Ocean and Plume Science
Management Uncertainties, Questions and Potential Actions
(Work Group draft 11/27/13)

(The work group thinks the following four questions should form a logic path, but that logic path needs to be more fully developed by all the Forum members.)

1. **How have estuary, plume and near ocean ecosystem functions, processes and relationships been altered?** **(Need to address the temporal aspect of this question. Also should identify to what extent these ecosystem functions and processes have been altered due to man-induced influences.)**

    Has estuary, plume and near ocean carrying capacity for juvenile salmonids and competitors been altered?

    Have major upwelling patterns changed over time?

    Have forage fish composition and abundance patterns been altered seasonally, annually, temporally or spatially?

    Have salmonid predator composition and abundance been altered?

    What will be the magnitude of change in ocean and plume conditions due to climate change induced acidification and hypoxia?

2. **What has caused changes in estuary, plume and near ocean ecosystem functions and processes?** **(Emphasis should be on human-induced changes and be specific about the mechanism.)**

    How has Columbia River hydrosystem flow regulation influenced estuary, plume and near ocean ecology?

    How has dredging and spoil deposition affected estuary, plume and near ocean ecology?

    How do changes in water temperature affect estuary, plume and near ocean ecology?

    How have non-native or invasive species affected estuary, plume and near ocean ecology?

    What factors influence forage fish competitor abundance and composition in the estuary, plume and near ocean?

How has the magnitude, species composition and size/timing of hatchery releases affected estuary, plume and near ocean ecology?

What factors influence juvenile salmonid prey abundance and composition in the estuary, plume and near ocean?

What factors influence major upwelling patterns and upwelling productivity effects?

What factors influence acidification and hypoxia?

What is the interaction between upwelling, acidification and hypoxia and effects on productivity?

Diking and changes in flow management has caused the loss of shallow water habitat in estuary.

3. **What has been the effect of changes in estuary, plume and near ocean ecosystem functions and processes?** (Take a species-specific approach)

How has temperature and/or flow regulation affected fish condition, seawater readiness, and ocean entry timing?

How has reduction in large woody debris (LWD) inputs and LWD density in the estuary, plume and near ocean influenced salmonid survival?

How have increased release numbers, timing and species composition of hatchery fish influenced early ocean survival of natural-origin fish? Where and when does density dependence occur in the estuary and near ocean environments?

How will acidification and hypoxia influence salmonid survival, prey dynamics, predator dynamics and migratory patterns?

What are the major predators in the plume and ocean? How does predator composition vary between salmon species–races as well as temporally? What are predation rates in the plume and near ocean?

What are the major forage fish competitors in the plume and near ocean? How does composition and abundance of forage fish influence early ocean survival of salmon?

What factors influence the length of time juvenile salmonids spend in plume habitat, and does the length of time influence survival?

What has been the influence of and response to changes in upwelling patterns and ocean productivity on juvenile salmon survival?

How does fish condition and timing of smolt transportation, and number of dam bypass encounters during in-river migration, influence estuary and early ocean survival?

What is the relative importance of local drivers in the acidification process, including those that are man-induced?

How has loss of shallow water habitat in estuary affected the capacity and survival of anadromous fish?

How has creation of man-made islands from dredge spoils affected the abundance of avian predation in estuary?

How has development and operation of hydrosystem influenced marine mammal predation in estuary?

4. **What management actions can be taken to improve salmon survival and management effectiveness based on knowledge of estuary, plume and near ocean ecology and dynamics?**

What ecosystem functions need protection, restoration, enhancement or reconnection within the estuary and ocean plume due to impacts from actions within the Columbia River mainstem?

Can hatchery releases be adjusted in response to poor ocean conditions, predator abundance, food availability, and potential density dependence effects?

How might alternative storage and flow release schedules be utilized to improve estuary and early ocean survival?

How can hatchery release times, sizes, and transportation times be optimized to benefit survival of juvenile salmonids based on knowledge of capacity, density dependence, and predator, prey and competitor information?

Do hatchery diets, growth rates, and size-at-release have an effect on post-release survival?

How does variability in ocean conditions and productivity effects on anadromous salmonids limit freshwater restoration actions?

How can ocean and plume information be used to improve harvest management by improving accuracy and precision of run-forecasting, SAR predictions, abundance predictions, return timing predictions, and age structure predictions?

Can year-to-year and seasonal variations in key salmon survival influencing estuary, plume, and near ocean factors be predicted accurately and timely for use in real time adaptive management decisions?

What actions can be taken to improve fish condition of transported and in-river migrants so that estuary and early ocean survival rates are improved?

How can management be adapted to focus at the ecosystem scale?

Are there any management actions that can be taken to alter or mitigate for climate change induced acidification/hypoxia?

How much lead time is needed to implement adaptive management changes based on real time estuary, plume and near ocean information?

[Note: need to add questions concerning restoration of shallow-water habitats, reduction or removal of dredge spoil islands, and predator control actions.]

Table for Mgt. Question #1: How have estuary, plume and near ocean ecosystem functions, processes and relationships been altered?

Alterations or Changes in:	Tidally-influenced Estuary	CR Plume	Near-shore Ocean
Physical/Chemical Characteristics			
➢ Upwelling	N/A	Y-?	Y
➢ Acidification	Y	Y	Y
➢ Hypoxia	Y-?	Y	Y
➢ Temperature	Y	Y	Y
▪ Climate-driven			
▪ Water regulation-driven			
➢ Flow changes	Y	Y	Y
➢ Sediment changes	Y	Y	Y
Food Web			
➢ Carrying Capacity	Y	Y	Y
➢ Prey Base	Y	Y	Y
Species Interactions			
➢ Predation			
▪ Avian o Estuary-Terns & DCCO o Murres & shearwaters	Y	Y-?	Y-?
▪ Piscivorous o Pikeminnow o Hake	Y	Y-?	Y-?
▪ Marine mammals	Y	?	?
➢ Changes in competition	Y	Y	Y
➢ Changes in disease	?	?	?
Other considerations:			
*Invasive species			
*Fish health and condition			

Also need to identify whether the changes identified in table are the result of natural variation or are significantly human-induced.