variation……for salmon" and some of the analyses presented in Juneau were oriented towards the prediction of recruitment strength for Bristol Bay sockeye populations. Back in 1992, I published some simulations studies that examined the likelihood of predicting recruitment from the early life stages of marine fish (Bradford, 1992), which emphasized (along with many other authors) that recruitment is often the result of chain of events, and that in any year the dominance of a particular stage, period or event will depend on all the other parts of the life cycle. As well, there is substantial uncertainty surrounding a correlation between recruitment and an environmental or abundance measure when there are few data points available. Even

with a 10-year series, the confidence intervals for an observed R^2 of 0.5 will range from 0.1 to 0.9, making it impossible to ascertain strength of the true underlying process. This may be the reason why significant correlations between recruitment and environmental signals from short (albeit hard won) series of data often deteriorate with the addition of more years data, during which time other variables have more influence on recruitment variation.

I mention this because an initial survey such as conducted by BASIS to date could evolve in at least three directions:

1. Continue as an extensive survey for a much longer period of time until significant predictors of salmon recruitment are developed. This probably entails at least a decade of work, which might be difficult to sustain.
2. Use the preliminary years of study to develop quick and simple recruitment predictors that can be sustained over the long term. Examples might be to reduce the sampling to a few key sites, or search for readily available or remotely sensed indicators that can be obtained annually at little effort. The success of this approach will depend on the actual presence of a key recruitment indicator, as opposed to the scenario of many small environmental processes affecting survival discussed above. This concern may be allayed if there is an actual pre-recruit abundance metric that can be estimated. The approach also requires some amount of stationarity in the environment so that the results of the extensive sample and indicator development process are relevant in the future. Unfortunately, in an environment of rapid climate change it is unclear whether this will be true.
3. Use the baseline results as a platform for more mechanistic studies of the recruitment process. Approaches that are based on the performance of individuals (e.g., thermal, salinity and other preferenda, foraging behaviour, food quality and bioenergetics, growth, anti-predator behaviours) that are based on the premise that individuals are constantly attempting to maximize their lifetime fitness have the potential to be robust to rapidly changing environmental conditions that could confound more correlative or bottom-up approaches.

Thus, for salmon at least, I advise that the BASIS program managers begin the process of thinking about ways to move from the descriptive survey-type to the next stage that will bring them closer to their goal of understanding the way ocean conditions in the Bering Sea can affect salmon productivity. This is the challenge faced by all juvenile salmon-oceanographic surveys, and only a few have moved beyond the descriptive phase.

Mention was made of work to parameterize a bioenergetic model for sockeye salmon. This is a useful step, and has been attempted for salmon a few other contexts. Investigators suggested that a bioenergetics model could be used to create an energetic chart for Bristol Bay akin to the approach taken for stream dwelling fishes by Nislow (2000) and others. Although such a model will require a suite of assumptions, it should be possible to combine available information and data collected from ABL's lab studies to proceed. Carl Walters once remarked that the main beneficiaries of models are the modellers, referring to the process of thinking about and building the model being

important as the results. I think this comment is relevant to BASIS, as some sort of ecosystem model will be useful for synthesizing and integrating the field results.

While the energetics approach proposed by OCC is aimed at determining the level of food resources in Bristol Bay for salmon, it should be possible to turn the approach around to ask what impact the migrating sockeye salmon juveniles (and other salmon species) are having on prey species. Based on the observed density, growth (or at least the increase in size at time), the diet and its energy content, and metabolic parameters, a first order estimate of the total prey consumed is possible. This model could be made somewhat spatially explicit (perhaps as a "boxcar" model), and could consider the production dynamics of the prey species as well. Although the resulting estimates would be imprecise, it might provide useful insight into the significance of salmon as top-down controllers of productivity in Bristol Bay.

The material presented to us also mentions that samples were collected for stable isotope and lipid analysis, although few details are provided. I have had some experience with both tools, and note that as our understanding of stable isotope dynamics increases, the interpretation of these data becomes more and more complex. Issues such as the variability in fractionation of isotopes, and non-equilibrium conditions resulting from rapidly growing fish and ever-changing diets means that stable isotope analysis is not an easy "add-on" to an existing study, but that it will require considerable effort on its own. Careful attention should be given to the question of whether the results of an stable isotope analysis (SIA) study would significantly enhance those provided by the detailed diet studies already underway. Similarly, lipid studies are also in their infancy, and I don't believe there's enough known about the seasonal, spatial, or species-specific variability in lipid levels to be able to provide guidance to a sampling program or to suggest a 'normal' range of values that can be used to assess fish health, or environmental quality. In addition, samples collected in bulk in Bristol Bay will be from a mixture of populations, which could add variability to the results, unless individual-based GSI is available. Both SIA and lipid analysis are interesting areas of research, but both will require considerable effort to be successful.

BASIS investigators should use, as extensively as possible, previously conducted research as means of extending the data series and comparing conditions across the decades. The work of Straty in the late 1960's for Bristol Bay was discussed at the CIE review, and BASIS results have been compared to the earlier findings in Farley et al. (2005). Straty also proposed some testable hypotheses, including suggesting that colder temperatures would slow migrations from the bay, and that because salmon were concentrated along the south shore (during this cold period), there was potential for food limitation. There also appear to be differences on salmon diets between periods. The fact that the earlier surveys were conducted during a very cold era should be capitalized upon as a "natural experiment".

Finally, in the presentation to the CIE, a specific reference was made to the observation that recruits/spawner (R/S) for Bristol Bay sockeye was both higher and more variable in the post 1976 era, with the inference being the new regime is resulting in

more unpredictable survival. However, survival (i.e., R/S) is multiplicative and lognormally distributed (Peterman, 1981) and the variance is expected to rise with the mean for untransformed data. A quick analysis of the data embedded in the presentation suggests that SD(ln(R/S) for the pre-1976 period is slightly higher than for the 1976+ period. Thus, there is nothing unusual about the variability in R/S before and after 1976. The mean is higher, as has been observed by many researchers who have examined the effects of the 1976 regime shift on Bristol Bay sockeye salmon.

BASIS and non-salmonid and ecosystem management (TOR #2).

It was our understanding that AFSC's ecosystem management objectives relate to the salmon program when considering the potential effects of management actions for salmon on other valued components of the ecosystem, as well as the impacts to salmon of the management of non-salmonid populations of the region. The salmon program also has the potential for spin-off benefits by providing data on non-salmonid species (such as those in the prey field).

The BASIS program is focussed on the epipelagic zone where salmon are found, and from the presentations it is apparent that the sampling is providing a good characterization of the physical and chemical environment, as well as data on the lower trophic levels. Diet data provides an indication of the linkages between elements of the epipelagic zone, and a bioenergetics approach could be used to estimate the flux or energy flow between zooplankton and forage fish, and between those prey and salmon. These analyses, coupled with data collected by the BASIS program should be sufficient to address questions at the 'order of magnitude' level. Estimating the impact that salmon have on prey species and whether the salmon populations are limited by the abundance of prey could potentially be addressed.

A fuller understanding of trophic interactions in the Bering Sea will require collaborations beyond the BASIS program, and in particular, integration of surveys and assessments of the benthic communities. For example, the abundance of age-0 pollock that are potentially available as salmon prey will presumably be a function of the adult Pollock stock size and early life history processes. Unfortunately, predicting age-0 abundance from spawning biomass or environmental variables is likely very difficult, but a reconstructed recruitment time series from stock assessment models may have utility as a proxy for age-0 abundance. This might be useful for evaluating long-term changes in prey species for salmon, and also for evaluating the impact of juvenile salmon foraging on local Pollock abundance.

Responses to the questions from ABL

ToR 1-A. What applications of marine salmon research at AFSC best provide an understanding on the effects of climate/physical drivers that may cause changes in aspects of North Pacific ecosystems such as trophic food webs and forage fish populations?

Q-1. Are we making progress on understanding climate effects on distribution, abundance, growth, and condition factors?

The Bering Sea is a productive ecosystem, and others have documented changes in temperature, ice, plankton, fish and marine mammals and birds that have occurred as a result of a combination of human actions (mainly harvest) and climate change (e.g., NRC 1996). Further, the analysis of stock and recruitment data for salmon by Peterman and others for the eastern North Pacific suggests that salmon productivity in Bristol Bay should increase with increasing air and water temperatures.

Thus the question might be: what is the role of BASIS among the other ongoing projects in understanding the effects of climate change on salmon populations?

On the issue of distribution, the recent findings of BASIS, and the earlier data from Straty suggest a good link between distribution and migration patterns of Bristol Bay sockeye and ocean temperatures. The results from BASIS might provide insight into whether the observed changes in migratory patterns (distribution) are themselves responsible for increases in productivity.

The abundance of juvenile salmon in the catches will be a function of the number of parent spawners, conditions in freshwater, and in the first few months at sea that are not sampled by the BASIS cruises. Thus, it is unclear whether estimating the abundance of salmon in the fall via catch rates will be a useful indicator the effect of climate, or will provide insight into the mechanisms involved. Nonetheless, the early results are promising, and it will be interesting to see if the patterns observed in CPUE and subsequent recruits/spawner continue.

The study of diet, energetics, condition (energy content, lipids), and growth, when coupled with observations of prey abundance and possibly foraging behaviour do have potential to provide insight into the role of climate on salmon productivity. As noted earlier, these are measurements at the scale of individual fish, and therefore have the potential to integrate all the environmental effects on fish productivity. In effect, these measures allow us to 'see' the environment from the fishes' perspective, rather than the perspective provided by the nets and instruments that we have at our disposal.

The mapping (in time and space) of juvenile salmon size and condition against likely foraging conditions may be useful in detecting if within-year spatial variation in condition exists, and whether it is related to prey abundances. It would be helpful if otoliths or scales could be used to determine time at sea and to account for variation in ocean entry and migration rates among and within populations.

Often, it has been found that growth and survival conditions in the first few months at sea are critical for recruitment strength. This is not the period that is directly sampled by the BASIS program; the fish that are collected are the survivors of this early marine phase. However, recent workers have suggested that survival during the first winter at sea may also be important. Presumably fish condition (size and lipid stores)

will be contributors to survival. BASIS investigators at ABL should consider the first winter at-sea survival hypothesis, and the extent to which their information can contribute to understanding the role of climate change on it.

Question 2: Are we making progress on understanding the trophic dynamics in the Bering Sea ecosystem on distribution, abundance, growth and condition of epipelagic fishes?

This question could be interpreted as asking whether the actively managed species (pollock, salmon, herring) and the other forage species interact with each other in terms of competition or predation so that climate, fishing or effects on one species will have effects on the others. The situation is complicated by the fact that two of the key species (pollock and salmon) have complex life cycles, and much of their population dynamics are affected by processes in habitats other than the epipelagic zone of the Bering Sea that is sampled by BASIS.

The BASIS program is clearly making progress on this question. The relative abundance and spatial distribution of the key species is being estimated by the surveys, at least for the fall sampling season. Diet data will indicate the potential for competition and predation. Zooplankton and forage fish data provide information on the relative abundance of prey items.

These elements should allow for the construction of a simple food web for the study area and season. Estimates of fish growth, diet, water temperature, and the use of bioenergetics models should allow for approximate estimates of the food consumed by each major species, and thus the energy flow between the major elements of the food web. Through the use of either a simple static or more complex dynamic food web model, coupled with estimates of abundance for the study area, it should be possible to estimate the potential impact of one species on another. It is not clear whether the Bering Sea Ecopath model (Trites et al., 1999) would form the basis for a more detailed evaluation of epipelagic zone and its coupling with the whole Bering Sea ecosystem, but that approach should be considered.

In summary, the BASIS program has made considerable progress in describing the key components required for an analysis of trophic interactions. It is suggested that the investigators begin to think about how their field data can be incorporated into an analytical framework such as a food web model. While the building of a full ecosystem model may not be ultimately successful, model building is a useful organizing device, and it may reveal particularly profitable areas of research in the field or laboratory.

Question 3. Are we making progress on developing indicators to measure changes in climate and ecosystem?

An indicator is used to describe current condition in relation to a reference condition or to assess change over time. An indicator must be relevant to the

management objectives, have sufficient precision and spatial and temporal coverage, be cost effective, and communicable to stakeholders. Many indicators are proxies; in effect, they are simple or practical metrics that are well correlated to the objective or condition of real interest. For example, the concentration of certain chemicals in the air or water is used as a measure of ecosystem 'health'.

Long-term indicators of ecosystem condition or climate change are likely to be remotely sensed, or obtained through indirect means such as the use of ships of opportunity. These types of metrics are likely to be proxy measures, and the value of a program like BASIS is to ascertain the strength of the relation between a candidate proxy measure and the components of the ecosystem of real interest. For example, the proposed link between the extent of sea ice cover and spring plankton blooms suggests that sea ice can be used as an indicator for changes in productivity of the Bering Sea. Increased understanding of the linkages between ecosystem attributes that can be indexed easily and the management objectives should allow for the selection of a set of indicators that are the most informative.

The Panel was not well apprised of the management need for these indicators leading to the conclusion that this was largely 'bottom-up' approach. As in many aspects of applied science, there is a need to engage managers who might have (or have expressed) the need for these indicators to identify their critical objectives, the spatial and temporal time frames, and the sensitivity that is needed. Management objectives such as the monitoring of 'ecosystem health' and 'climate change' are generally too vague to operationalize, and the task of moving from vague objectives to specific metrics is a difficult one that is still not particularly advanced. The process will likely be interactive, involving scientists and managers, and it should sharpen the search for indicators among the many forms of information on the Bering Sea being collected by BASIS and other investigators.

In summary, it seems that more work is needed at the interface between managers and scientists in carefully specifying the requirements for ecosystem indicators for the Bering Sea. With a refined list of requirements it should be possible to develop appropriate indicators using the results of the BASIS program, along with other sources of data.

The Southeast Alaska Coastal Monitoring Program (SECM)

This program bears some similarity to BASIS in that the field component consists of annual oceanographic and fisheries surveys of coastal waters. The focus is on salmon in the epipelagic waters, and their food and predators. The core study area is relatively limited, and it is designed to focus on the outmigration of juvenile salmonids from the northern part of SE Alaska.

From the material presented at ABL I was left with impression that the program was attempting to cover as many goals/objectives as possible (with a corresponding

number of ‘clients’), and that it perhaps could benefit from a more focused approach. The origins of this program were apparently rooted in concerns about competition between hatchery chum and wild chum and pink salmon as they move from natal areas to the outer coast. This issue has long been identified in other areas, including, for example, a model of Georgia Strait, British Columbia that was developed in 1978 by Walters et al. (1978), as well as detailed studies that have been conduced on the central British Columbia coast, Puget Sound, Georgia Strait, and elsewhere over the past 50 years.. Additionally, some recent findings for SE Alaska were nicely summarized in Orsi et al (2004).

The results presented also suggest utility for forecasting the catch of pink salmon the following fishing season from the July catch of juveniles, and presenters noted that the program was going to be expanded into the southern part of SEAK to extent the forecasts. This finding brings up the question of whether a primary goal of SECM is to provide forecasts for ADF&G, and whether it is appropriate to pursue resources for this goal (presumably taking staff away from other objectives). Perhaps more interesting from a scientific perspective is whether the strong correlations between July juvenile pink salmon catches and the commercial catch mean that the strong drivers of recruitment for these pink salmon occur during the very early marine phase, before these fish are available to SECM sampling gear. A more sophisticated approach that uses time series approaches and to account for variations in spawner abundance might be able to determine whether the correlation with July at-sea abundance is due to variation in spawner abundance, freshwater survival, or early marine survival. If indeed the critical mortality period is prior to the main SECM sampling, it might be meaningful to reflect on the objectives of the program relative to salmon survival and to consider some realignment of activities if salmon productivity is considered a primary goal of the program.

Question 4: Does the SECM program contribute to an understanding of trophic dynamics of the SEAK epipelagic ecosystem?

The program to date has collected useful information and generated some interesting results. Because the program was started to address the hatchery-wild competition issue, the sampling is relatively restricted in scope to the outmigration path for the major hatchery stocks. It is difficult to know how much the results from this area (especially in terms of interannual variation) can be extrapolated across the region because of the intricate geography of the area. But, by being restricted in scale, there is the potential for more detailed investigations of the study area.

Though not an oceanographer, I can envision that the SEAK marine ecosystem is affected by the Gulf of Alaska, the configuration of the coastal channels and inlets, some very large rivers, and strong atmospheric influences. Thus, the stated goal of the SECM program of monitoring and detecting ecosystem change may be particularly challenging in such a dynamic setting, especially since the sampling design cuts across a variety of habitats from near-shore to open ocean. A different sampling protocol may be more appropriate for monitoring climate change.

Recommendation: The SECM program may be too broad in scope, given the available resources, and I would suggest that the team might benefit from a careful review of its scientific objectives, perhaps in a workshop-type format with some outside experts that could provide a broader context. Given the existing knowledge base, the discussion could focus on a research plan based on addressing questions of broad scientific interest, but also address the AFSC's management objectives. This exercise might consist of developing a conceptual ecosystem or food web model that could be used to identify knowledge gaps or research questions. The goal of the modelling exercise would be to prioritize the research efforts and to provide a framework and rationale for future work.

The Little Port Walter (LPW) and Auke Creek (AC) field stations.

ToR 1-E. The AFSC presently operates two permanent field stations in Southeast Alaska, at Little Port Walter (LPW) on Baranof Island and Auke Creek (AC) near the Auke Bay Laboratory. Research on a broad range of resource issues has been conducted for many years where each station, located on or near streams with healthy natural runs of anadromous salmonids, have experimental hatchery capabilities. Research at both stations has typically included cooperative involvement with other federal and state agencies, universities, and constituent groups. The review panel should provide input on the usefulness and relevance of research at these two stations in helping NOAA Fisheries develop a better understanding of the role salmonids play in regional North Pacific ecosystems and in helping to maintain healthy, viable salmon populations and their associated fisheries.

Question 5: Do the LPW and AC data time series add to our understanding of climate variability, biological productivity, and potential consequences of future climate change?

Long-term data sets of biological information are worth their weight in gold for studying environmental effects such as climate change. The collection of data at the AC station was described in some detail to the Panel, and it is a credit to Mr. Taylor and colleagues that this data series has been continued since the 1960s. The Auke Creek facility has also been the site of ground-breaking studies on salmon genetics by University of Alaska at Fairbanks faculty and collaborators, although this work was not the subject of the CIE review.

Personally, I have been aware of the data collected at Sashin and Auke Creeks for some time, but I had thought that the data were somewhat unavailable, or underutilized. We were told about efforts to summarize the information from Auke Creek, though not Sashin Creek. Sashin Creek data go back much farther, but it was unclear of the status of those data in recent years. I remain convinced that the data from both stations are underutilized.

The presentations delivered at the CIE review suggest some of the avenues of research that might be pursued with the AC and LPW time series. Changes in the physical environment in freshwater document a perhaps not-well perceived change in the coastal environment over the last half century. While simple statistics such as mean temperatures were presented, presumably a much more detailed analysis would be possible of the components of climate change in terms of water temperature, ice conditions, and potentially incorporating weather information from the Juneau airport.

The long record of biological data from these stations provides real links between the physical changes and the performance of salmon populations. For example, the studies of pink salmon survival in relation to timing of ocean entry could be used to look to predict the impacts of freshwater climate change on ocean survival, and the selective pressures on life history traits. We are often told that climate change will have positive benefits for Alaskan salmon populations because of changes in the ocean environment, but I do not believe those predictions have explicitly considered potential counteracting effects of changes in freshwater. Presumably changes in size, growth, age structure, timing or seasonality and productivity (survival) can also be examined.

Other questions, unrelated to climate change, could also be addressed by these data series. Because there are multiple species being sampled, it is possible to examine coherence in survival and other traits among species, consider interactions among them, and also coherence between freshwater and marine survival rates. Many other aspects of salmon population dynamics could be examined.

I recommend that ABL look to raising the profile of these long-term data series by engaging active salmon population dynamics researchers to explore these data more thoroughly. It seems that a number of high quality publications could arise from the datasets from collaboration between the very experienced ABL staff, and researchers more familiar with current understanding with climate change issues and population processes. This collaboration might be with graduate students supervised by an experienced faculty member, or via a post-doctoral fellowship program. The opportunity to take advantage of the vast experience of current ABL staff would be an important component of this collaboration.

Conservation Biology and Genetics Questions

ToR 1-B. Given that hatchery operations in the Pacific Northwest are identified as one of many causes for the decline in wild stock abundance (leading to multiple ESA listings), and given that Alaska, with generally abundant and healthy wild stocks also has a significant large-scale hatchery program, what level and types of hatchery-wild stock interaction studies are needed to address present and future Alaska salmon issues?

Question 1: The LPW Chinook program.

The questions being addressed by this program are very relevant to the large number of hatchery and conservation efforts underway in the Pacific Northwest. The distinct advantage of the LPW program is the simplicity of the underlying situation; effectively, there are relatively few hatchery populations in the region, and the donor stocks are isolated by distance from the hatchery operations.

The main results to date concerning changes in maturation schedules of the hatchery population relative to the donor stocks have been well-documented in other populations in the Pacific Northwest, and I would not consider those results surprising. If it can be thoroughly documented that the change in maturity rates are not due to selection for early breeders (this is what I was told during the panel review), then the response might by due to some form of selection on correlated traits. It is possible, for example, that there is a survival advantage for juveniles of early maturing parents because those individuals might end up being larger at the time of release into the ocean if their emergence times were earlier, and they had more opportunity for rearing than juveniles that were more delayed in their emergence.

There appears to be great potential to the experimental set-up for chinook salmon at LPW. The use of molecular or other markers to follow the fate of individual families (e.g., McLean, 2004 Ecology 85:2979-2985) is an opportunity to examine the traits that affect survival, growth, and maturation at sea. Imposed, directional selection can be used to test hypotheses about direct and correlated responses to hatchery practices. I would encourage the project leaders to set some specific program goals for the next few years that address some of the outstanding questions that remain regarding the implication of domestication on salmon populations. In my view, the program can enhance its visibility on an international scale by carefully considering existing knowledge and looking for research questions that both take advantage of the LPW situation and are innovative.

Finally, I was unable to find any publications on the LPW chinook experiments, with the exception of those related to aquaculture production issues and the Hard and Heard (1999) paper on straying. The development of a publication plan for this project might also be beneficial to organize the information that has been collected over the past 25 years, and help to prioritize future activities.

Question 2. Steelhead Program at LPW

I cannot comment on the technical aspects of this program, but I do support the general objectives as it is relevant to a number of conservation activities at an international scale. The investigators have published some of their results, and I would encourage them to stay abreast of salmon conservation efforts in other part of the Pacific basin to ensure their activities are timely, relevant, and leading-edge.

Question 3: Hatchery-Wild interactions in PWS and SEAK.

The issue of hatchery-wild interactions involving chum and pink salmon are basically ones of competition of juveniles for food and perhaps space. As I noted earlier this question has been raised in the Northeast Pacific over the past 25 years, and various studies have been conducted to consider these interactions.

Retrospective studies such as Wertheimer et al. (2004, in Leber et al.) can be useful at detecting possible interactions, and for developing working hypotheses for field studies. Correlative studies have to be interpreted with considerable care, especially when variables are inter-correlated, and time trends are present. In the case of Prince William Sound, pink salmon the findings of ABL staff are supported by the extensive interdisciplinary studies of UAF and ADF&G researchers. The main result appears to be that survival is heavily affected by density independent factors that affect both hatchery and wild populations, and although pink salmon can have a considerable impact on the food base, the advection of new material and the productivity of the region is sufficient to support large salmon populations. This is also consistent with the general finding that while adult salmon size is often affected by salmon abundance (see Peterman 1984 for an early indication of this finding), there is yet little evidence that salmon survival in the marine environment is density dependent.

I am unclear whether field studies such as those conducted in the Taku area or the SECM can shed further light on the question of competitive interactions among hatchery and wild pink or chum salmon without a more quantitative approach that addresses the dynamic nature of juvenile salmon use of these habitats, the productivity and flux of forage, and the role of other competitors. Some of these elements were addressed in the Orsi et al. (2004) paper for SECM project, but as I noted earlier, more effort should be given to a framework for how the key questions will be addressed.

ToR 1-C. What GSI research is needed to support ecosystem research in the North Pacific Ocean and forensic or enforcement activities? Are the technical methods used at ABL appropriate for the task?

Questions 4 and 5.

The technical aspects of these questions are beyond my area of expertise. I would note, however, that DNA analysis to determine stock origin and CWT recovery are now routine management activities, and the presence of these activities at ABL appears to one of historical arrangement among institutions, rather than any specific research need related to ABL's mandate.

Summary

The Auke Bay Laboratory has a long history of contributions to our knowledge of salmon in the North Pacific. Among its staff are individuals with vast experience of the local region, and in the activities and interplay of the many organizations and nations that

have a stake in salmon. Also, ABL has embarked on a number of long-term studies and is in possession of datasets that are both extremely rare and valuable.

We were told that salmon research at ABL is at a bit of a crossroads. In the past, ABL salmon projects were aimed at describing the local environment and addressing salmon issues of regional concern. But now the mandate of NMFS and AFSC has changed to be focused on a more habitat and ecosystem approach to management, and in particular to understanding the interaction between human activities and environmental factors on marine ecosystems. This is especially true for salmon where state and regional authorities are responsible for their day-to-day management.

In reviewing the ABL salmon programs in light of the changing institutional environment, I would urge ABL project leaders to begin to think about their work in a broader context, both in terms of the new mandate, and with respect to the most recent scientific developments. When I listened to the presentations, the stated goals or objectives of the programs did not always jump out at me from a scientific perspective. Sometimes, these were issues that have been worked on extensively in other areas, or the objectives were too broad to be operationalized. Many of the programs have developed enviable baseline or monitoring datasets, and these seemed well positioned for more detailed or focused studies to explore mechanisms, test hypotheses, or develop new ways to address long outstanding questions.

The need for an enhanced emphasis on the quality of science is evident from reviewing the ABL salmon publication list that was provided to us. With some notable exceptions, I found that relatively few papers have been produced for the front line journals in fisheries science, oceanography or ecology. There are many potential reasons for this, including institutional priorities and the culture within the laboratory. I would suggest that 'raising the bar' on the type of publications produced by the salmon sections would enhance their visibility and stature within NMFS and the greater scientific community.

In my report, I have suggested that ABL salmon researchers take some time to review their work in the broader scientific context to move away from a site-specific or case history-type approach. Is there a component of their work (or a direction) that would constitute a significant contribution of wide interest in that field that it could be published in a top journal? Is there a need for new personnel and expertise to move in those directions? I believe a slightly more 'aggressive' approach to designing studies would result in commensurate gains in quality of the science and the stature of the laboratory.

Finally, ecosystem approaches to management are integrative in nature, and that integration is probably best achieved by characterizing ecosystems with models. I recommend that ABL seek an ecosystem modeller whose charge would be to integrate the salmon program's results from the epipelagic zones that it samples with those of the benthic and groundfish program to explore possible tools for ecosystem management that meet the needs expressed by NMFS's new program direction.

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APPENDIX A

AFSC Salmon Research CIE Review

Draft Agenda and Panel Discussion Questions

Day	**Topic**	Duration (h)	Presenter
Day 1 8:30 am – 5:30 pm	**Introduction** **8:30-10:30**	Welcome (15 min) Rules (10 min) Lab overview (AFSC) (20 min) Salmon: history (abundance, politics, research: build to WHY we are here NOW) (1/2 hour) Problems (1/2 hour): State management/Federal research/International Management Direction from AFSC on salmon management	Steve
	Ocean Ecology and Climate 10:45 – 5:30 *(Lunch provided)*		
	BASIS overview	0.5 h	Jack
	Ocean Ecology and Climate Question 1	2 h overview 10 min discussion 50 min answer questions 30 min	Jack
	Ocean Ecology and Climate Question 2	1-1/2 h overview 10 min discussion 40 min answer questions 20 min	Jack
	Ocean Ecology and Climate Question 3	1 h overview 10 min discussion 30 min answer questions 15 min	Jack
	No-host dinner 7:00 pm - TBA		
Day 2 8:30 am – 6:00 pm	SECM overview	½ h	
	Ocean Ecology and	1-1/2 h	Bill

	Climate Question 4	overview 10 min discussion 40 min answer questions 20 min	
	Ocean Ecology and Climate Question 5	1 h overview 10 min discussion 30 min answer questions 15 min	Bill
	Conservation Biology and Genetics 11:30 – 6:00 *(Lunch provided)*		
	Conservation Biology and Genetics Question 1	1 h overview 10 min discussion 30 min answer questions 15 min	Bill
	Conservation Biology and Genetics Question 2	1 h overview 10 min discussion 30 min answer questions 15 min	Bill
	Conservation Biology and Genetics Question 3	1 h overview 10 min discussion 30 min answer questions 15 min	Alex
	4 Conservation Biology and Genetics Question 4	1 h overview 10 min discussion 30 min answer questions 15 min	Jack
	Conservation Biology and Genetics Question 5	1 h overview 10 min discussion 30 min answer questions 15 min	Jack/Bill
	Dinner on own		
Day 3 8:30 am – 5:30 pm	Panel discussion *(Lunch provided)*	2-1/2	
	Panel followup questions with staff	1	

	Panel discussion and writeup	4	
	Closeout	½	
	TOTAL HOURS	24	

Ocean Ecology and Climate Questions

1. The Bering-Aleutians Salmon International Survey (BASIS) project examines the ocean ecology and climate of the Bering Sea. Trophic interactions occur between gadids, salmonids, and clupeids in the epipelagic ecosystem of the Bering Sea. An objective of this project is to understand how trophic dynamics affect distribution, abundance, growth, and condition of fishes of the epipelagic ecosystem of the Bering Sea. Does this project meet this objective and why? What other research could be conducted to address this objective?
2. Large-scale changes in the Bering Sea ecosystem have been attributed to climate changes, such as loss of sea ice and warmer sea temperatures. Another objective of BASIS is to understand how these changing ocean conditions and climate affect distribution, abundance, growth, and condition of fishes of the epipelagic ecosystem of the Bering Sea. Does this project meet this objective and why? What other research could be conducted to address this objective?
3. Climate and ecosystem indicators can be used to support an ecosystem approach to management. Examples of such indicators are time series of fish growth and abundance, zooplankton abundance, and episodic phytoplankton blooms. Another objective of BASIS research is to develop indicators that measure climate and ecosystem change in the Bering Sea. Does this project meet this objective and why? What other research could be conducted to address this objective?
4. The Southeast Coastal Monitoring (SECM) project examines the ocean ecology and climate of southeast Alaska. Research cruises include multiple time series of observations of epipelagic trawling and associated biophysical measurements in an important migration corridor for juvenile salmon. Other important species competing for the same resources include gadids, clupeids, and cetaceans. Objectives of this project are to develop an understanding of the trophic dynamics and ocean conditions of the epipelagic ecosystem of southeast Alaska and to compare the Southeast ecosystem with the Gulf of Alaska and the Bering Sea. Does this project meet this objective and why? What other research could be conducted to address this objective?
5. The AFSC presently operates two permanent field stations in Southeast Alaska, at Little Port Walter (LPW) on Baranof Island and Auke Creek (AC) near the Auke Bay Laboratory. The stations provide long time series of data on salmon productivity, life history parameters, and climate. The objective of these time series is to add to our understanding of climate variability, biological productivity, and potential consequences of future climate change. Does this project meet this objective and why? What other research could be conducted to address this objective?

Conservation Biology and Genetics Questions

1. Chinook salmon hatchery programs in Southeast Alaska, a region with a limited number of relatively small wild stocks of Chinook salmon, were developed to compensate for catch limitations imposed under US-Canada salmon treaty accords even though hatcheries in other areas have been identified as one significant cause of stock declines and ESA listings. ABL conducts research on two experimental hatchery stocks of Chinook salmon at a remote field station by making comparisons with multi-generations of hatchery fish and their wild founder counterparts that are unaffected by habitat loss, introductions of other fishes, or hatchery influences. The objective of this research is to understand if, how, and why changes in hatchery stocks differ from their wild founders and to help avoid pitfalls related to hatchery-caused declines in wild stocks. Does this project meet this objective and why? What other research could be conducted to address this objective?
2. The experimental conditions for steelhead research at ABL, broadly supported by cooperative participation with partners including NOAA scientists and others from the Pacific Northwest (including in some cases funding support), are not available in other regions. Unique genetic gene banks exist in Alaska such as 70 years of freshwater isolation of an anadromous-origin population of steelhead in a lake, which may be useful in ESA recovery programs in the Pacific Northwest where, for example, ten Evolutionarily Significant Units (ESUs) of steelhead are listed under ESA. The objective is to determine if these unique genetic gene banks can be used in the ESA recovery programs. Does this project meet this objective and why? What other research could be conducted to address this objective?
3. Large scale hatchery programs for pink salmon in Prince William Sound and chum salmon in Southeast recently have been implicated in declines in wild stock productivity for these species in those regions. ABL scientists participate and take leadership roles, along with university, state, and private sector partners, in related research programs in these regions, including retrospective modeling studies, to examine if and how these hatchery programs may be affecting productivity of wild stocks. One objective of ABL hatchery-wild stock interaction research is to better understand if hatcheries pose a threat to healthy wild stocks, including through ecosystem change. Does this project meet this objective and why? What other research could be conducted to address this objective?
4. Objectives of the salmonid portion of the fish genetics research unit at ABL, using allozyme, mtDNA, microsatellite DNA, and single nucleotide polymorphisim (SNP) techniques, are to: 1) identify discrete stocks or unique geographic groupings of salmon stocks caught in mixed stock fisheries; 2) make forensic determinations of stock origins of salmon caught in illegal fisheries; and 3) determine stock-specific migration pathways of salmon in oceanic waters. Does this project meet this objective and why? What other research could be conducted to address this objective?
5. A major management concern for NOAA Fisheries in Alaska is monitoring and documenting bycatch of prohibited species, including salmon, in large groundfish fisheries in the Gulf of Alaska and Bering

Sea. The numbers and stock origins of salmon bycatch become important issues for the management and continuance of the groundfish fishery as well as the well being of salmon stocks involved. Two ABL research programs, the use of genetic stock identification (GSI) techniques and coded wire tags (CWT), are currently utilized in monitoring and documenting stock origins of salmon bycatch in these fisheries. The objective of this work is to determine the stock origin of salmon bycatch in these fisheries. Does this project meet this objective and why? What other research could be conducted to address this objective?

Appendix B

STATEMENT OF WORK
Consulting Agreement between the University of Miami and Dr. Michael Bradford

July 25th, 2005

General

Most salmon-related research at the Alaska Fisheries Science Center (AFSC) is currently conducted by scientists at the Center's Auke Bay Laboratory (ABL) near Juneau, Alaska. There is a long history behind Federally-based salmon research in Alaska waters dating to pre-statehood periods involving predecessor agencies of NOAA Fisheries (the original Bureau of Fisheries in the Department of Commerce and the Bureau of Commercial Fisheries in the Department of Interior). Following Alaska statehood in 1959, management of salmon fisheries within state jurisdictional waters became the purview of the State of Alaska. During the first 20 years of statehood, NOAA Fisheries (then the Bureau of Commercial Fisheries, Department of the Interior) supported state management with extensive basic research on many aspects of freshwater and early marine salmon life history. This research was conducted at the ABL and its five field stations located from Bristol Bay to Southeast Alaska. Outside of state waters and within the U.S. EEZ (between 3 and 200 miles), management of salmon fisheries remained a Federal responsibility and is now under the purview of the North Pacific Fishery Management Council (NPFMC). It should be noted that NOAA Fisheries spends over $50 million annually on salmon issues in the Pacific Northwest and about $3 million in Alaska, not counting pass through funds to states and other entities.

International treaties and accords requiring conservation and management of Pacific salmon on the high seas among North Pacific Rim countries have provided an additional Federal element requiring active participation in these arenas by NOAA scientists. As a result, research focused on Alaska salmon resources and related issues by NOAA Fisheries has continued to the present day and is centered on the overriding need for wise use and conservation of these resources plus the rationale that Pacific salmon, a vital keystone living U.S. marine resource, are a significant component of major North Pacific marine ecosystems in terms of total biomass and trophic interactions. AFSC salmon related research also involves a broad range of cooperative partnerships with international fora, academia, other Federal agencies, private sector, and industry constituents.

Four Programs are involved in salmon research at ABL; Marine Salmon Interactions (MSI), Ocean Carrying Capacity (OCC), Stock Identification and Analysis (SIDA) and Habitat Investigations (HI).

Marine Salmon Interactions (MSI) research involves two broad areas, Early Ocean Salmon (EOS) and Stock Enhancement Aquaculture (SEA). The EOS component is focused on early marine ecology of juvenile salmon and associated species. This research considers effects of biophysical parameters, climate fluctuations and inter-

annual variability on the abundance and distribution of salmonids within various marine habitats and development of year-class strength leading to recruitment and ultimate adult production. EOS maintains a long-term time series of five research cruises conducted annually with repeated sequential sampling at 13 stations along a major migration corridor as young salmon move through different habitats from inshore to offshore waters. The SEA component of MSI is focused on enhancement technology, brood stock development, hatchery-wild stock interactions, and Endangered Species Act related research for listed stocks of salmonids. MSI operates and manages two field stations: Little Port Walter (LPW) Station on Baranof Island and Auke Creek (AC) Station near ABL. Both stations have well developed experimental hatchery capabilities for anadromous studies and operate permanent counting weirs on significant salmon streams. AC maintains a long-term time series of involving environmental and climatic data along with freshwater and marine survival profiles on 7 species of endemic salmonids. MSI also operates and co- manages a modern food habitats, stomach content, and plankton analysis laboratory, an image-analyses laboratory, and a coded-wire tag laboratory.

The Ocean Carrying Capacity (OCC) Program conducts research in the Gulf of Alaska and the Bering Sea to learn what marine conditions limit production of salmon and associated marine species. After the Ocean Regime Change of 1976-77, salmon populations in North America from central British Columbia northward throughout Alaska and in Asia increased to record levels. However, research at the Auke Bay Laboratory showed that by the mid-1980's most species of salmon had become significantly smaller in size and older in age: e.g., by the early 1990's chum salmon had become about 46% smaller in weight than they were in the early 1970's in both North America and Asia. These size and age changes suggested that carrying capacity for salmon in the North Pacific Ocean was limited under certain conditions. The OCC Program was initiated in 1995 to address these issues about carrying capacity. The research strategy for this Program has three major components: 1) research on the distribution and migration of juvenile, immature, and maturing salmon and associated marine species in coastal and offshore waters; 2) monitoring age and size at maturity and abundance of salmon populations; 3) retrospective studies on changes in age and growth of salmon populations. In 2002, the OCC Program became involved in a basin-scale ecosystem study of salmon and forage fish populations throughout the Bering Sea in collaboration with Japan and Russia. This study is called the Bering-Aleutian Salmon International Survey (BASIS) and is coordinated through the North Pacific Anadromous Fish Commission which is made up of the USA, Canada, Japan, Russia, and Korea.

Stock Identification and Analysis (SIDA) research at ABL is centered around the development of genetic markers to identify discreet stocks or geographic groupings of Pacific salmon and several rockfish species and to identify species of larval rockfish. Most of the research is directed at salmon issues which include identification of stocks or groups of stocks of salmon harvested in various mixed stock fisheries, caught as bycatch in U.S. groundfish fisheries, seized from illegal high-seas driftnetters by the U.S. Coast Guard, or migrating through the Bering Sea and the Gulf of Alaska. Techniques used are allozymes, mtDNA, microsatellite DNA and single nucleotide polymorphisms (SNP). These markers are being developed in cooperation with U.S. State and Federal Agencies

and universities, and fisheries agencies of Canada, Japan, Russia, and the Republic of Korea. SIDA researchers are also actively involved in the development of statistical methods for stock identification analyses, the most recent of which is a new Bayesian statistical technique that allows estimation of stock structure in mixed-stock samples without the knowledge of baseline information.

The Habitat Investigations (HI) Program emphasizes chemical and ecological processes that occur in a variety of habitats ranging from coastal, to tidal, to watershed habitats. Current research focuses on contaminants, habitat utilization, bioenergetics, and habitat restoration. Contaminants research quantifies threats from polycyclic aromatic hydrocarbons (PAH) to reproductive, nursery, and feeding habitats for various life stages of salmon, herring, and groundfish. Much of this work has focused on assessing the long term effects of the Exxon Valdez oil spill, but there is PAH research on other issues such as monitoring releases of pollutants from 2-stroke recreational water craft. Research on nearshore habitats is used to identify essential fish habitat, particularly by sensitive life stages of many different fish, and to identify the chemical or physical impacts of human development on quality of eelgrass and kelp bed habitats. Bioenergetic research assesses the nutritional value of forage species, including juvenile salmon, as measured by changes in lipid class, fatty acid, and caloric composition of these forage species. Such studies seek to evaluate how habitat quality changes seasonally and spatially by understanding how a prey organism allocates energy between growth, reproduction, and fat storage. Habitat restoration research focuses on restoring an urban salmon stream to a productive state.

The AFSC salmon research peer review will evaluate the relevance and appropriateness of ongoing research by AFSC scientists focused, at least partially, on Pacific salmon resources occurring throughout the Gulf of Alaska, Bering Sea, and adjacent waters. Due to differing life histories and varied migration patterns salmon involved in these marine waters originate not only from Alaska streams and lakes but also from Pacific Northwest states and other countries around the North Pacific Rim including Canada, Russia, Japan, China, and Korea. This CIE review should evaluate current salmon studies at AFSC, and, if needed, recommend changes in their scope and direction, along with suggested levels of funding and personnel to accomplish this research.

The AFSC salmon research review will require 3-4 nationally and internationally recognized authorities in one or more of the following disciplines: marine ecology, Pacific or Atlantic salmon biology, animal behavior, population dynamics, fisheries genetics, international fisheries treaties and accords, salmon hatchery issues, and freshwater and marine salmon habitat issues.

The AFSC will provide a detailed background document on current salmon-related research at AFSC/ABL along with a set of relevant papers, publications and documents of recent research results to support this review.

Terms of Reference

The terms of reference for the AFSC salmon research review are as follows:

TOR #1: The AFSC's primary research mission is to generate the best scientific data available for understanding, managing, and conserving living marine resources in Alaskan waters and the environmental quality essential for their existence. Primary species of interest are groundfish, crab, and marine mammal populations. Salmon are an important secondary species due to research responsibilities derived from international agreements. In addition, AFSC salmon programs receive direct funding from Congressional PPAs and NOAA research initiatives pertaining to ESA-related issues, the ecological role of salmon in the marine environment, and enhancement technology and impacts. The review panel should provide input on recommended directions in AFSC salmon related research in Alaska, and identifying appropriate levels of research directed at salmon management questions and at Alaskan ecosystem and habitat issues.

Specific questions to be addressed by the review panel in regards to this TOR include the following:

A. What applications of marine salmon research at AFSC best provide an understanding on the effects of climate/physical drivers that may cause changes in aspects of North Pacific ecosystems such as trophic food webs and forage fish populations?

B. Given that hatchery operations in the Pacific Northwest are identified as one of many causes for the decline in wild stock abundance (leading to multiple ESA listings), and given that Alaska, with generally abundant and healthy wild stocks also has a significant large-scale hatchery program, what level and types of hatchery-wild stock interaction studies are needed to address present and future Alaska salmon issues?

C. What GSI research is needed to support ecosystem research in the North Pacific Ocean and forensic or enforcement activities? Are the technical methods used at ABL appropriate for the task?

D. The North Pacific Anadromous Fish Commission (NPAFC), a five nation International Convention focused principally on salmon resources of the North Pacific Ocean, encourages coordinated and cooperative research by member parties in both Convention Area waters and adjacent territorial seas. As the NPAFC Science Plan calls for research focused on early marine life of salmon, how can ABL research on juvenile salmon best provide a better understanding of the role salmon play in various components of the North Pacific ecosystem?

E. The AFSC presently operates two permanent field stations in Southeast Alaska, at Little Port Walter(LPW) on Baranof Island and Auke Creek (AC) near the Auke Bay Laboratory. Research on a broad range of resource issues has been conducted for many years where each station, located on or near streams with healthy natural runs of anadromous salmonids, have experimental hatchery capabilities. Research at both stations has typically included cooperative

involvement with other federal and state agencies, universities, and constituent groups. The review panel should provide input on the usefulness and relevance of research at these two stations in helping NOAA Fisheries develop a better understanding of the role salmonids play in regional North Pacific ecosystems and in helping to maintain healthy, viable salmon populations and their associated fisheries.

TOR #2: Three years ago, the NPAFC initiated BASIS (Bering-Aleutian Salmon International Survey), a yearly, basin-scale survey of the Bering Sea's pelagic ecosystem using survey vessels from Russia, Japan, and the USA. This international research program was developed by ABL scientists who continue to maintain a strong leadership role in this program. Although BASIS studies ostensibly address salmonid issues in the Bering Sea, research on forage fishes and the Bering Sea ecosystem have been key components of the national BASIS research programs. The review panel should provide input to the AFSC on the utility of BASIS research programs.

Specific questions to be addressed by the review panel in regards to this TOR include the following:

A. What is the potential for BASIS surveys to address current Bering Sea non-salmonid management and ecosystem research needs: what key management and scientific questions/hypotheses could be addressed by BASIS, either in its current form or through an augmented program?
B. How can the AFSC best utilize BASIS as part of its research mission in Alaska?

The report generated by the consultant(s) should provide recommendations addressing each of the terms of reference and specific questions stated in this statement of work.

Specifics

The consultant's tasks consist of the following:

1) Become familiar with the AFSC salmon research program and other pertinent literature.
2) Attend the salmon research peer review meeting in Juneau-Auke Bay, Alaska from July 11 – 14, 2005.
3) Develop a report based on the terms of reference for the review.
4) No later than July 28, 2005, submit a written report consisting of the findings, analysis, and conclusions (see Annex I for further details), addressed to the "University of Miami Independent System for Peer Review," and sent to Dr. David Die, via e-mail to ddie@rsmas.miami.edu, and to Mr. Manoj Shivlani, via e-mail to mshivlani@rsmas.miami.edu.

Submission and Acceptance of Reviewer's Report

The CIE shall provide via e-mail the final reports of the consultants in pdf format to Dr. Lisa L. Desfosse for review by NOAA Fisheries and approval by the COTR, Dr. Stephen K. Brown by June 10, 2005. The COTR shall notify the CIE via e-mail regarding acceptance of the report. Following the COTR's approval, the CIE shall provide the COTR with pdf versions of the final report with digitally signed cover letters.

Appendix C

The following materials were provided to the panel prior to the review:

1. AFSC future research directions.
2. ABL Salmon program research summaries.
3. CIE Agenda and questions (which appears as Appendix A above)
4. ABL 2005 Milestones
5. ABL 1995-2005 salmon publication list.