APPENDIX I

National Marine Fisheries Service Mainstem Columbia River Estuary Recovery Plan Module

APPENDIX I – NATIONAL MARINE FISHERIES SERVICE MAINSTEM COLUMBIA RIVER ESTUARY RECOVERY PLAN MODULE

The text in this appendix was provided to the SRSRB by NMFS. It has been reviewed by the SRSRB, but not approved or incorporated into the SRSRP. The SRSRB believes that this "Estuary Module" needs to, among other things, more fully address predation on juvenile and adult salmon by marine mammals and other predators. The SRSRB will work with the NMFS to modify this module to be appropriate for incorporation into the overall ESU recovery plans for populations in the Recovery Region.

MAINSTEM COLUMBIA RIVER ESTUARY RECOVERY PLAN MODULE
NMFS SUMMARY
AUGUST 1, 2005

Purpose of this Summary

The purpose of this summary is to describe the *Columbia River Estuary and Lower Mainstem Recovery Plan Module* (estuary module) currently in development and to briefly discuss the estuary, lower mainstem, and plume as they relate to salmon and steelhead recovery. Much of the information summarized here on the role of the estuary and plume in the life history of salmon and steelhead is taken from a technical memorandum on the *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: An Evaluation of the Effects of Selected Factors on the Salmonid Population Viability* (Fresh et al., 2004). This technical memorandum provides a succinct discussion of how four major limiting factors affect salmonids in the estuary, lower mainstem, and plume and articulates the current general thinking about the role of the estuary and plume in the life history of salmon and steelhead.

Development of the estuary module will rely upon the Fresh et al. paper and upon a number of other important references, including the sub-basin plans for the Columbia River estuary prepared by the Lower Columbia River Estuary Partnership and the Lower Columbia Fish Recovery Board.

Mainstem Columbia River Estuary Recovery Plan Module

The estuary module will serve as the estuary and lower mainstem portion of all Columbia Basin ESA recovery plans (i.e., in support of plans for the Snake River, Upper Columbia, Mid Columbia, Lower Columbia, and Upper Willamette River ESUs). As such, the estuary module will analyze limiting factors and threats and needed actions (or strategy options) for all listed Columbia Basin ESUs. The area addressed by the module extends upstream to Bonneville Dam and downstream to the plume.

The estuary module will help establish the relationship between fish utilization of, and benefit from, upper basin habitat and functions and fish utilization of, and benefit from, the lower mainstem and estuary portion of the Columbia River. The analysis and strategy options will focus on estuary processes and habitat conditions, including flow, tidal effects, ecological interactions, and toxics. Other factors, such as harvest and hatcheries will be highlighted, but addressed in greater detail in the other recovery plans currently under development.

The module will include options for management actions, or strategies, that link to the various limiting factors identified for the estuary, lower mainstem, and plume. The narrative will include a qualitative discussion of how the management actions can affect survival and address the impact of each limiting factor on species recovery. The narrative will also include a description of the uncertainties and research needs for limiting factors and management actions. In most cases, it is not possible to quantify expected changes in survival as a result of estuary recovery actions.

The estuary module will be completed in December 2005.

Why the Estuary and Plume are Important to Salmon and Steelhead?

Fundamental to the view that estuaries are an important part of the life history of salmon and steelhead is the concept that salmonid ESUs are composed of multiple independent populations, or discrete breeding units, that vary with respect to their spatial and temporal use of habitats. In more recent years, the estuary has come to be regarded as part of the continuum of ecosystems that salmon and steelhead need to utilize to complete their life cycle. In particular, the work conducted by NMFS (Bottom et al. 2001) has found that juvenile salmon and steelhead are present in the estuary year round

Variability in climate, instream flow conditions, harvest practices, hatchery operations, and accessibility of habitats by salmon and steelhead help define how populations use estuarine habitats, including arrival timing in the estuary, duration of estuarine residence, and fish size. Throughout the entire estuary, the distribution and quality of habitats has been affected (and continues to be affected) by a variety of anthropogenic factors (e.g., urbanization) and natural changes (e.g., climate change).

NMFS evaluates the status, or "viability," of salmonid populations and ESUs over long time frames. Four indicators of viable salmonid populations (VSP) are used to assess viability: abundance, productivity, spatial structure, and diversity. Levels of these attributes in aggregate define extinction risk or persistence probability of populations. The status of the populations in aggregate are used to determine the status of an ESU as a whole. Estuaries help contribute to the viability of salmon and steelhead populations and ESUs by contributing to the range of places salmon and steelhead can use (spatial structure), providing support for the life history strategies to use these places (diversity), and providing habitat capacity to produce successful recruits (abundance and productivity). Although all four VSP parameters are critical to recovery and are interrelated, the contribution of estuaries to the spatial structure and diversity of populations is an especially important role of the estuary in supporting population viability.

Two attributes associated with use of estuarine habitats, size of fish at estuarine entry and time of estuarine entry, can be used to define six general life history strategies that can potentially be expressed by all anadromous populations: (1) early fry, (2) late fry, (3) early fingerling, (4) late fingerling, (5) subyearling, and (6) yearling. Although each life history type can produce members that use each strategy, the relative proportion of members associated with each strategy varies by life history type. Ocean-type populations are dominated by the fry and fingerling strategies while stream-type populations are dominated by the yearling strategy.

Studies of use of the Columbia River plume were initiated recently by NOAA Fisheries to investigate the role of this habitat region on juvenile salmon and steelhead. The evidence obtained to date suggests the plume serves salmon and steelhead in multiple ways. For example, the plume appears to facilitate primary production during the spring freshet period. The plume also appears serves to distribute juvenile salmon and steelhead in the coastal environment.

Limiting Factors: What We Currently Understand About Salmon and Steelhead Viability in the Estuary?

Of the possible estuarine factors that could affect viability, NOAA's Northwest Fisheries Science Center (Science Center) has defined the effects of four factors on salmon and steelhead in the Columbia River estuary: flow, habitat, contaminants/toxics, and predation. These four were selected from a larger list of factors affecting salmon and steelhead in the estuary based upon whether: (1) a significant change in the factor from historic conditions was evident, (2) the factor could potentially affect population viability, (3) there was quantitative data available that could be used to analyze effects of the factor, and (4) the factor could be linked to hydropower operations in the Columbia River Basin.

Flow is a fundamental factor affecting characteristics of salmon and steelhead and their habitat in the estuary and plume. The interaction of flow and tides with the land creates and maintains estuarine habitat. Large scale changes in flow occur as a result of spatially explicit interactions of short and long term climate cycles with the watershed. Operations of the Federal Columbia River Hydropower system (e.g., generation of electricity, flood control, and irrigation) have had significant affects on attributes of flow, including reducing the mean annual flow, reducing the size of spring freshets, almost completely eliminating overbank flows, and changing the timing of ecologically important flow events. The hydrological changes, along with floodplain diking, represent a fundamental shift in the physical state of the Columbia River ecosystem.

Major changes in the estuary resulting from flow alterations that are especially relevant to salmon and steelhead include a loss of vegetated, shallow-water habitat and changes in the size, seasonality, and behavior of the plume. Such changes potentially have significant consequences for both expression of salmonid diversity and productivity of the populations. In particular, because the changes in habitat are most pronounced in shallow-water areas, effects on the ESUs and life history strategies (the fry and fingerling strategies) that use and depend upon these shallow-water areas is most significant. Further, altering and reducing plume size and intensity may affect ESUs expressing the yearling life history strategy.

The location and types of habitats present in the Columbia River estuary have been substantially altered from historic conditions. Although the entire estuary has not yet been surveyed, the main changes that have been identified have been a major loss of emergent marsh, tidal swamp, and forested wetlands; shifts in organic matter important to estuarine food webs; and changes in features of the plume. Shallow-water dependent life history strategies (fry and fingerlings) have been most affected by the loss of the vegetated habitat types in the estuary while larger life history strategies have been most affected by changes in the plume. Alterations in attributes of flow and the construction of dikes and levees have caused these changes. Diking is a significant change primarily because it severs the connection of the habitat with the river so it provides no direct (use) or indirect (export of organic matter for food webs) benefit to the fish.

Exposure to waterborne and sediment-associated chemical contaminants has the potential to affect survival and productivity of both ocean and stream-type stocks in the estuary. Stream-type ESUs (e.g., upper Columbia River Chinook salmon, Snake River steelhead, etc.) are likely to be most affected by short-term exposure to waterborne contaminants such as pesticides and dissolved metals. These chemicals can disrupt olfactory function and interfere with such behaviors as capturing prey, avoiding predators, imprinting and homing.

Predation is a major source of mortality of all salmonid populations. Although many predator prey interactions in the Columbia River estuary appear to have changed from historic conditions (e.g., northern pikeminnow), we have little quantitative data on most predators. One exception to this is Caspian tern predation which has significantly increased recently due to a change in nesting habits of the birds in the Columbia River estuary. The main impact of tern predation is on ESUs with stream type life history types, especially steelhead. This is primarily because the dominant migratory periods employed by salmonids with a stream type life history most overlap with the nesting period of the terns.

How Limiting Factors Affect Salmon and Steelhead

Based on an analysis provided by the Science Center (Fresh et al, 2004) the following factors were determined to be limiting to population viability:

	Flow	Habitat	Contaminants/Toxics	Predation
Ocean-type ESU	X	X		
Stream-type ESU	X			X

For stream-type ESUs, flow and predation were identified as having an ability to affect population viability. Flow changes in the basin are primarily a result of dam operations whereas habitat changes are a function of both hydropower operations and other, non-hydro issues, notably the construction of dikes and levees in the estuary. The main effects of flow on stream-type ESUs are on the dominant life history strategies (e.g., yearlings) in the plume. Predation affected stream-type ESUs because Caspian terns in particular tend to prey on larger, yearling size fish. The main effect on stream-type ESUs of making changes in flow and predation will be realized as gains in spatial structure and diversity.

For ocean-type ESUs (e.g., Lower Columbia River chum salmon and Snake River fall Chinook), flow and habitat were rated as having a high ability to affect population viability. The combined effect of flow and habitat changes on estuarine habitat has been to reduce the amount of shallow water habitat (especially vegetated habitat such as swamps and marshes) and disrupt organic matter inputs from these vegetated habitats. The dominant life history strategy of ocean-type Chinook salmon (i.e., fry and fingerling) extensively use shallow water habitat which is where the main flow and habitat changes have occurred. The main effect on ocean-type ESUs of making changes in habitat and flow will be realized as gains in abundance and productivity.