Response for 30002: Optimization of FCRPS Impacts on Juvenile Salmonids: Restoration of Lower-Estuary and Plume Habitats

Abstract for 30002:

This project assembles a group of leading coastal scientists to tackle a complex, urgent problem, optimization of the interaction of the Federal Columbia River Power System (FCRPS) with the lower Columbia River estuary and plume in support of endangered salmonids. The timing and magnitude of flows released by the FCRPS strongly affect juvenile salmonids as they move through the estuary and plume. Restoration of the properties of the lower estuary and plume that constitute habitat for juvenile salmonids requires advances on several fronts. We seek to:

- *Objective 1: Define how the lower-estuary and plume interacted historically with coastal currents, how operation of the FCRPS has altered the lower-estuary and plume, and how climate change and the FCRPS will impact the system in coming decades.*
- *Objective 2: With Action Agencies, define needs and opportunities for science-based input to operational FCRPS management practices, given uncertain climate and coastal circulation forecasts.*
- *Objective 3: With FCRPS managers, define management scenarios: a) that are based on physical understanding, b) that can be evaluated in terms of habitat opportunity and other constraints on the system, and c) whose implementation can lead to a qualitative improvement in survival of juvenile salmonids.*

Innovative oceanographic methods, remote sensing, management science and analyses of numerical model results will be used to achieve the goals of the project, as it moves from research toward provision of definite strategies over the next 6 to 10 years. A Project Advisory Board (PAB) that includes Action Agency personnel, FCRPS managers and external scientists will be formed to help ensure productive application of the insights achieved. Tight cooperation with work carried out in the estuary and plume by the National Marine Fisheries Service (NMFS) will be facilitated by participation of PIs in this project as well as in two projects proposed by NMFS.

Introduction to Response -- Relationships with other Proposals

This project is one of the three linked proposals: 199801400 ("*NMFS-Plume*"), 30001 ("*NMFS-Estuary*"), and 30002 (this proposal, "*Optimization*"). Together, these projects address recovery of the Columbia River estuary and plume as diverse and vital habitats for juvenile salmonids. We believe that future 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 of all three is crucial in order to provide sufficient knowledge to define useful future management options. The whole is greater than the sum of the parts!

The *Optimization* project is unique in several respects:

1. Management Scenarios: *Optimization* will define future management scenarios that are based on scientific understanding of the estuary and plume, and Pacific Northwest climate processes. Management strategies for the estuary and plume cannot provide benefits to juvenile salmon without this scientific basis. Although *NMFS-Plume* involves some of the same investigators as *Optimization*, the role of Foreman, Hickey, Kosro and Miller in *NMFS-Plume* is to provide specific data or numerical model products in the first two years of the program. They will not in most cases be involved in subsequent years of *NMFS-Plume*. Thus, their intellectual contribution to understanding historical and current plume processes and defining future management scenarios comes only through the *Optimization* project.

2. Habitat Opportunity: *Optimization* will help define habitat opportunity metrics that facilitate evaluation of management scenarios via the numerical modeling funded by *NMFS-Plume* and *NMFS-Estuary*. Without new insights from the physical and climatological analyses funded by *Optimization*, it will be very difficult to devise the physical metrics that can be evaluated in a numerical model and that decisively differentiate current and future management practices. For example, a definition of a useful habitat opportunity metric related to fronts requires not only defining how fronts affect salmonids (by *NMFS-Plume* and *NMFS-Estuary*), but also using historic and current data to understand how fronts respond to the FCRPS and coastal forcing (by *Optimization*). Similarly, the remote sensing performed by *Optimization* is vital to understanding how the plume turbidity and Chlorophyll fields should be included in habitat metrics. Insights gained through *Optimization* will guide the representation/modeling of these fields by *NMFS-Plume*.

3. Management Science: *Optimization* will use management science to analyze the annual FCRPS decision cycle in critical years (e.g., extreme high and low flow and strong ENSO years) to determine how FCRPS managers use forecast information. The concept of analog years (e.g., representing future management scenarios in terms of representative past years) will be used to formulate management strategies, in consultation with FCRPS managers (through a Project Advisory Board or PAB). Using this approach, our management scenarios will have real practical utility for improving juvenile salmonid survival in the estuary and plume, a utility that is not provided by any other project. Effort expended in this area will reduce the time required to devise new management strategies for the FCRPS and make the strategies proposed more accessible to FCRPS managers.

4. Multi-Year Observations: Only *Optimization* will make multi-year measurements of physical processes, beginning before and extending after the proposed *NMFS-Plume* observations in 2004. Two categories of physical data are especially critical: a) measurements of small-scale processes in fronts and eddies that provide plume salmonid habitat, and b) aircraft remote sensing of salinity, turbidity and Chlorophyll. Turbidity and Chlorophyll cannot be modeled at this time, and turbidity will not be modeled at all by *NMFS-Plume* and *NMFS-Estuary*. While they are critical parameters for salmonid survival, there is little knowledge base about there behavior at this time. Without the data provided by *Optimization*, biological results will be difficult to use to guide formulation of future management scenarios.

5. Coordination: *Optimization* will provide key linkages to other ongoing and proposed studies of Pacific Northwest coastal oceanography. The plume is a poorly understood environment. Other funded and proposed research could, over the next few years, contribute considerably to the understanding of the plume's coastal circulation, primary production context, and particle dynamics as they impact salmonid survival. These new insights are important for genera-

tion of useful management scenarios. Without the participation of PIs Hickey, Kosro and Miller in *Optimization*, linkages to other research programs that will generate these insights will be lost after the numerical model demonstration is completed (year 2). Loss of the opportunity to direct the attention of these other programs toward Pacific Northwest Salmon issues would be unfortunate. Programs like the upcoming National Science Foundation (NSF) Buoyancy Initiative (starting 2003) are highly competitive, and funding is limited. Any given program can only address a defined suite of issues. Funding of *Optimization* would improve the chances of bringing additional funding to the plume area and increase the amount of attention given to salmon issues in other programs. The highly leveraged funding of these PIs through *Optimization* would, therefore, have an unusually large payoff for the FCRPS. Timing is also critical. Delayed funding of *Optimization* would weaken the chances of bringing other projects to the Pacific Northwest and decrease the attention given to salmon issues in the programs that are funded.

The role of the *Optimization* project can also be understood in terms of the definitions of monitoring provided on p. 12 of the *Preliminary Review* document:

> ***Tier 3 (research) monitoring*** *is for those projects or groups of projects whose objectives include establishment of mechanistic links between management actions and salmon or other fish or wildlife population response (NMFS Tier 3). Bisbal (2001) defines this level of effort as effects or response monitoring; the repeated measurement of environmental variables to detect changes caused by external influences. The key words here are "establishment of mechanistic links" and "detect changes caused by external influences."*

Effective future management of the FCRPS to benefit juvenile salmonids in the estuary and plume requires establishing linkages between changes in plume processes and forcing by climate and the FCRPS. *Optimization* brings together the "critical mass" of Pacific Northwest coastal scientists that makes possible the necessary conceptual advances. Their analyses will be carefully coordinated with the numerical modeling program and biological analyses to be carried out by *NMFS-Estuary* and *NMFS-Plume*, so that the insights gained will contribute to development of new management strategies that would not otherwise be generated.

Response to General Comments:

General Comment: "*While the ISRP fully agrees that "the project assembles a group of leading coastal scientists", with the need to consult with management agencies, and the potential value of establishing a Project Advisory Board, we are concerned that the current knowledge level does not justify this level of effort at this time. However, as we have noted above, this may simply reflect our current understanding of how these activities fit together.*"

Response: Development of future management strategies must be based on carefully integrated physical and biological analyses and numerical modeling, as described in our three linked proposals. The CORIE plume model will be calibrated and validated by the end of 2003, with a model demonstration in yr 2. Still, development and evaluation of management scenarios requires new physical process understanding (generated from existing and newly collected data) and will generate demands for new observations to resolve issues that arise during analysis of scenarios. If useful management scenarios are to be generated in less than a decade, then sub-

stantial involvement of physical scientists is essential from the outset. This point can be illustrated by considering the potential strategies mentioned in Section 9.b.8 (under "Scientific Background, p. 13). Consider the idea that flow cycle could be managed relative to coastal upwelling and the spring transition date. In this way, river flow could be timed to improve the plume and coastal production that is essential to juvenile salmon survival. Since only a limited flow volume is available in spring, implementation of some such scheme seems almost unavoidable. Yet implementation of such a scenario would require a quantum improvement in our understanding how the plume and coastal upwelling interact, and how the resulting production and particle fields affect salmonids. Observations, analyses and modeling of El Niño and La Niña years are required. The relevant physical observations and analyses are not funded by *NMFS-Plume*. Beginning the process now is vital, given strong inter-annual climate variability and the time constraints set by the *Biological Opinion*. See also the comment (above) on coordination.

General Comment: "*The majority of the scientific background and tasks, however, address Objective 1 that is very similar to objectives and tasks included in proposal #199801400. Objective 2 is limited to analysis of the use of climate information by FCRPS managers (page 25), and Objective 3 involves the development and analysis of management scenarios to improve salmon production in estuary and plume.*"

Response: The relationships amongst the three linked proposals is summarized in Figure 1, while the structure of the *Optimization* proposal is summarized in Figure 2. It is correct that most of the effort of *Optimization* is associated with multi-year acquisition of vital vessel and remote sensing data and data analyses. However, the analyses in Objective 1 include those of numerical data from model runs (by *NMFS-Plume*) describing historical and future management scenarios. *Optimization* will, moreover, be coordinated with *NMFS-Plume* and *NMFS-Estuary*, so that there is no overlap with either project. As noted above, *Optimization* is the only project that will allow future management scenarios to be defined on the basis of physical process understanding and analyses of the FCRPS decision process. With regard to Objectives 2 and 3 of *Optimization*:

- Objective 2 provides the management science basis for formulation of useful management scenarios. As noted, Objective 2 analyzes the annual FCRPS decision cycle and the use of uncertain environmental forecasts (e.g., of flow and temperature) by decision-makers. There are compelling reasons for this course of action. First, these forecasts are amongst the most important information used in FCRPS management. Second, future management scenarios will be much more useful if they are formulated in a way that allows FCRPS managers to recognize similarities to (and departures from) management practices in recent years. Finally, the scientists involved in the project must understand how the FCRPS has responded to past challenges (extreme flows, ENSO years) in order to apply their insights to the process. Although this task consumes relatively few resources, it is vital to the success of all three linked proposals. Note also that Dr. Pulwarty (the PI that will carry out Objective 2) will also be involved in Objective 3.

- Objective 3 provides for the definition and evaluation of proposed management scenarios by the PIs and the Project Advisory Board (PAB). *NMFS-Plume* and *NMFS-Plume* carry out the actual computer simulations that embody the scenarios, and the analyses of the numerical data making up each scenario are part of Objective 1. Objective 3 then evaluates the implica-

tions of each scenario for the FCRPS, likely resulting in modifications and improvements. Substantial input from the Pacific Northwest coastal science community to this process will only occur through *Optimization*. This participation is critical to achieving a systematic connection between proposed future scenarios and the climate and coastal forcing that in large part control estuary and plume habitat. Especially if the Management Workshops (Objective 5 of *NMFS-Plume*) are delayed, the participation of the PAB in developing 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.

General Comment: "*Note: Footnote 1, section 9b limits the study area of this proposal to lower estuary seaward of Rm-5 and the plume, and surrounding coastal areas of central Oregon and southern Washington*".

Response: This definition of the primary area of interest is based on physical reasoning. The origin of the plume (the plume lift-off zone) is almost always seaward of RM-5. Thus, our area includes the plume and surrounding coastal waters relevant to the study of the plume. This definition also provides overlap with the study area of *NMFS-Estuary*. The area of overlap includes the fronts associated with plume lift-off that are of interest to all three projects. Aircraft remote sensing of salinity, temperature, Chlorophyll and turbidity will, however, will extend landward of RM-5 and include a larger part of the estuary, in part for operational reasons. Flights will originate in the estuary at Warrenton, so coverage of the entire salinity intrusion reach of the system can occur rapidly at the beginning and/or end of each flight. These remote sensing data will be quite beneficial to *NMFS-Estuary*.

Response to Specific Comments:

Comment: 1) "*Section 9f, page 10. Figure 6. The symbols in Figure 6 are not printed correctly in the caption making interpretation of the figure impossible. The figure is the same in printed copies and on the CD.*"

Response: Figure 6 has been provided in hardcopy.

Comment: 2) "*Objective 1, tasks 1.a. and 1.b. It is not at all clear to the ISRP why these data collection and analysis tasks are not part of the Plume proposal (#199801400), and how these data would be integrated into the large analysis under that proposal. In meetings we were informed that the numerical modeling of the plume dynamics would be conducted under the Plume proposal but these analyses seem inconsistent with that understanding. (also see Section 9d.)*."

Response: The existence of two separate proposals (*NMFS-Plume* and *Optimization*) allows participation of the Pacific Northwest coastal scientists in formulation of science-based management scenarios. We have jointly decided that the projects can be more effectively managed and the scientific work more efficiently carried out through overlap of PIs between proposals rather than through a hierarchical structure within a unified proposal. Joining the proposals together would change the management structure but would have only a marginal effect on total costs.

In terms of differentiating functions, *NMFS-Plume* provides only the physical data collection (in 2004) and analyses strictly necessary for demonstration of the CORIE numerical modeling. The analyses in Objective 1 include, moreover, those of the numerical data generated by historical and management scenarios. The work in Objective 1 is included in *Optimization* (not *NMFS-Plume*) because the PIs that will carry out the bulk of the analyses are involved in *NMFS-Plume* only for provision of specific data or modeling products. Optimization also provides the multi-year collection of physical data necessary for the development of soundly based future management scenarios. As noted previously, the most critical categories of data are: a) process data regarding the response of small-scale processes to river flow and coastal forcing, and b) remote sensing of properties not modeled by *NMFS-Plume* and *NMFS-Estuary* (e.g., turbidity and Chlorophyll). Frontal properties, turbidity and Chlorophyll will all figure prominently in definitions of habitat opportunity.

Comment: 3) *A critical uncertainty to us is the lack of definition of "habitat opportunity", a term used as a metric for salmon habitat suitability in the Plume proposal and this proposal. A useful clarification for both proposals would be how the investigators intend to define that metric and what types of parameters would be involved. A related concern would be how easily such a metric could be measured without extensive and costly surveys?*

Response: All three linked proposals use habitat opportunity metrics to evaluate the merits of future management scenarios. Definition of habitat opportunity for the plume is primarily the responsibility of *NMFS-Plume*, but requires insights from the biological and physical scientists, input from FCRPS managers and definition of the FCRPS decision-making context. The evaluation of habitat opportunity for management scenarios will be carried out using the CORIE numerical model (modeling funded by *NMFS-Plume* and *NMFS-Estuary*), so that no surveys are required for this purpose. This approach has been demonstrated in prototype for the estuary by Bottom et al. (2001). As stated in *NMFS-Plume*, initial definition of habitat metrics will likely involve properties that can be modeled or estimated in the near future: plume area and volume, frontal properties (perhaps including relationships to upwelling fronts), plume salinity, plume orientation and turbidity. As *NMFS-Plume* biological models become functional, Chlorophyll will likely be added. While it is clear that metrics can be defined and modeled, detailed definitions of metrics are an output from the proposed work not an input. If the suggested management scenarios were actually implemented, then implementation monitoring would be required. Emphasis will be placed on habitat opportunity metrics that could, when scenarios are implemented, be monitored by remote sensing, to minimize costs.

Bottom D.L., C.A. Simenstad, A.M Baptista, D.A. Jay, J. Burke, K.K. Jones, E. Casillas, M.H. Schiewe, 2001, *Salmon at river's end: the role of the estuary in the decline and recovery of Columbia River salmon*, National Marine Fisheries Service, Seattle, WA., 271 pp.

Comment: 4) *The ISRP is concerned that the term "Optimization" is misleading in that it implies a single recommendation and maximum production of salmonids. This Region has surely learned that this is not realistic and we do not believe that these proponents endorse such a simply "best" inference (their objectives do not use this term). If the Basin incorporates climate change and plume dynamics into their annual FCRPS management plans in order to improve*

salmon production that would be a significant contribution from this research (*although the economic and social components of these management decisions should likely also be factored in*)

Response: The PIs strongly agree that the term "optimization" should not be interpreted to imply that there is a single optimum solution to salmon management problems. The dilemma in most adaptive management programs is that the problem is over-constrained. Not all constraints can be satisfied by any management regime, and variable environmental and economic conditions may cause the utility of a given solution to vary widely from year to year. Our choice of wording emphasizes our belief that considerable improvements in juvenile salmonid survival are possible, if the response of salmonids to the estuary/plume physical environment and the response of the physical environment to FCRPS forcing are defined and modeled. Moreover, development of a better understanding of the role of the plume and estuary in juvenile salmonid survival may actually ease some management conflicts. When for example, the needs of different stocks impose conflicting demands regarding flows in more landward parts of the basin, it may be possible to benefit one stock in the river and one in the estuary/plume. Management science (Objective 2) and input from the PAB (Objective 3) will help us in understanding the many components of FCRPS management decisions. Understanding the broader context in which FCRPS managers must function is vital to formulating science-based management scenarios that are also practical.

Comment: 5) *If objectives 2 and 3 were to proceed without a functioning numerical model at this time, what activities would be undertaken and do the proponents still see a value in establishing the PAB and definition of management scenarios? Each scenario could take substantial time and involve numerous assumptions, how would the number of these scenarios be handled without developing into a huge list of contradictory predictions like some past modeling studies in the Basin have evolved into?*

This comment has two sub-parts. The three estuary/plume proposals make up a carefully integrated whole. They are all, therefore, dependent to some degree on each other. In this case, definition of management scenarios could be carried out on the basis of data analyses and PAB input. They could not be evaluated as planned, however, without numerical modeling to be carried out by *NMFS-Plume*. Fortunately, the CORIE modeling is already functional and will be fully calibrated and validated by the end of 2003, so this issue is largely moot.

Although the number of scenarios to be evaluated over the next three years is constrained, there is the potential for generation, over time, of an unwieldy number of such scenarios. The *Optimization* project is critical in several respects in preventing this undesirable outcome:

a) Our management scenarios will be based on process understanding and input from FCRPS stakeholders, not "seat-of-the-pants" adjustments to the present management regime. The examples in Section 9.b.8 (under "Scientific Background, p. 13) are again relevant. Each is based on an insight that will be tested (along with other ideas) by the data analysis and historical scenario part of the project (Objective 1).

b) The management science analyses conducted in Objective 2 will guide formulation of scenarios, so that the process of their generation and evaluation is compact and productive.

c) The PAB will be instrumental in sorting the wheat from the chaff, as far as scenarios are concerned.

Comment: 6) *The indirect costs in the budget appear unreasonably high and need to be justified.*

Response: The 64% Facilities and Administration (F&A) cost rate in the budget is that approved for the OGI School of Science and Engineering of Oregon Health & Science University (OHSU) by the Department of Health and Human Services as the cognizant agency of the federal government on February 26, 1996. It applies to all project expenditures except capital equipment (>$3,000), subcontract amounts after the first $25,000 and tuition. Under-recovery of F&A costs constitutes cost-sharing on the part of OHSU. In general, OHSU approves cost-sharing of federal awards only when it is a program requirement applicable to all proposers. The OHSU President must specifically approve all cost-sharing commitments.

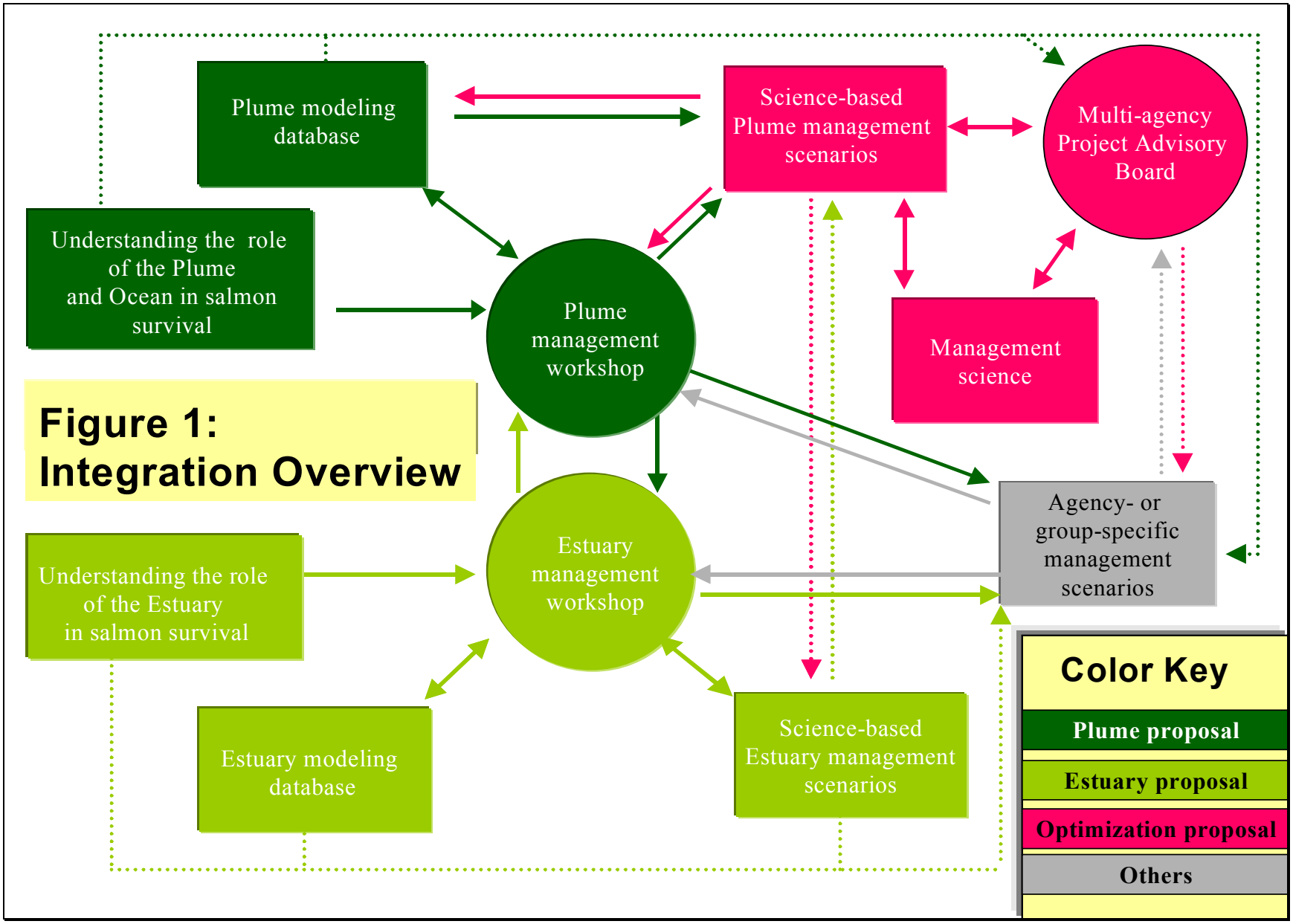
Plume modeling database
Science-based Plume management scenarios
Multi-agency Project Advisory Board
Understanding the role of the Plume and Ocean in salmon survival
Plume management workshop
Management science
Figure 1: Integration Overview
Agency- or group-specific management scenarios
Understanding the role of the Estuary in salmon survival
Estuary management workshop
Estuary modeling database
Science-based Estuary management scenarios
Color Key
Plume proposal
Estuary proposal
Optimization proposal
Others

Figure 2: View from *Optimization*