Delta Restoration Plan
Species Life History Models
Revised Guidelines – July 27, 2007

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1.0 Introduction

The California Department of Fish and Game, working with the CALFED Science Program and other CALFED agencies, is engaged in the development of a series of conceptual models for the Delta that can inform decision making regarding future conservation and restoration actions. The following provides general guidelines for the preparation of these species models, including how the models will be used, definitions of terms, information that should be included in each model, and a basic outline that should be followed. These guidelines have been amended following beta-testing of the overall Delta Restoration Plan (DRERIP) suite of models in order to facilitate vetting of likely restoration actions.

The purpose of these guidelines is to promote consistency between the structure, format, and level of information contained within each species model. The guidelines are also intended to improve the application of the models, including linkages between the species models and related ecosystem element conceptual models being developed separately that describe natural processes, habitats, and stressors acting upon the population dynamics of the component species within the community.

These guidelines lead to the formation of conceptual models that include four necessary components, each of which are described in further detail below:

A. Graphical components (conceptual model diagrams)
B. A stressor table
C. A narrative component
D. Literature cited section

The ERP agencies are prepared to provide staff assistance, should it be needed, to aid in the formatting or compilation of graphical components and stressor tables (Items A & B above) consistent with DRERIP needs. At a minimum, we are asking model developers to clearly provide the information necessary to complete these two components (presumably within the narrative component, and through direct interaction with assisting staff). If you would like to take advantage of this assistance, or have any questions about content and requirements for completing these models, please contact Daniel Kratville (DRERIP Species Model Coordinator) (916) 445-1730 after review of these guidelines.

2.0 Purpose and Use of Species Conceptual Models

The purpose of the species models is to describe the basic biology (life cycle and life history) of several key species, and to articulate explicitly the current state of knowledge regarding factors influencing their reproductive success, growth, and survival—the underlying population dynamics as we understand them. This information will necessarily direct appropriate restoration actions most efficiently, and forms the foundation for adaptive management within the CALFED ERP process.
It is critically important that these models address the most appropriate outputs (outcomes) to define particular restoration actions and objectives towards long-term population viability of your particular species. This information includes a comprehensive treatment of the threats facing different lifestages of these species under different seasonal scenarios and conditions. This information is necessarily species-dependent. For example, sturgeon can survive many years of deferred reproductions but smelt cannot. Harvest impacts and demands on stripers are very different than on sturgeon and so the relevant life history outputs must be different. It is up to each developer to indicate which model outputs relate best to the long-term survival of their species; and how, for example, harvest rates and time horizons figure into those outputs.

Some expository suggestions for appropriate model outputs (by species) follow, for illustrative purposes. These are not meant to be exhaustive, only exemplary. Ultimately it is up to the author to define these relevant outputs for us.

<u>Delta smelt model outputs:</u>
a. minimum annual population size (not only in good
years, a lower critical threshold to avoid losing them entirely)
b. distribution similar to recent historic range

<u>Longfin smelt outputs:</u>
a. minimum biannual population size
b. return to relationship with outflow (we may not be able to control
outflow but perhaps we can control the stressors that prevent them from
using outflow like they used to) It will do us no good to get a model that only tells us to
pray for rain.

<u>Splittail</u>
a. spawning access at least every 5 years (as long as this happens, won't fecundity take care of the rest?)
b. distribution consistent with Sommer et al.

<u>Green Sturgeon</u>
a. survival of upmigrating adults and downmigrating young in wetter
years, when they spawn. Do we care about sturgeon conditions
in drier years? What does the author/NMFS think?
b. fecundity/health of adults - long lived species may be subject to
more contaminant effects - what does the model output on this?

<u>Salmon</u>
a. total escapement, including harvest rates typical of some recent
period

b. minimum population size for listed runs, given harvest rates overall
c. fecundity/health of spawners, particulalry endocrine disruptive
effects on spawning success

The models will be used (in conjunction with our ecosystem process, habitat, and stressor models) to:

1. evaluate proposed restoration actions and targets in the Delta as they influence the species;
2. identify and develop new actions to meet habitat restoration goals and objectives including reduction of stressors;
3. identify indicators or performance measures to measure success toward meeting ERP goals and objectives;
4. identify research needed to fill critical knowledge gaps;
5. represent the basic (expert consensus) understanding of the ecology of the given species;
6. help identify monitoring needs for these species and their associated driver indicators;
7. form the foundation for risk assessment for protection and recovery planning associated with these species; and
8. form the conceptual framework to serve as the foundation for the ERP adaptive management process.

3.0 The Driver-Linkage-Outcome (DLO) Approach

The DRERIP conceptual models follow a deterministic paradigm, using the DLO approach: drivers (D), linkages (L), and outcomes (O). **Drivers** are physical, chemical, or biological forces that control the species or system of interest. **Linkages** are cause-and-effect relationships between drivers and outcomes. **Outcomes** are response variables (such as reproductive success, growth, and mortality) that the conceptual model is attempting to explain. In the context of the DRERIP species conceptual models, “ultimate” outcomes reflect population-level responses to drivers.

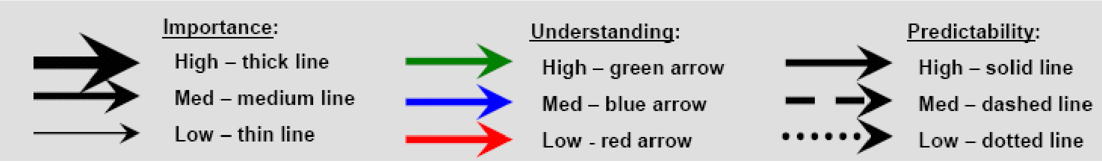
The path between an environmental driver (e.g., temperature regime in a specific subarea) and a species “ultimate” outcome (e.g., reproductive performance) may pass through one or more intermediate steps; in such a condition, there can be one or more “intermediate outcomes” from one or more drivers that serves as a “driver” for the next outcome in the series. Where the numbers of drivers and intermediate outcomes are large, consider presenting a simple “overall” DLO diagram coupled with multiple DLO “submodel” diagrams (“nested” models) in order to keep graphics from becoming too complex and key information from becoming buried. Please include a key to the submodels in the overall diagram for easy cross-reference.

Some key elements to keep in mind while presenting the DLO models, include:

Drivers – in preparing the model, identify the full suite of environmental variables important to the species. Address all aspects of **water quality** (e.g., salinity, temperature), **physical habitat** (e.g., vegetative structure, flow velocities), and **stressors** (e.g., chemicals, predation, poor water quality, lack of habitats for key life stage requirements). Some of these drivers will be replicated within the stressors table; however, key (important) stressors or limiting factors should also appear in the graphical model (and, of course, in the narrative).

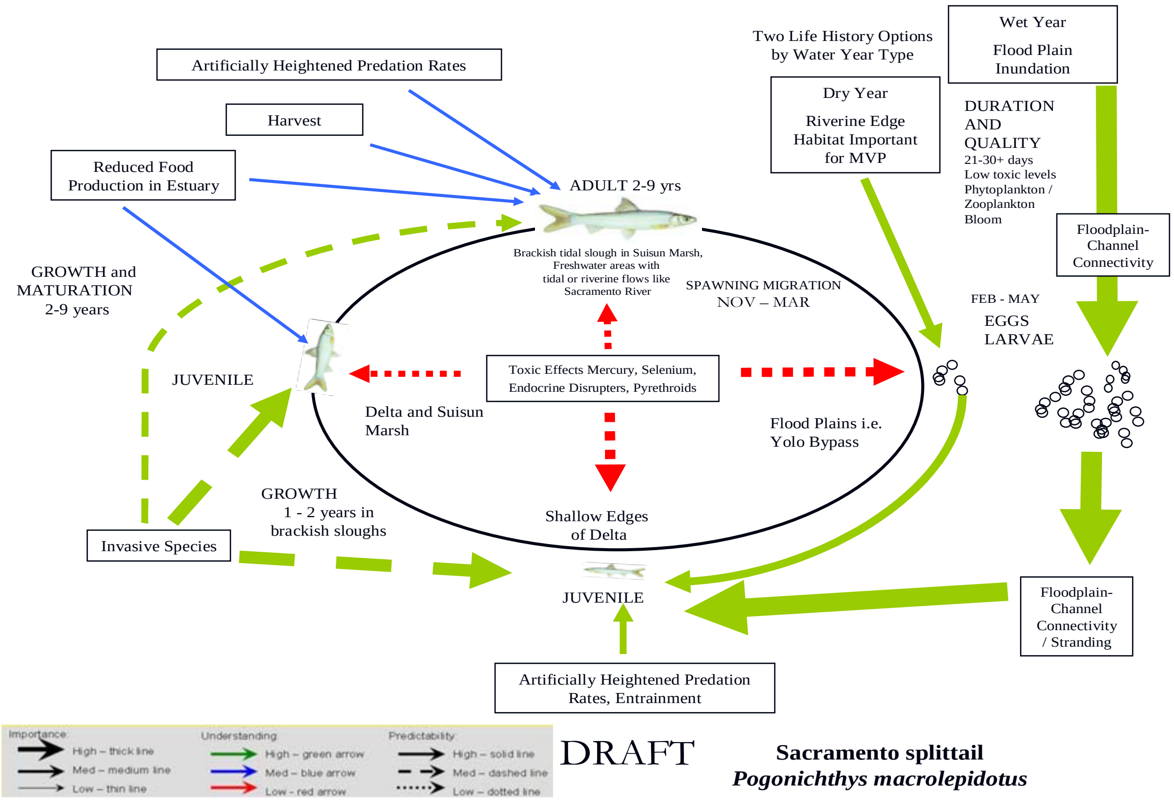
Linkages and Linkage Characteristics – Linkages are depicted as arrows between cause (drivers) and effect (outcomes). Please provide four attributes of each linkage using the style guide below:

a. **Direction** of the effect - Positive/negative effect: show a "+" or "-" for the linkage as it influences the outcome expressed
b. **Importance** or magnitude of the effect - displayed using thickness of line. Where possible, include quantitative values, e.g., % of variability, strength of relationships, etc.
c. **Understanding** about the relationship based on established literature knowledge, shown using line color
d. **Predictability** of the effect shown using line type (solid, dashed, or dotted line).



For example, a medium-thick solid green line would indicate a predictable relationship that is well understood and has an intermediate influence on the outcome variable of interest.

Figure 1 displays an example graphic developed for splittail. This example has the life cycle stages, DLOs, and some distribution characteristics in one graphic.



Sacramento splittail
Pogonichthys macrolepidotus

The following terms are used for coding **Importance**, **Predictability**, and **Understanding** of the linkages between drivers and outcomes. These definitions of **importance, predictability, and understanding** apply to each linkage, or cause-effect relationship, between an individual driver and individual outcome described in the conceptual models. The graphical forms of the conceptual models apply line color, thickness, and style to represent these three terms.

As we have come to learn from developing the many conceptual models, a bulk of the "science" within the model resides within the linkages, hence the significance of using these three terms effectively.

Importance

A) Definition

The degree to which a linkage controls the outcome *relative to* other drivers and linkages affecting that same outcome. Models are designed to encompass all identifiable drivers, linkages and outcomes but this concept recognizes that some are more important than others in determining how the system works. If a driver is potentially more important under particular environmental conditions, the graphic should display the maximum level of importance of this driver with the narrative describing the range of spatial and temporal conditions associated with this driver.

Note that Importance at the individual linkage stage considers Scale.

B) Criteria

4 = High importance: expected sustained major population level effect, e.g., the outcome addresses a key limiting factor, or contributes substantially to a species population's natural productivity, abundance, spatial distribution and/or diversity (both genetic and life history diversity) or has a landscape scale habitat effect, including habitat quality, spatial configuration and/or dynamics.
3 = Medium importance: expected sustained minor population effect or effect on large area or multiple patches of habitat
2 = Low importance: expected sustained effect limited to small fraction of population, addresses productivity and diversity in a minor way, or limited spatial or temporal habitat effects
1 = Minimal or no importance: Conceptual model indicates little or no effect

Predictability

A) Definition

The degree to which the performance or the nature of the outcome can be predicted from the driver. Predictability seeks to capture the variability in the driver-outcome relationship. Predictability can encompass temporal or spatial variability in **conditions of a driver** (e.g., suspended sediment concentration or grain size), variability in the **processes that link the driver to the outcome** (e.g., sediment deposition or erosion rate as influenced by flow velocity), or our **level of understanding** about the cause-effect relationship (e.g., magnitude of sediment accretion inside vs. outside beds of submerged aquatic vegetation). Any of these forms of variability can lead to difficulty in properly measuring and statistically characterizing inputs to the model.

B) Criteria

4 = High predictability: Understanding is high and nature of outcome is largely unconstrained by variability in ecosystem dynamics, other external factors, or is expected to confer benefits under conditions or times when model indicates greatest importance.
3 = Medium predictability: Understanding is high but nature of outcome is dependent on other highly variable ecosystem processes or uncertain external factors. OR Understanding is medium and nature of outcome is largely unconstrained by variability in ecosystem dynamics or other external factors
2 = Low predictability: Understanding is medium and nature of outcome is greatly dependent on highly variable ecosystem processes or other external factors OR Understanding is low and nature of outcome is largely unconstrained by variability in

ecosystem dynamics or other external factors
1 = Little or no predictability: Understanding is lacking OR Understanding is low and nature of outcome is greatly dependent on highly variable ecosystem processes or other external factors

Understanding

A) Definition

A description of the known, established, and/or generally agreed upon scientific understanding of the cause-effect relationship between a single driver and a single outcome. Understanding may be limited due to lack of knowledge and information or due to disagreements in the interpretation of existing data and information; or because the basis for assessing the understanding of a linkage or outcome is based on studies done elsewhere and/or on different organisms, or conflicting results have been reported. Understanding should reflect the degree to which the model that is used to represent the system does, in fact, represent the system.

B) Criteria

4 = High understanding: Understanding is based on peer-reviewed studies from within system and scientific reasoning supported by most experts within system.
3 = Medium understanding: Understanding based on peer-reviewed studies from outside the system and corroborated by non peer-reviewed studies within the system.
2 = Low understanding: Understanding based on non peer-reviewed research within system or elsewhere.
1 = Little or no understanding: Lack of understanding. Scientific basis unknown or not widely accepted.

4.0 Conceptual Model Structure and Content

The DRERIP Species Life History Conceptual Models should have four elements: graphical model(s), a stressor table, a narrative, and a literature cited section.

4.1 Graphical Components

In order to evaluate potential restoration actions, there are at least four types of information that should be contained in the graphic(s):

1. **Life cycle stages** (e.g., for fish: egg, embryo, larvae, juvenile, adult, etc.) at an appropriate scale to identify ecological interrelationships as they differ by region or lifestage.

2. **Temporal patterns** (seasonal, annual, or other pattern in abundance and distribution)

3. **Map showing geographic distribution patterns**: location and extent of key habitats—may also include summary qualitative discussion regarding relative habitat values within the extant Delta, including attractive areas to target for restoration. Should show seasonal patterns of abundance or distribution if present (e.g., Delta smelt head west in the summer…). Provide as much specificity as available about geographic distribution patterns and different limiting factors associated with each seasonal species-habitat concordance.

4. Series of **DLO Diagrams** (see description below) to describe the cause-effect relationships operating during different life cycle stages, temporal patterns, and geography. Actual number of diagrams will depend on the level of information necessary to convey.

4.2 Stressor Table Component

The stressor table will contain information on specific stressors designated by DRERIP. Model developers should address all stressors indicated, whether they affect your species or not. The format for the table is shown below. The same definitions for Importance, Understanding, and Predictability apply here and are defined above. The boxes for Importance, Understanding, and Predictability will use the “rank” that corresponds to tables 1, 2, and 3 as defined above. The Life Stage boxes are just a description of what stages are affected by the stressor, if applicable. The Geographic region corresponds to where in the system the life stage occurs. This value will come from the transport sub-regions identified in the transport model and are illustrated in Figure 2 below. The Mechanisim column will define in a few words the process by which the stressor affects the species.

Stressor	**Importance**	**Understanding**	**Predictability**	**Life Stage Affected**	**Geographic extent**	**Season**	**Mechanism**
					9 Regions		
Entrainment Small Ag							
Entrainment Power Plant							
Entrainment SWP/CVP							
Stranding							
Toxics Selenium							
Toxics Pyrethroids							
Toxics Mercury							
Toxics Endocrine Disrupters							
Artificial Predation							
Harvest Legal							
Harvest Illegal							
Food Availability							
Disease							
Water Quality Temp							
Water Quality DO							
Water Quality Salinity							
Water Quality Turbidity							
Habitat Loss Spawning							
Habitat Loss Rearing							
Habitat Loss Migration							
Invasive Species							
Operations DCC							
Operations Reduced Seasonal Flows							

Stressor	Importance	Understanding	Predictability	Life Stage Affected	Geographic extent	Season	Mechanism
Operations S-Delta Operable Gates							
Barriers Migration							
Hatchery							
Climate Change							

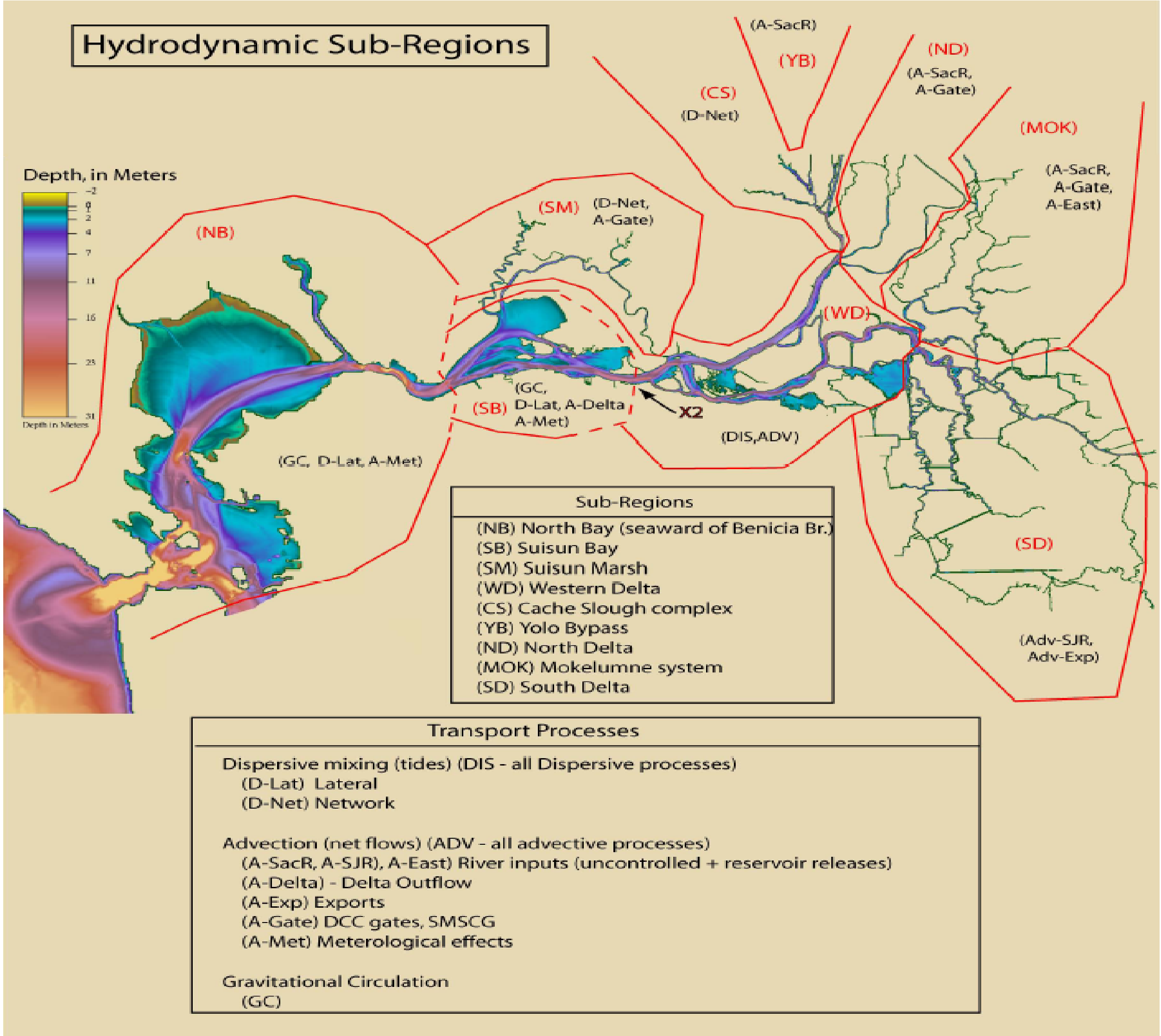


Figure 2. Hydrodynamic regions from the Hydrodynamic Model. The sub-regions identified here are to be used in the 'Geography' column for the Stressor Table.

4.3 Narrative Component

The narrative component of the life history model should be centered around the graphics described above. Numbered codes should be used to link the narrative to the graphics explicitly. Ultimately, the DRERIP models will be converted to web format where the text is accessible through the graphic; coding the text will make this transformation easier to do.

The narrative should explicitly cover the following:

The title, author, authors organization, authors email address and a date of draft need to appear at the top of the first page.

1. *Biology, Ecology, and Status*

Biology

- Fecundity
- Reproduction
- Development (e.g., for fish: swimming ability and growth
- Importance and nature of cohorts, interannual variabilty in reproductive success and effort, etc. (i.e., the narrative should describe differences like that between sturgeon and splittail which may spawn massively under appropriate conditions vs. smelt which must spawn every year vs. salmon spawning semelparously vs. stripers where some part of the population spawns every year but never all of them).

Ecology

- Environmental tolerances and, if known, how these change by life stage
- Environmental releasers for reproduction
- Trophic habits, position, and relationships throughout the life cycle
- Key dietary components (historic and current, if appropriate)
- Spatial distribution and timing of occurrence with particular reference to Delta occupancy
- Key potential limiting factors in completing life cycle
- Other ecological functions (e.g., does this species behavior facilitate nutrient/energy flow to different parts of the ecosystem?)

Status

- Historical and current population status (include reference to data sources from which evaluation is compiled).

2. *Habitats, Processes, Stressors, and Linkages*

How do changes in habitats, processes, and stressors affect biology, ecology, and status? At what temporal and spatial scales does the organism respond to habitat characteristics, processes, and stressors?

Habitats *<DRERIP is currently preparing the following habitat models: tidal marsh, perennial aquatic habitat, riparian, floodplains, aquatic vegetation; other habitat*

models that may be developed in the near future are managed wetlands, natural shorelines, shaded riverine aquatic>

- Habitat attributes during various life stages (can be treated as ideal versus extant)
- Interactions of spatial and temporal patterns in habitat quality and associated physical conditions
- Historic habitat changes that may have affected the species

Processes *<DRERIP is currently preparing the following process models: hydrodynamics, sediment transport, organic carbon, aquatic foodweb>*

- Critical processes affecting the species
- Species function in the community food web (predator/prey relationships, vector for energy and nutrient transport)

Stressors *<DRERIP is currently developing the following stressor models: toxicants (general toxicity, Hg, Se, pyrethroids), water operations, invasive aquatic veg, low dissolved oxygen >*

- Significant stressors affecting the species and its population status
- Limiting factors (linked to quantitative information, where possible; or barring that, a rank ordering to our best available knowledge)
- Include specific reference to what may be known about the relative importance of each of these stressors to the species and how these stressors affect the species

Non-Applicable Stressors

- Stressors that do not affect your species (from those listed in the stressor table) and reasoning for this decision.

Linkages

- Process and stressor linkages to life stage, season, and habitat (what, where, when?)

Degree of Understanding

What limits our certainty of any of the above items?

- Suggested targeted research
- Suggested monitoring activities or modifications to current monitoring efforts
- Important information gaps
- Areas of scientific disagreement

The narrative sections outlined above should incorporate some discussion of:

- The dynamic nature of the species’ population, including the role of uncontrolled drivers (e.g., local and global weather patterns);
- The nature of long-term population trends and the extent and source of variability in those trends;
- The need for further research efforts that will clarify the probable impact of management efforts.

- The best scientific information available regarding the species, including the source(s) of that information (i.e., peer-reviewed publication or grey literature); research conducted within this ecosystem or derived from research elsewhere);
- Ecosystem elements (e.g., critical processes, habitats, and stressors) that control the species' population biology, including pertinent geographic locations or life cycle stages;
- Critical temporal and spatial junctures where these ecosystem elements are most important to species recovery and sustainability; and highlight, when possible, specific limiting factors;
- The level of scientific understanding for each point (areas of disagreement, information gaps, etc.)
- Assumptions and gaps in the state of knowledge that limit the predictability of management outcomes.

4.4 Literature Cited

Provide citations for all information sources (including grey literature and personal communications) used to develop the above two components.

5.0 Definitions

Critical Threshold: A condition of an attribute that when exceeded (or fallen below) causes the influence of the attribute on the dynamics of the ecosystem to change in method or nature rather than merely in magnitude. Critical thresholds may or may not exist in any driver-outcome relationship and the intent for these conceptual models is to identify them when they exist. For example, dissolved oxygen would presumably have critical thresholds below which organism behavior and ultimately survival are affected.

Cumulative Effects: The interactive, synergistic, or contradictory combination of multiple conditions of or changes in ecosystem function or of drivers including stressors. For DRERIP, the focus is on the combined effect of multiple restoration actions or actions aimed to reduce stressors, but may also need to consider non-ERP actions.

Driver: an ecosystem element with a known or hypothesized important effect on another ecosystem element or on a target species. In coupled models, a driver can be an outcome from one model that feeds into and influences the behavior of another model (e.g., using a Delta hydrodynamic model to generate salinity variation that is an input to a vegetated habitat model). Drivers may be categorized as follows:

> *Uncontrolled drivers*: A driver that comes from the world external to the model and is not under management control or influence. Tides would be an example.
> *Managed driver*: A driver that is under direct management control or influence. Export would be an example.

<u>Ecosystem Element</u>: processes, conditions, habitats, or stressors that occur within the ecosystem.