State Water Resources Control Board

Analytical Tools for Evaluating the Water Supply, Hydrodynamic, and Hydropower Effects

Workshop 3

November 13, 2012

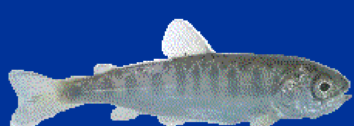
California Department of Fish & Game

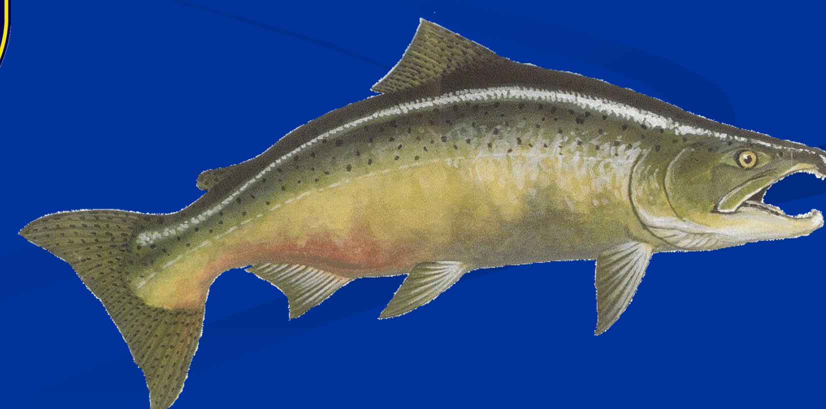
Workshop 3: Analytical Tools for Evaluating the Water Supply, Hydrodynamic, and Hydropower Effects

November 13, 2012

San Joaquin River Fall-run Chinook Salmon Population Model

"SALSIM"





Overview

- WQ Standards:
  - The standard in question dictates the model needed… If flow, then use a model with flow
- Model Versions:
  - V 1.6:
    - Directly addresses SJR south Delta inflow question
  - V 2.0 (SalSim):
    - Addresses south Delta, SJR & Trib flow questions
    - addresses multi-ecosystem questions

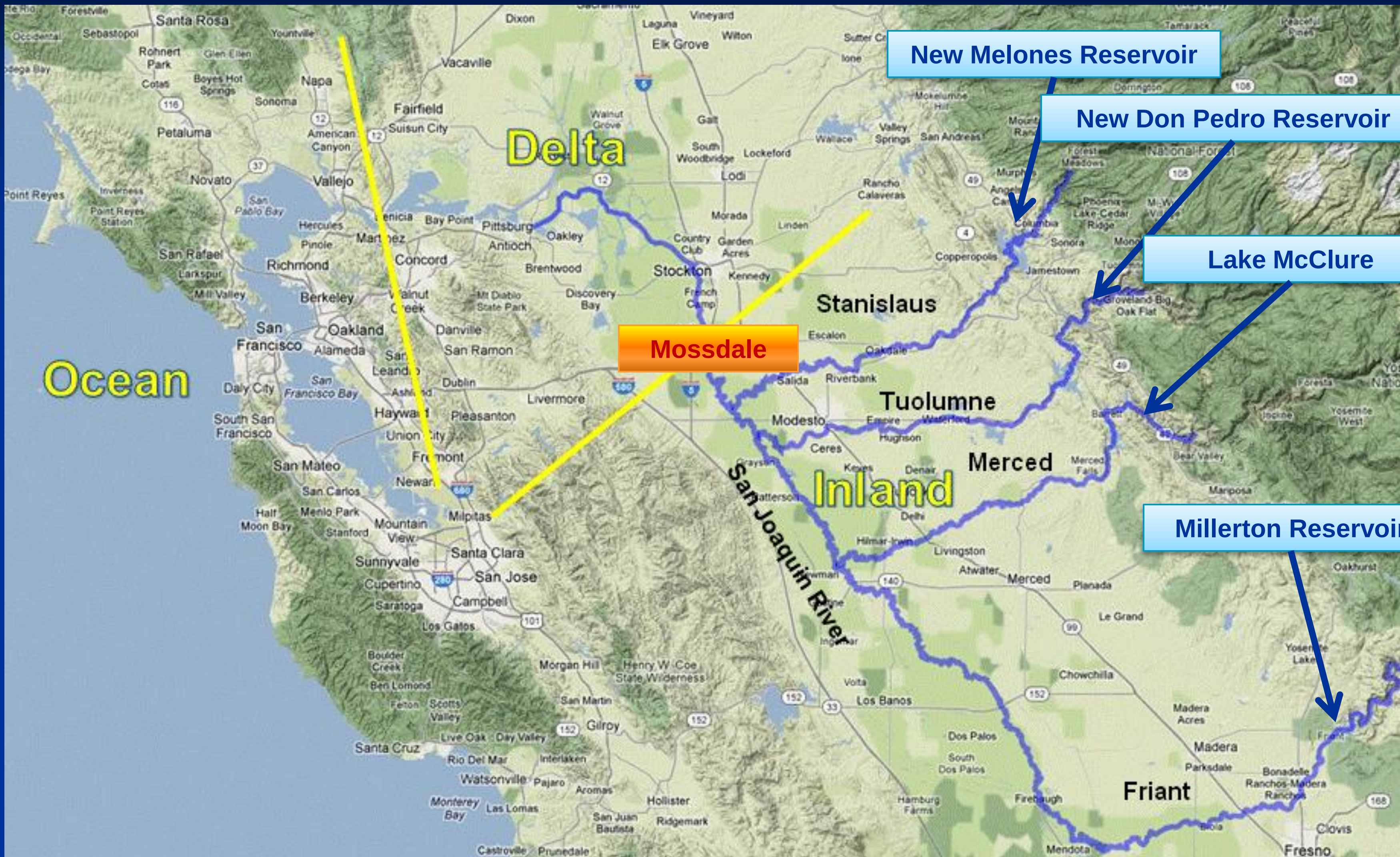
Why SalSim?

- Peer reviewed
- Will be:
  - Suitable for management use
  - Completely transparent
  - Well documented
  - Based on best available science
  - Developed using well established scientific procedures and protocols

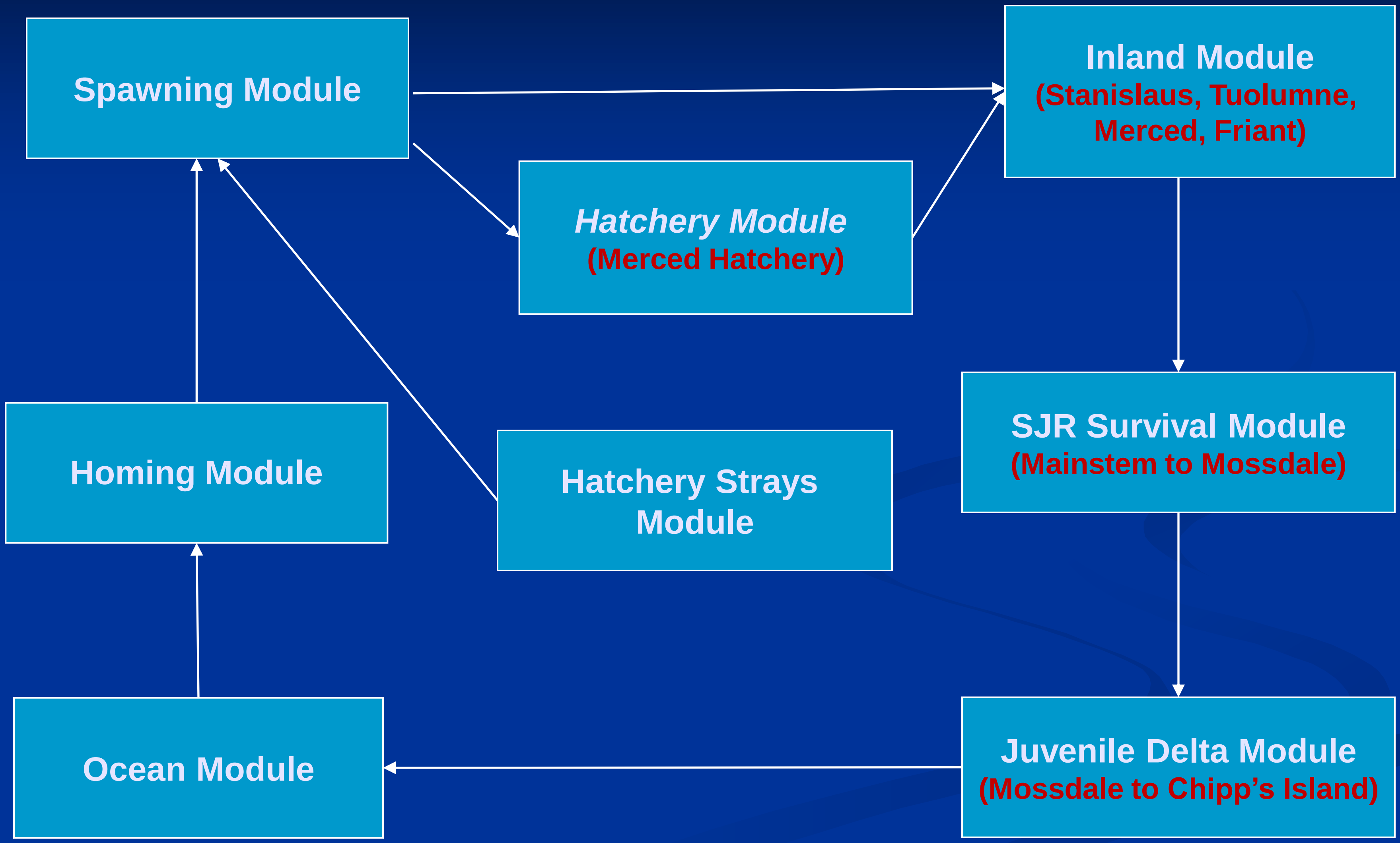
What is SalSim?

- Full salmon life cycle model
- Estimates survival, movement, and/or development in three ecosystems
- Includes variety of factors
  - Instream flow, water temp, predator abundance, harvest, exports, carrying capacity, hatchery, floodplain inundation, ocean conditions
- Includes Water op's and resulting water temp
- Determines fish production at each life stage
- Includes SJR mainstem and trib's

SalSim Geographical Footprint



SALSIM Modules



Inland Module

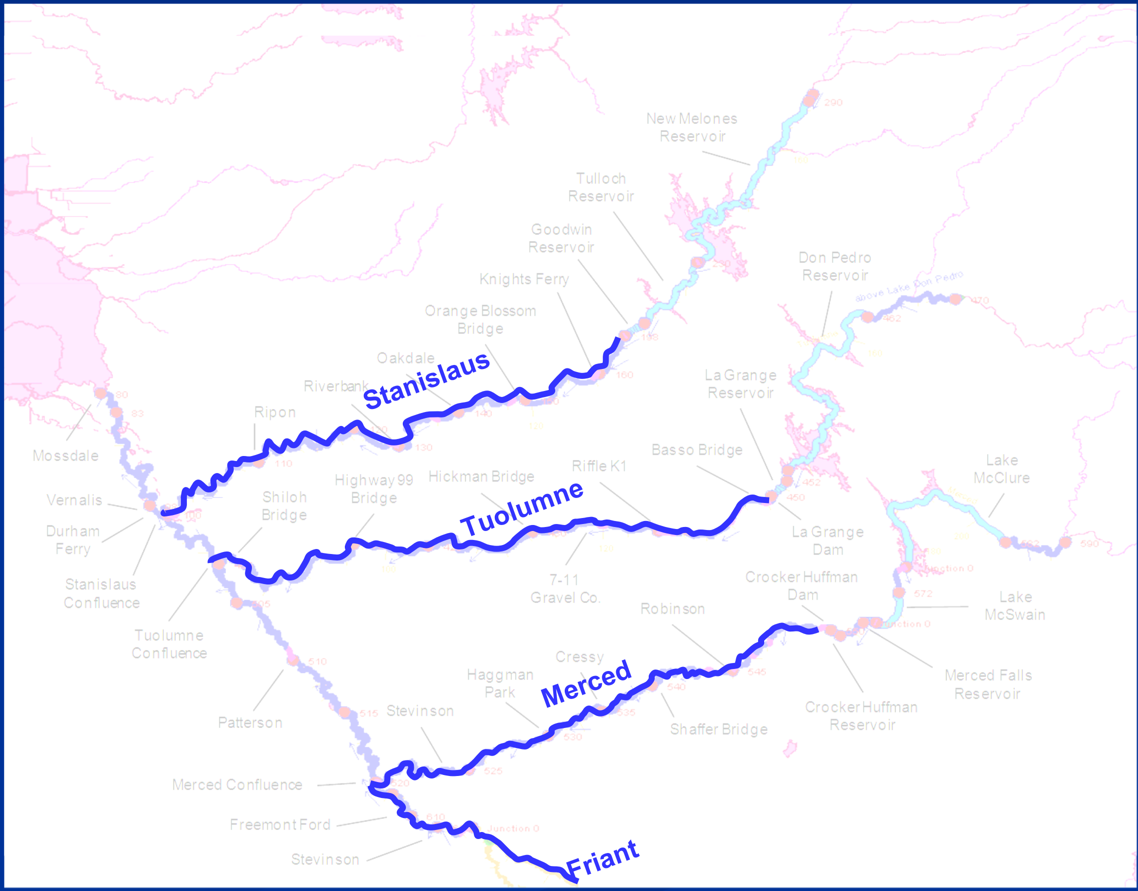
(Stanislaus, Tuolumne, Merced, Friant)

Survival and Development Factors

- Flow
- Water temperature
- Density dependence
- Predators areas

Movement Factors

- Variable speed cohorts
- Velocity and flow (including rate of change)
- Temperature
- Floodplain encroachment



SJR Survival Module

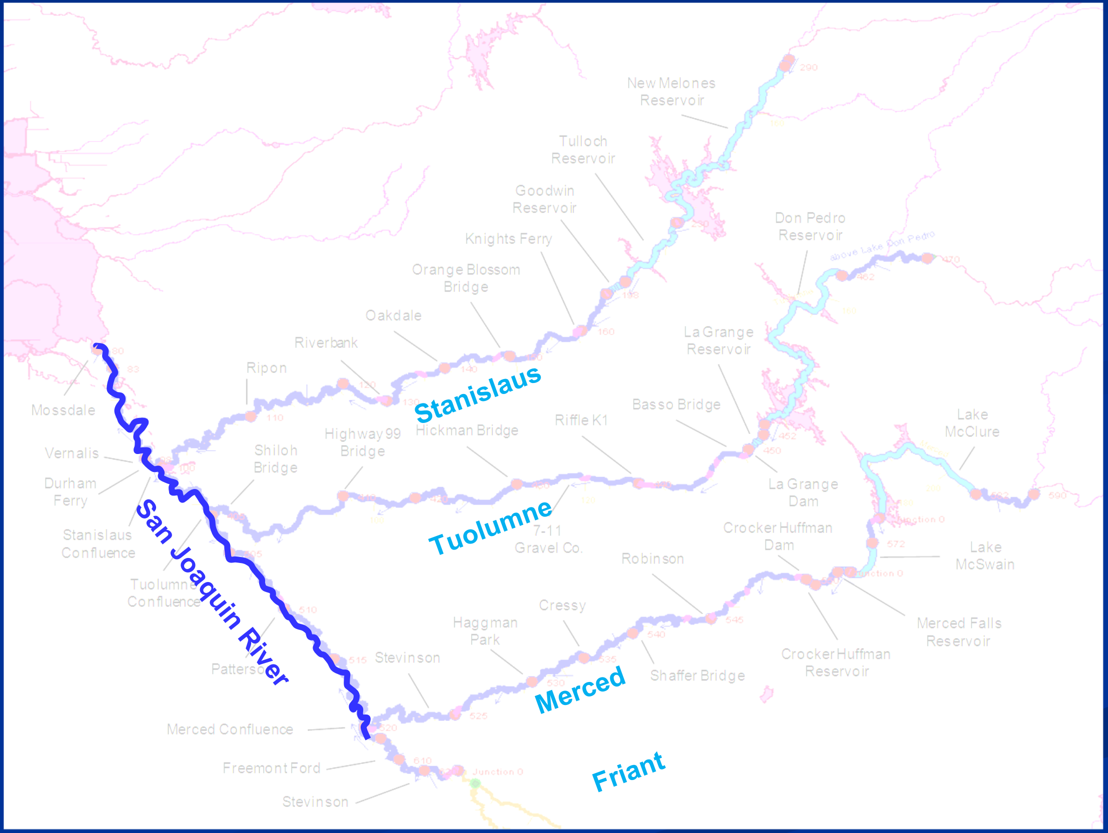
(mainstem San Joaquin River)

Survival and Development Factors

- Flow
- Water temperature

Movement Factors

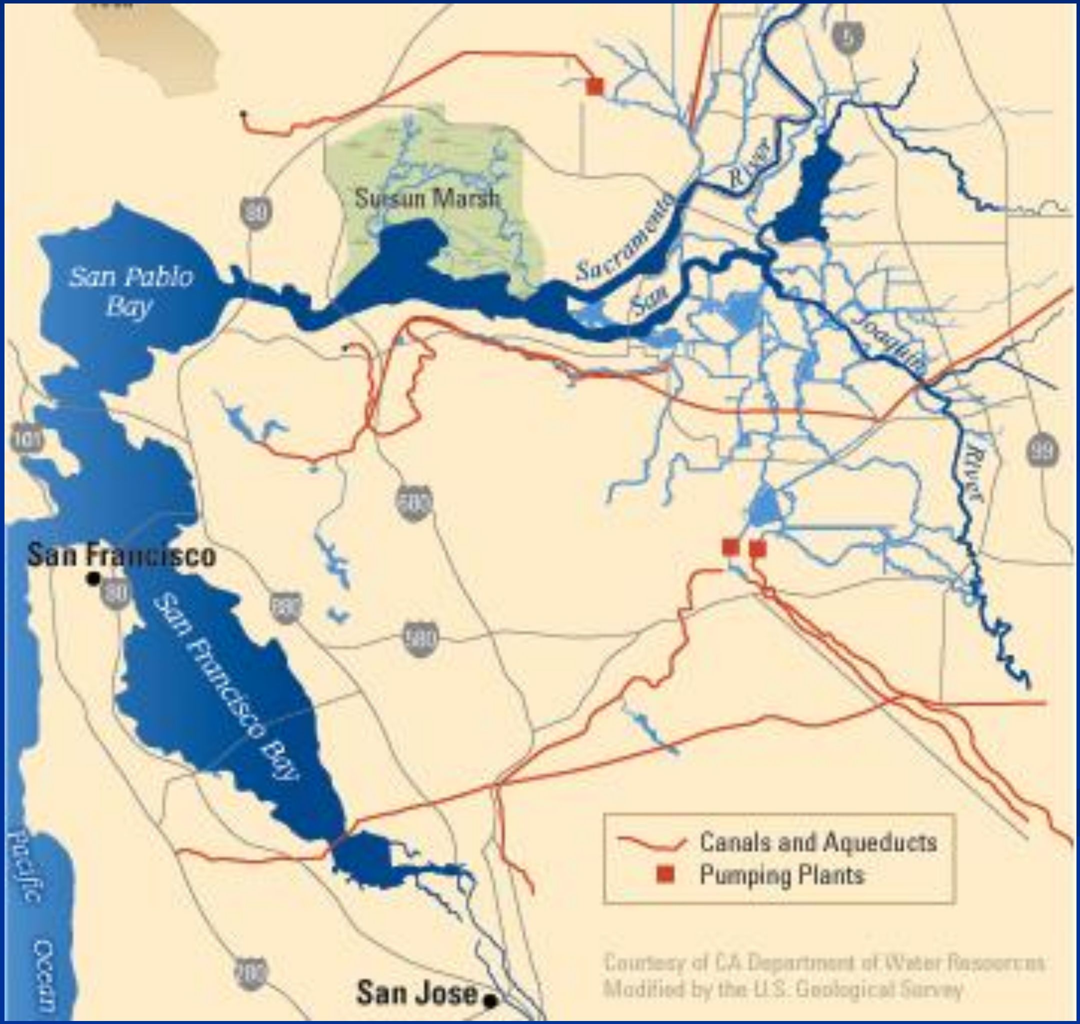
- Velocity and flow (including rate of change)
- Temperature



Juvenile Delta Module

Survival Factors

- Inflow to the Delta
- Water temperature entering Delta
- Water export
- Striped bass abundance
- HORB status (by day)



Ocean Module

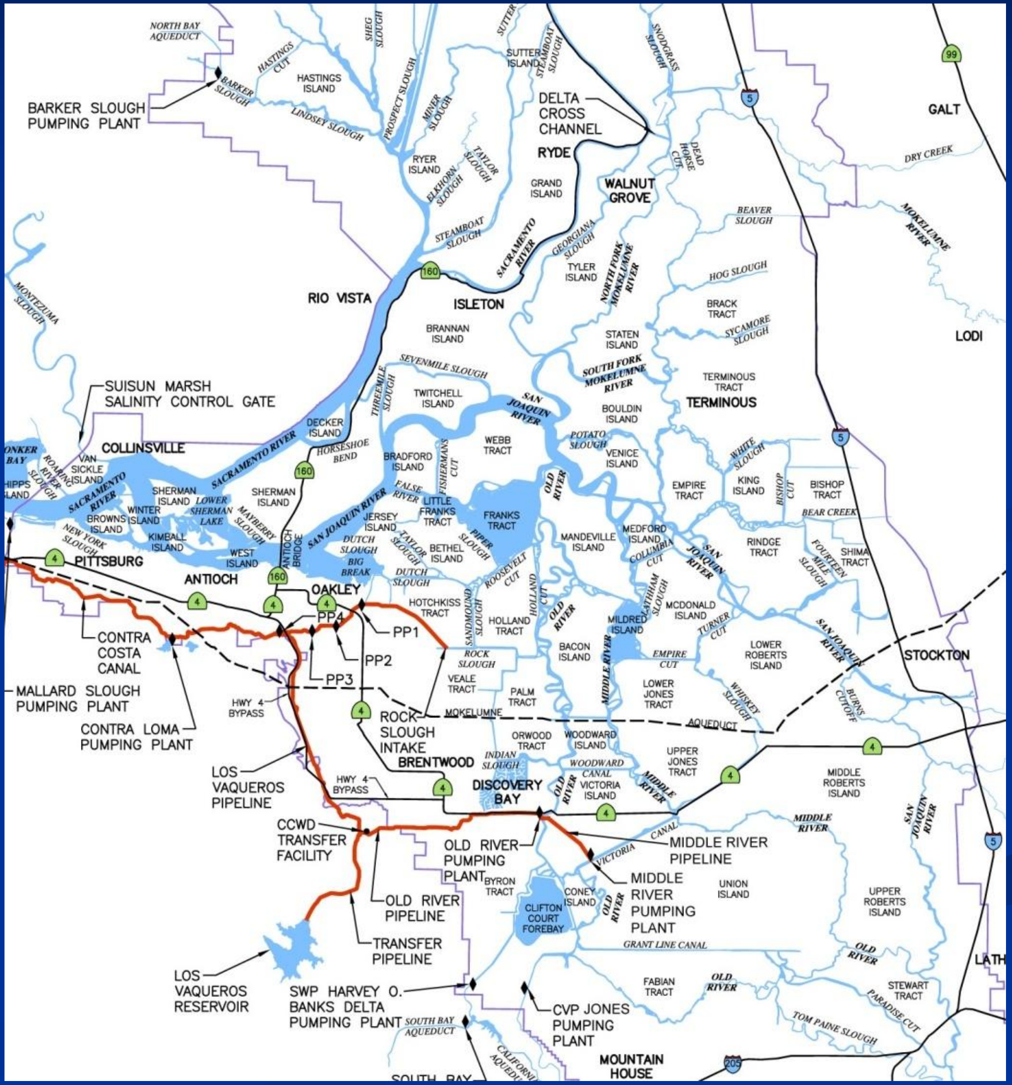
Aging and Survival Factors

- Sport fishing (Cal & Ore)
- Troll fishing (Cal & Ore)
- Ocean conditions (upwelling)

Homing Module

Homing and Straying Factors

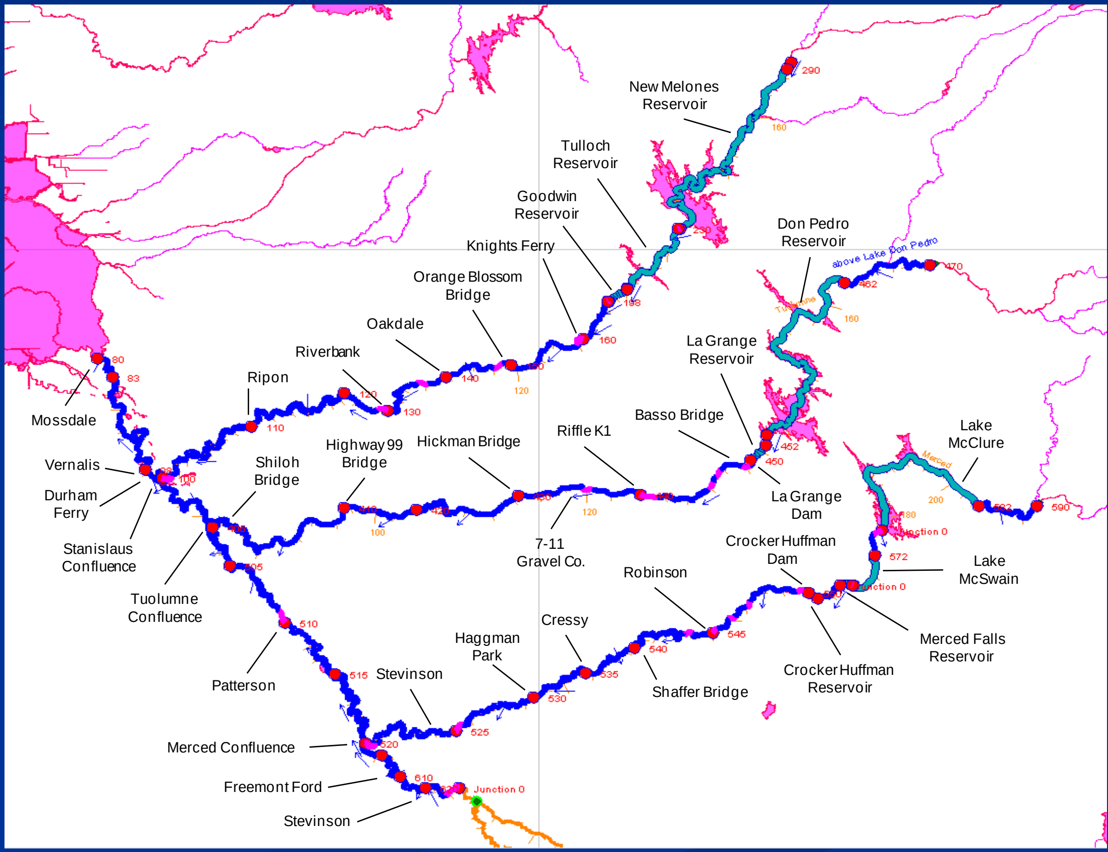
- SJR Delta inflow
- Delta exports
- Fish age



Hatchery Stray Module

Includes escapements from:

- Sacramento basin hatcheries
- Mokelumne basin Hatchery
- Merced River Hatchery



Spawning Module

Distributes spawners by:

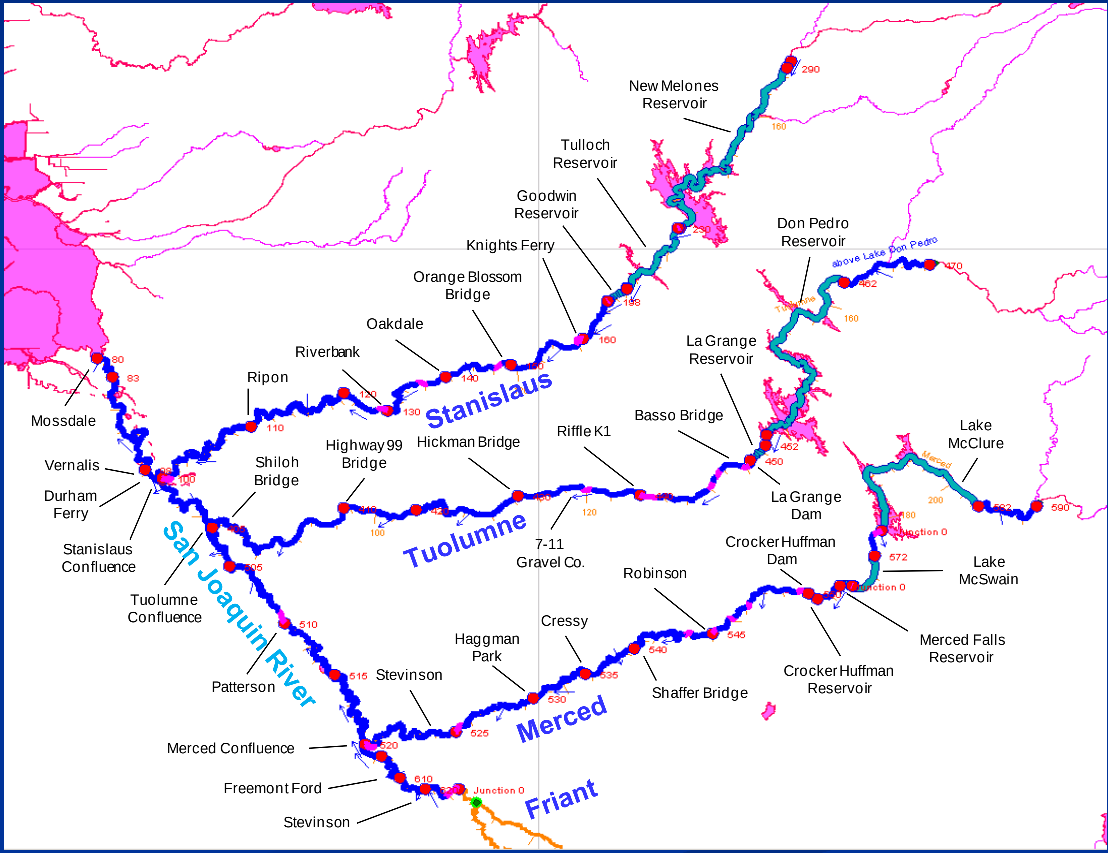
- River & date of entry

Partitions spawners by:

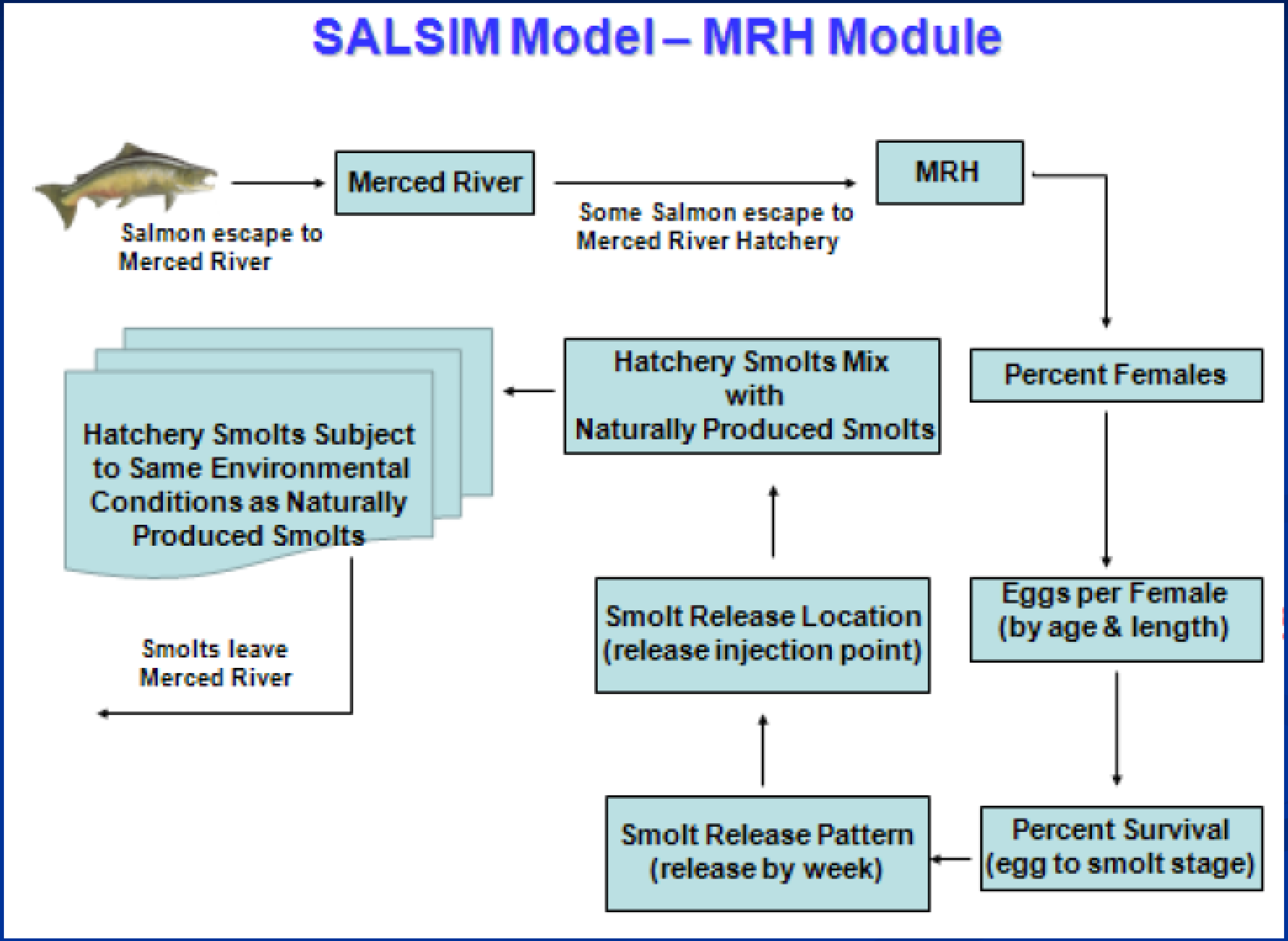
- Spawning reach
- Redd construction date

Based upon:

- Flow and H_2O temp three weeks earlier



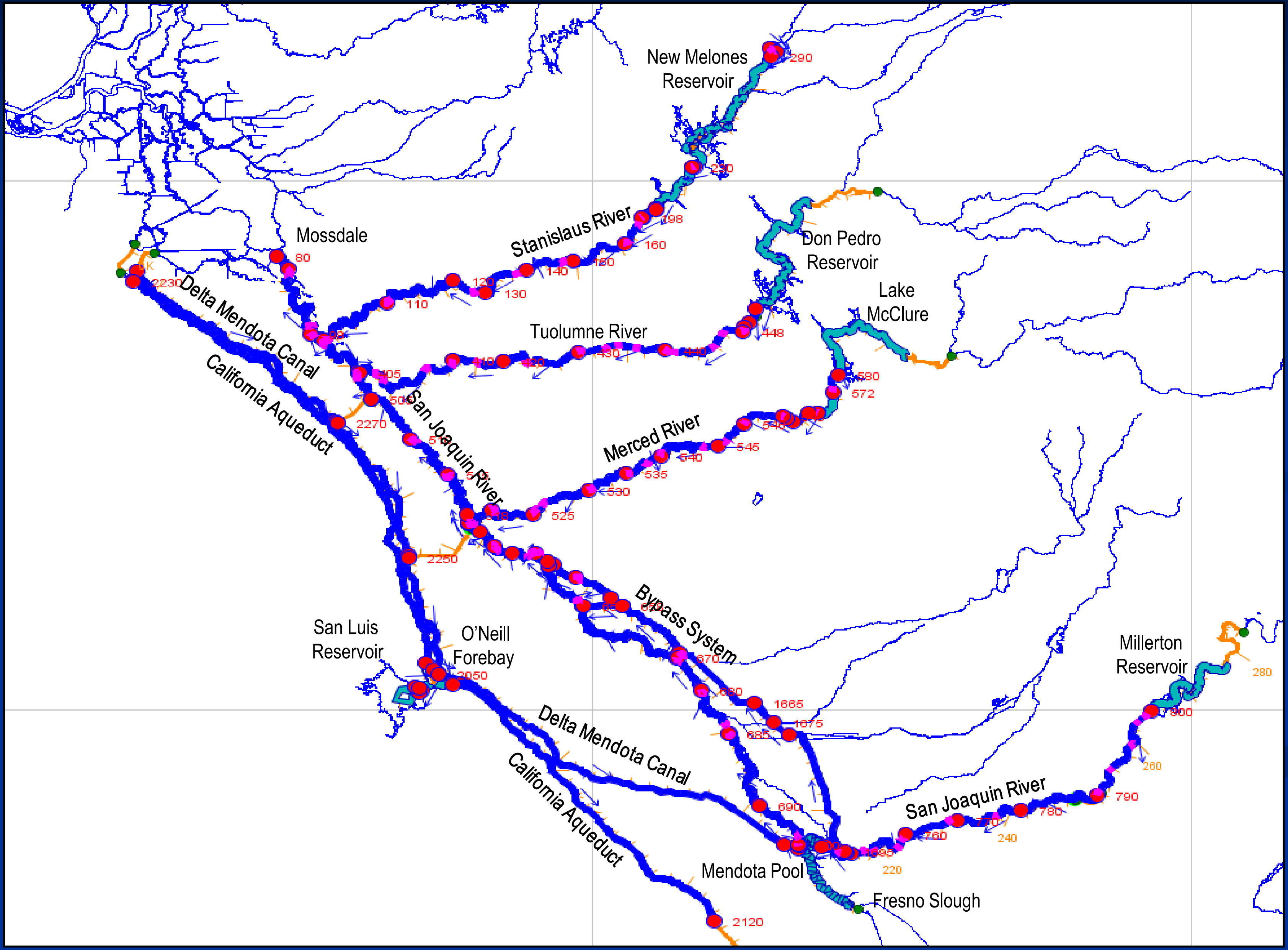
Hatchery Module



In Summary

- SALSIM is a system-wide full life cycle model
- Contains three sub-models
  - Water Operation Model
  - Water Temperature Model
  - Salmon Model
- Contains three inter-related geographical areas
  - Inland
  - Delta
  - Ocean
- Has ability to link with other basin wide models

Complimentary Basin-Wide Modeling Tools:
SJR Basin-Wide Water Temperature Model (HEC-5Q)



Model Development History "The Focus"

- Context:
  - Flow
    - Location - Vernalis
    - Time - Spring
    - What - Juvenile salmon
- CDFG's Submitted Evidence:
  - Standard is insufficient
- SWRCB: what should the standard be given the context of the standard?
- CDFG: We'll get back to you

Model Genesis

- 2005: SWRCB Periodic Review
  - Simple salmon production model (V.1.0)
  - Preliminary flow recommendations
- 2006: First Peer review
- 2007: Model Contracting
- 2008: Preliminary Model Refinement
  - Peer Review response
  - Intermediate models (V 1.5 & V 1.6)
- 2009: Nothing (contract funding frozen)
- 2010: Advanced Model Refinement
  - Version 2.0 (SALSIM)
- 2012: Second Peer Review

Peer Review #1

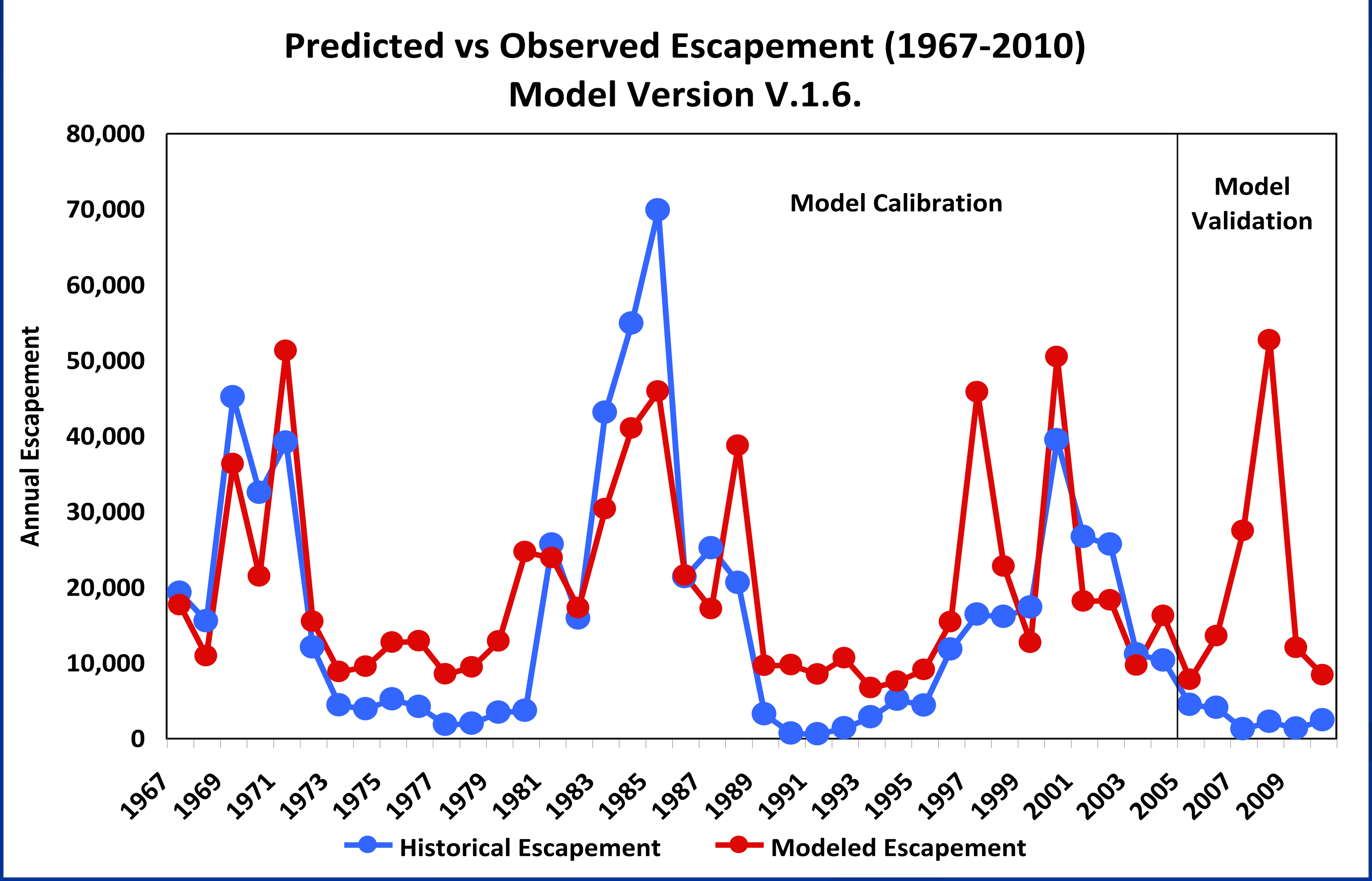
- Positive Comments
  - "If you want to use the model to suggest that more flow (within reason and practical amounts) and a longer, delayed time window would help the salmon, then I agree with the conclusions."
- Critical Comments
  - Provided detailed responses to all comments
  - Comments provided direction for further modifications, ultimately to V 1.6

Peer Response – Continued Development

- V 1.5: Increased statistical validity:
  - Use of constrained non-linear functions
- V 1.6: Continued to increase statistical rigor
  - Bounded math functions
  - Updated the salmon smolt survival relationship
- V 2.0: Conceptual Model for SalSim
  - Increased model resolution
  - Added MORE variables

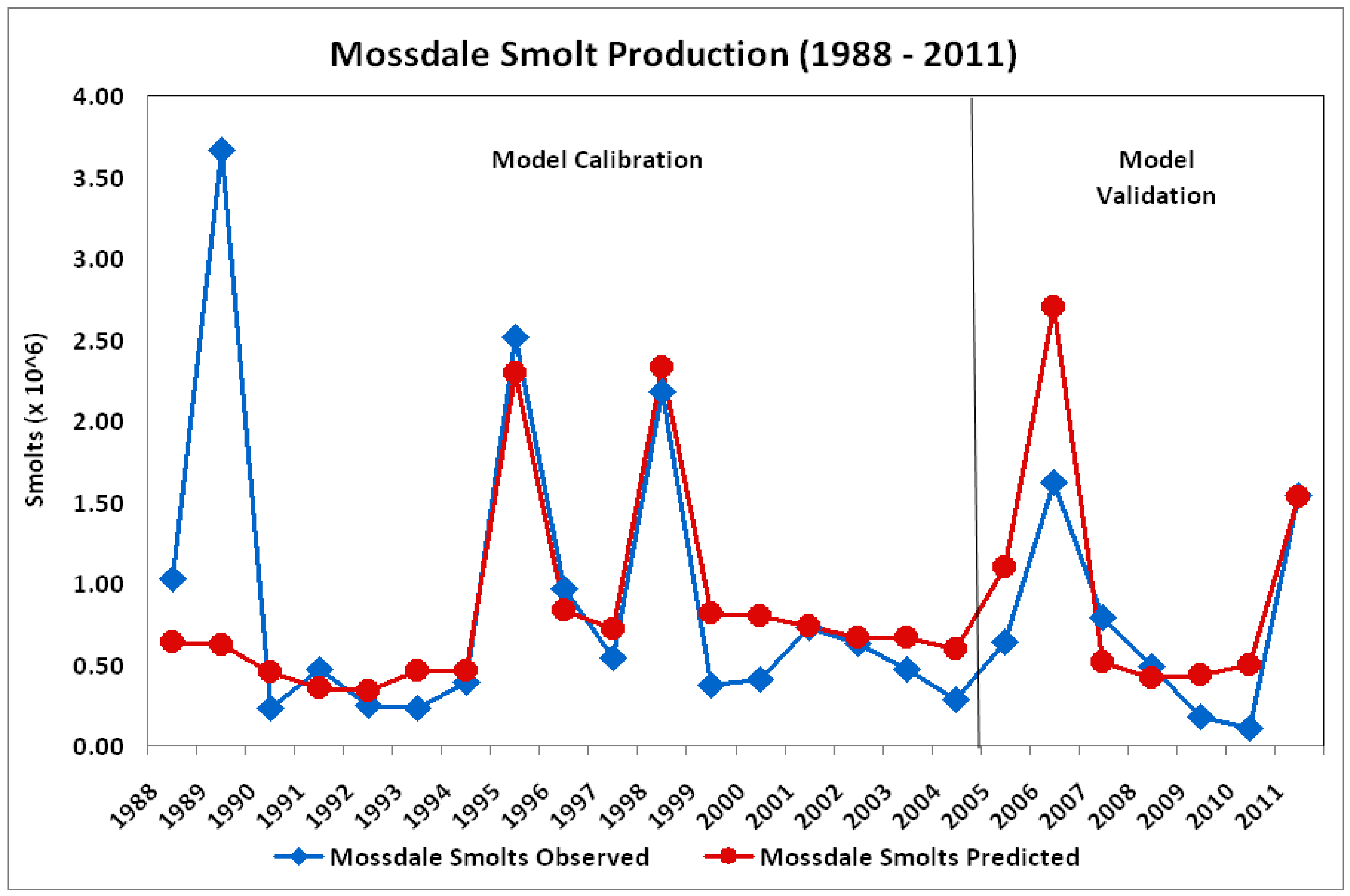
The Ultimate Test - Validation

Adults



The Ultimate Test - Validation

Juveniles



Back to SalSim

Salmonid Integrated Life Cycle Models Workshop

Report of the Independent Workshop Panel

June 14, 2011

"Our general recommendations are grouped under the categories of: PHILOSOPHICAL, COMMUNICATION, TECHNICAL, and OWNERSHIP. Many of these recommendations are known to model developers and users; we stated them here to provide a blueprint for future model development and for those readers who may not be familiar with the process of model building."
(*emphasis added*)

Modeling Guidelines

Salmonid Integrated Life Cycle Models Workshop		
Category	Possible Score	Score
Philosophical	9	9
Communication	8	4
Technical	34	31
Ownership	4	4
Total Score	56	48 (88%)

Peer Review #2

- Process
  - Open peer review
  - Submitted model & documentation
  - Gave presentation
- Peer Report
  - Received comments and recommendations
  - Model updated to reflect peer review recommendations
  - Peer review report and DFG’s response will be released with the model

SalSim's Status/Next Steps

- Prepared response to peer review
- Completing final computer programming
- Finalizing model calibration/validation
- Finishing model documentation
- Preparing to release model
  - January 2013

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Final Thoughts…SalSim

- Peer reviewed
- Will be:
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  - Completely transparent
  - Well documented
  - Based on best available science
  - Developed using well established scientific procedures and protocols

Thank You


Ocean
Delta
Inland
Stanislaus
Tuolumne
Merced
Friant
San Joaquin River

Observations Regarding the Use of Biological Models

- Focused on smelt-related models/methods
- Some specific biological model recommendations
- General observations regarding the use of models
- The importance of collaboration in model use

Specific Model/Method Recommendations

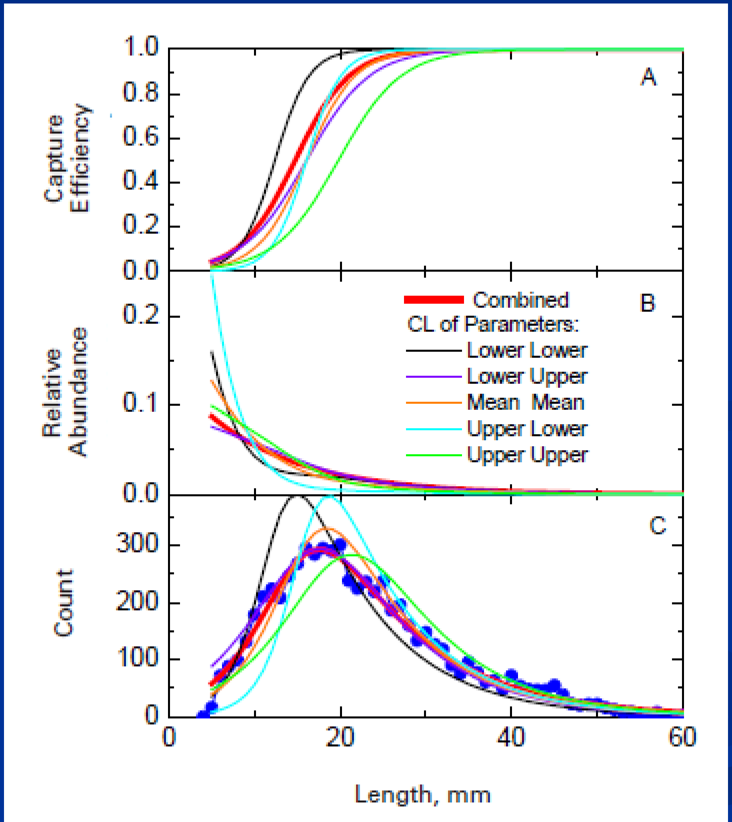
- Salvage-Density Method of Entrainment Assessment
- Kimmerer Proportional Entrainment Method
- Abundance – X2 (outflow) models
- Delta Smelt Abiotic Habitat Index

Salvage-Density Method of Entrainment Assessment

- Salvage divided by water volume exported
- Simple and transparent method for effectively salvaged species and lifestages
- Potentially useful for characterizing entrainment seasonality, and reconnaissance-level assessments of alternative export operations
- Results can be normalized to overall species abundance
- Most useful for CVP assessments
- Assumes linear relationship between salvage and exports, constant pre-screen loss and screening rates

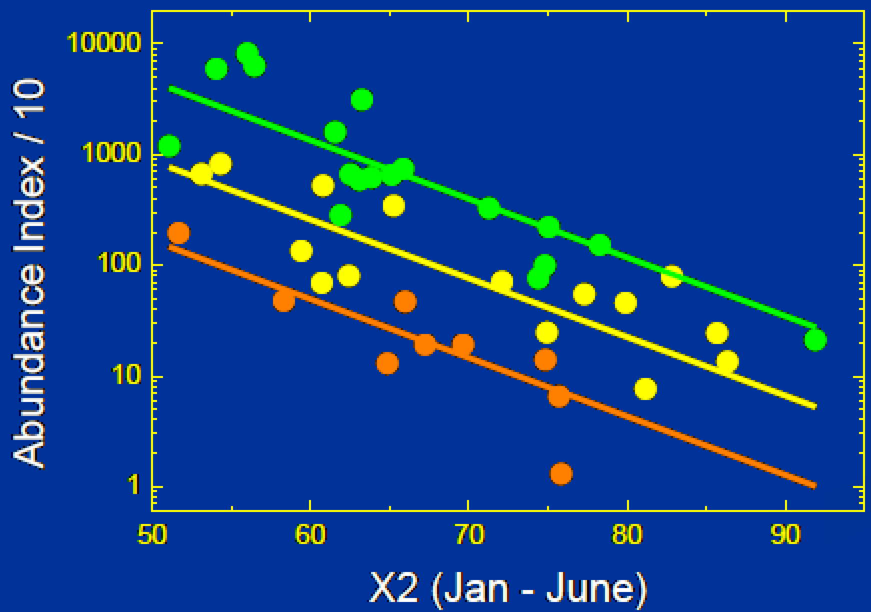
Kimmerer Proportional Entrainment Method

- Proportion of "population" <u>entrained</u> (CVP+SWP)
- Larval/Juvenile and adult delta smelt & emigrating salmon smolts
- For delta smelt, close to providing the population effect
- BDCP pursuing a robust effects analysis adaptation



Abundance – X2 (outflow) models (Longfin Smelt Example)

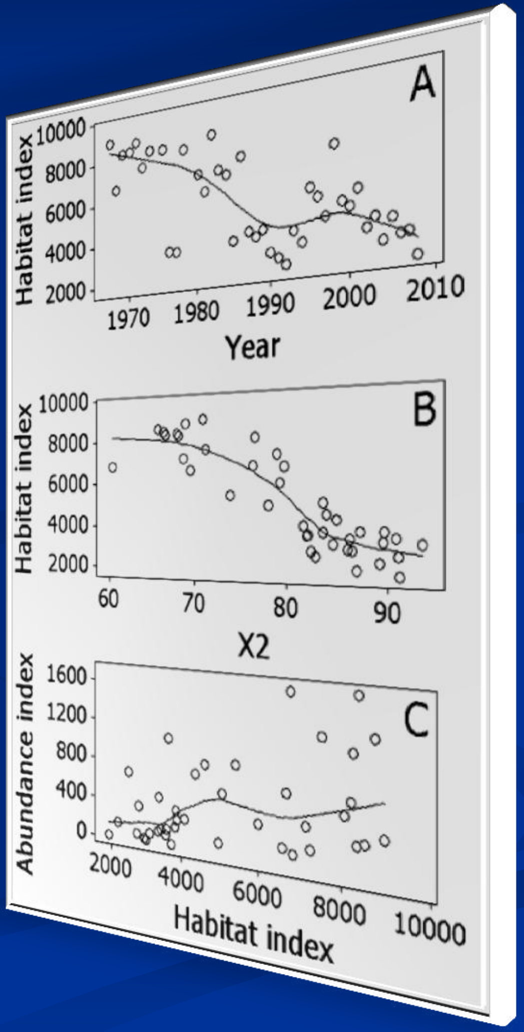
- Describes/predicts Age-0 response to outflow
- Updated through 2009
- Allows for 1987 clam-related step change



- Several credible potential mechanisms underlie model
  - Increased low salinity habitat
  - Increased larval transport
  - Increased turbidity (lower predation, less metabolic demand)
  - Improved food supply (more nutrients & reduced clam grazing)
- Inclusion of stock size improves model fit

Delta Smelt Abiotic Habitat Index

- Addresses basic habitat condition for the key lifestage
- Based on evidence that salinity and turbidity best predict juvenile delta smelt occurrence
- Predicts quantity and quality of available habitat at given X2 (outflow)
- Habitat size sensitive to outflow, and downstream seaward location enhances turbidity component
- Understanding flow/habitat relationship directly informs management
- Does not address biological components of habitat



General Recommendations Regarding Biological Model Use

- Limited to lifestage- and stressor-specific models
- Explicitly identify and assess key model assumptions and limitations
- Evaluate the strength of underlying statistical relationships
- Consider the efficacy and risks of projections beyond the range of underlying data sets
- Collaboration in model use is critical!

Some Smelt Lifecycle Model (LCM) Challenges

- Applicable full LCMs are not presently available, but may become available
- More data needs than data
- Weak covariates limit statistical-based LCM accuracy
- Absence of flow variables from statistical-based LCMs does not indicate a lack of flow importance, limits utility
- LCMs sensitive to assumed stock-recruitment relationships

Modeling Workgroup(s)

- Establish modeling workgroup(s) composed of technical representatives from interested agencies and NGOs
- Establish to support both physical and biological modeling
- Seek consensus on modeling tools, methods, & inputs
- Ensure that models are appropriate for questions being addressed
- Strive for thorough a priori mutual understanding of model assumptions and limitations
- Consult with input data-set experts, as appropriate

SWRCB Workshop 3:

Analytical Tools for Evaluating the Water Supply, Hydrodynamic, and Hydropower Effects

NOAA Fisheries

Candan Soykan

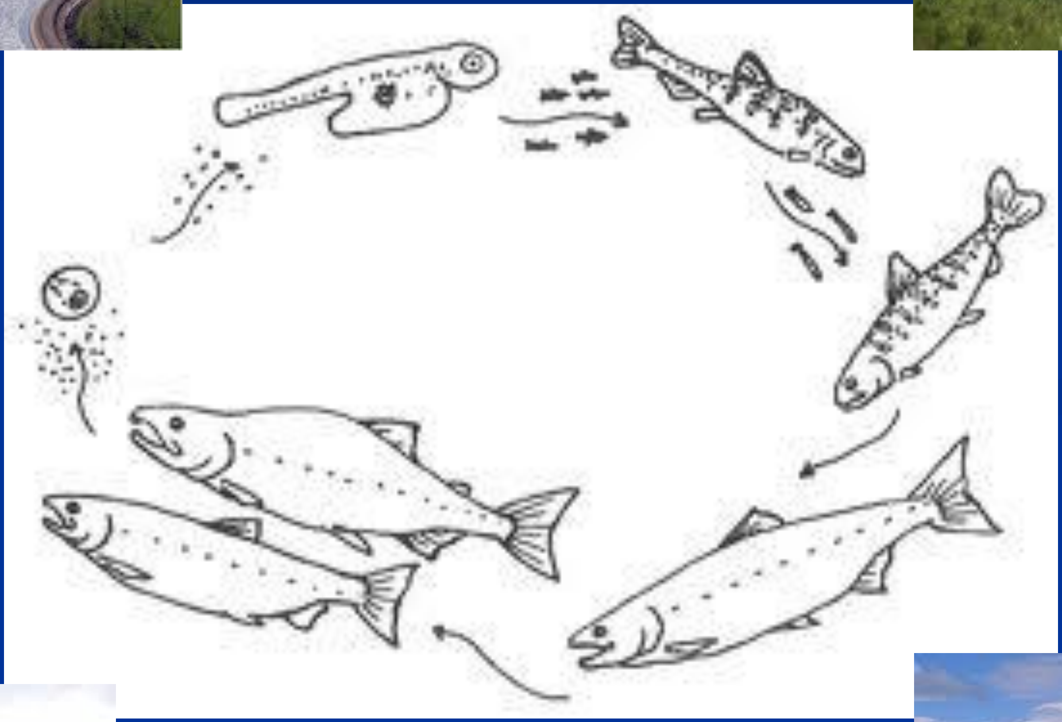
November 13, 2012

A Flexible, Multi-Input Life Cycle Model for Chinook Salmon in the Central Valley of California

Candan Soykan, Steve Lindley, & Leora Nanus (SWFSC)
Correigh Greene, Hiroo Imaki, & Tim Beechie (NWFSC)
Noble Hendrix (QEDA)
Russell Perry (USGS)

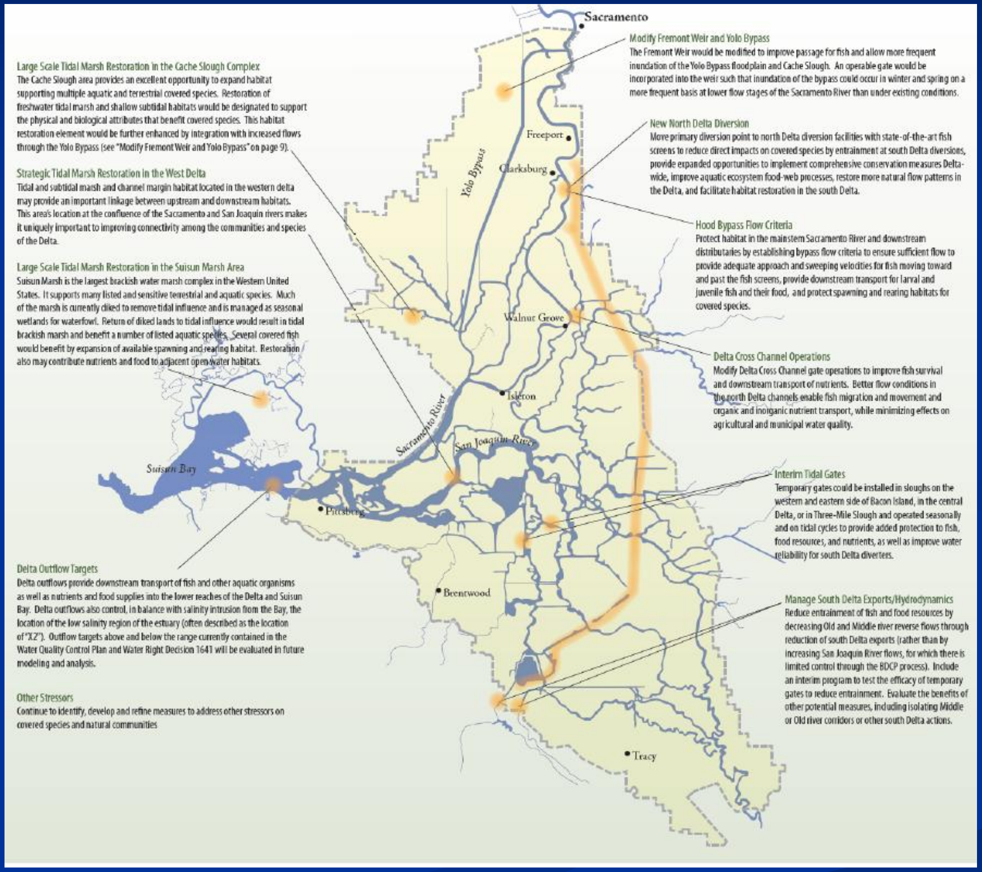
candan.soykan@noaa.gov

Winter-Run Chinook



Management

- Flow
- Water Temperature
- Habitat Restoration
- Predator Control
- Exports
- Harvest



Life Cycle Models

- Spatio-Temporal Resolution
- Input Parameters
- Model Structure
  - Theoretical Foundation
  - Model Purpose

Life Cycle Models

- Spatio-Temporal Resolution
- Input Parameters
- Model Structure
  - Theoretical Foundation
  - Model Purpose

All models are a gross simplification of reality

Each model simplifies reality in a different way

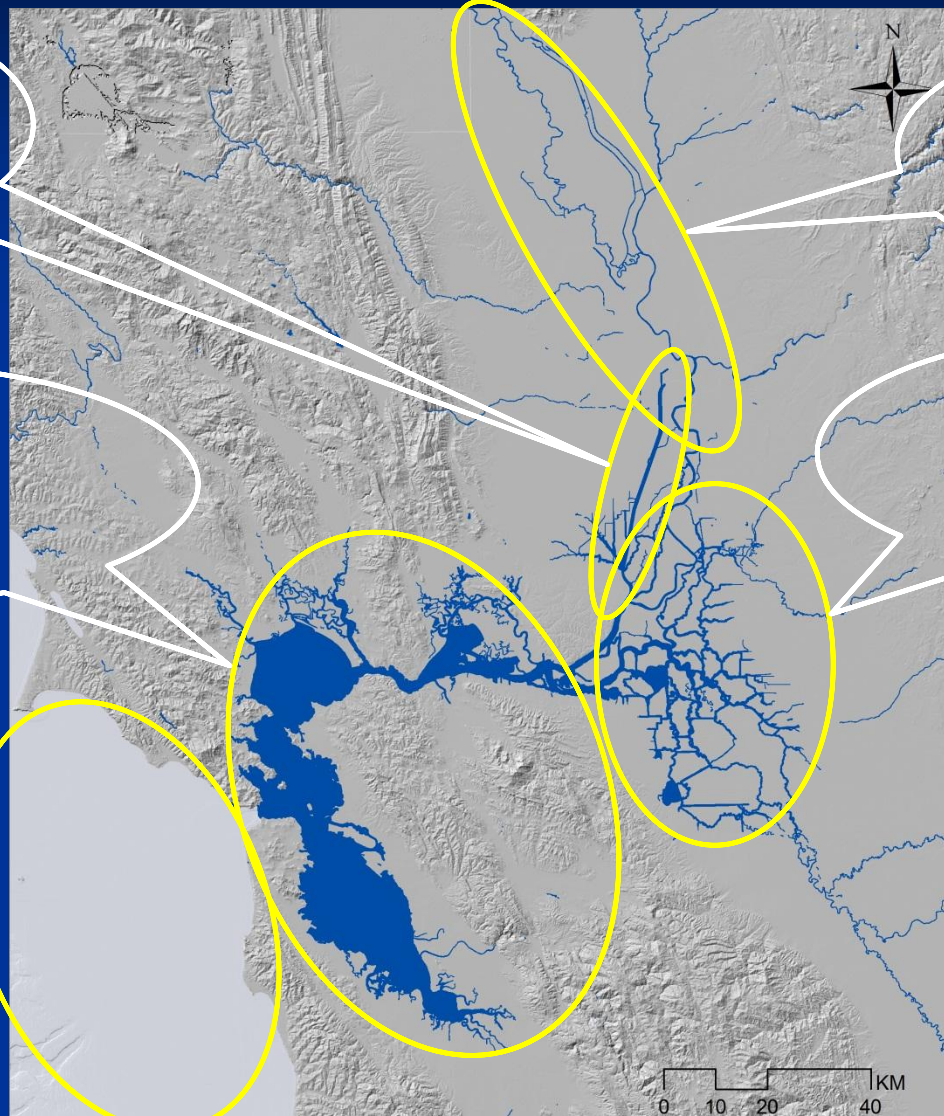
Model Purpose

- Address Chinook survival and capacity at different stages of the life cycle
- Leverage existing biophysical models
- Identify critical data gaps for future data collection efforts
- Address questions related to OCAP and BDCP management objectives

Spatial Resolution

Yolo
Rearing Stage
Smolt Stage

Mainstem
Egg Stage
Rearing Stage
Smolt Stage



Bay
Rearing Stage
Smolt Stage

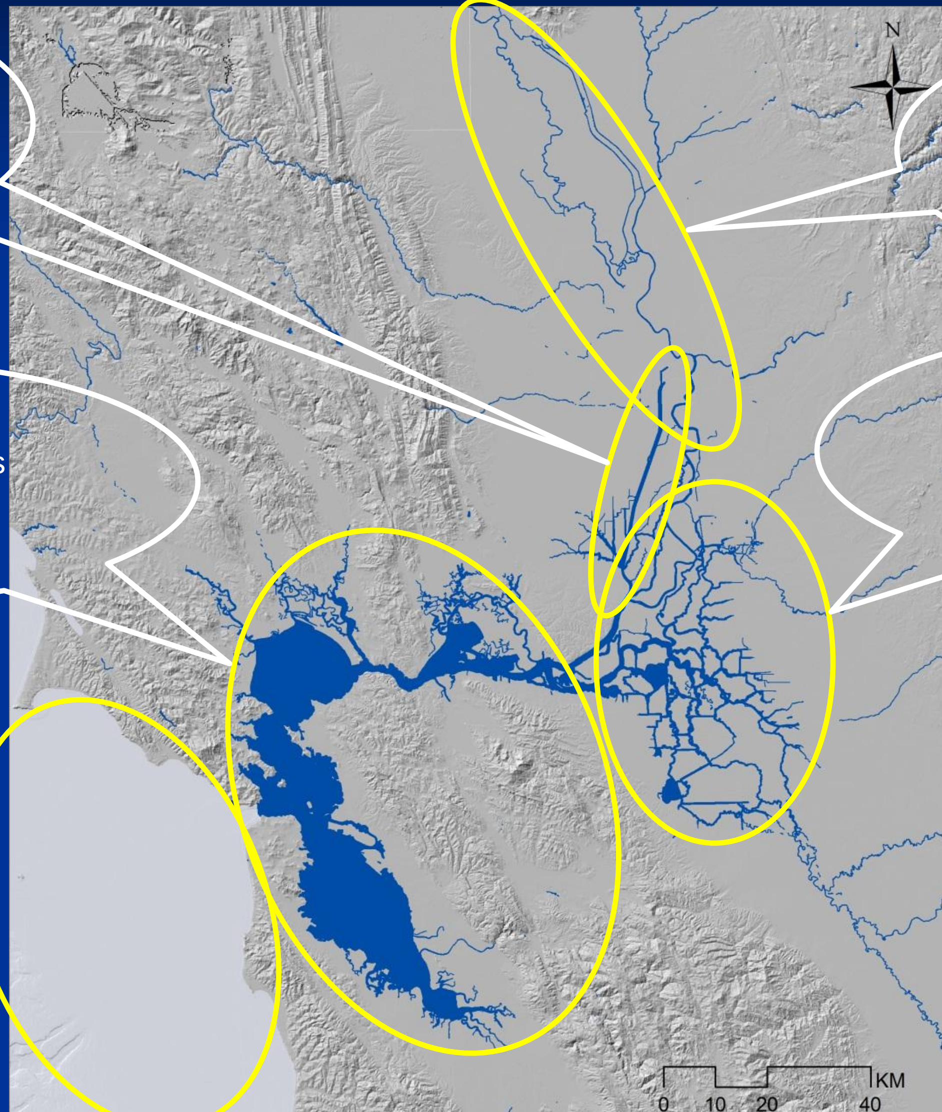
Delta
Rearing Stage
Smolt Stage

Ocean
Ocean Entry
Ocean Stage

Biophysical Inputs

Yolo
Flow
Temperature
Manning's n

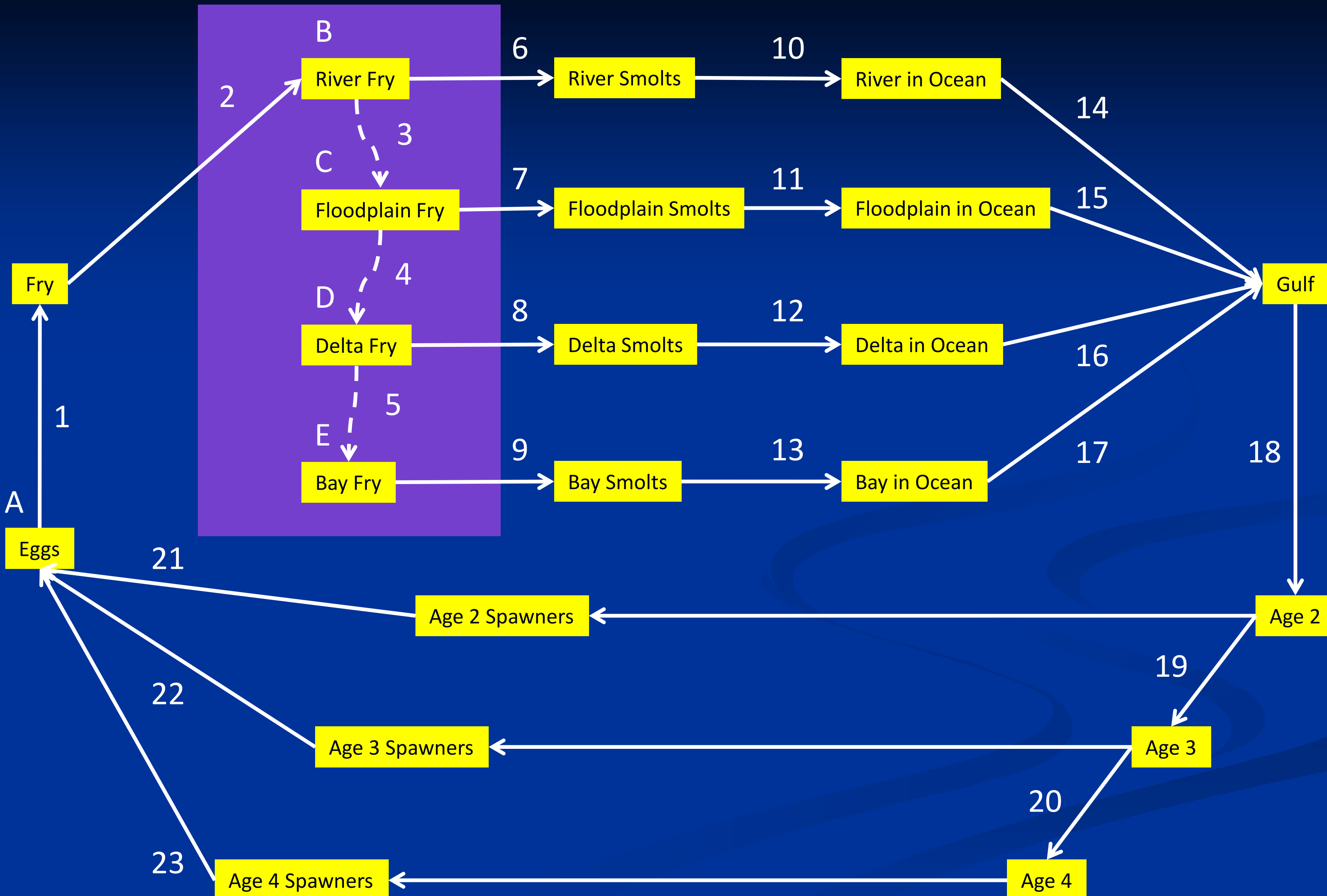
Mainstem
Flow
Temperature
Manning's n



Bay
Bank Characteristics
Channel Type
Levees
Depth

Delta
Bank Characteristics
Channel Type
Levees
Depth

Ocean
Climate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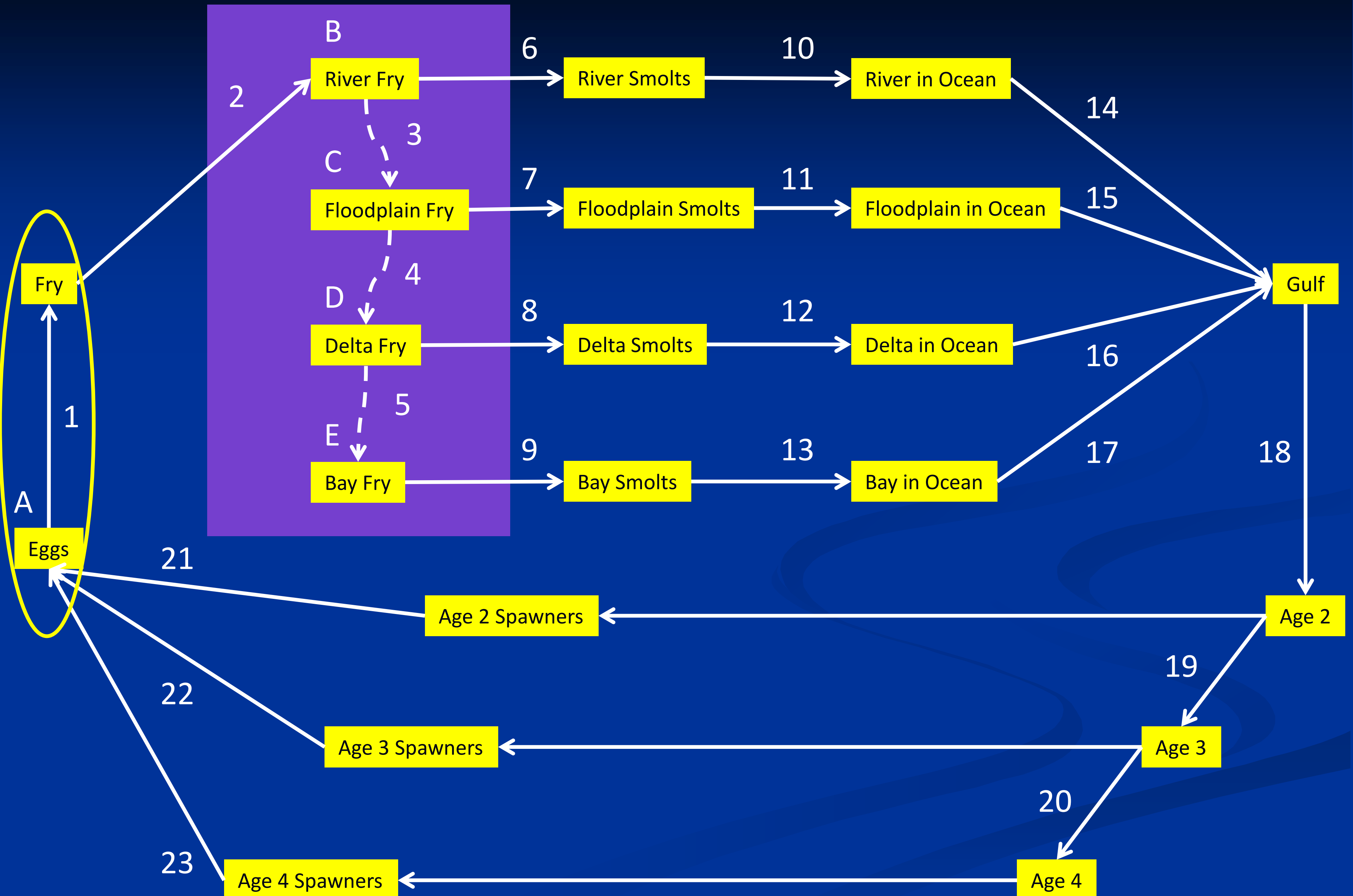

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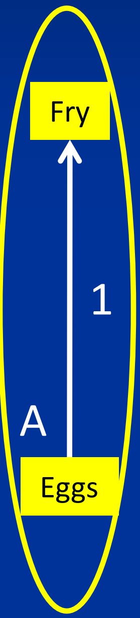
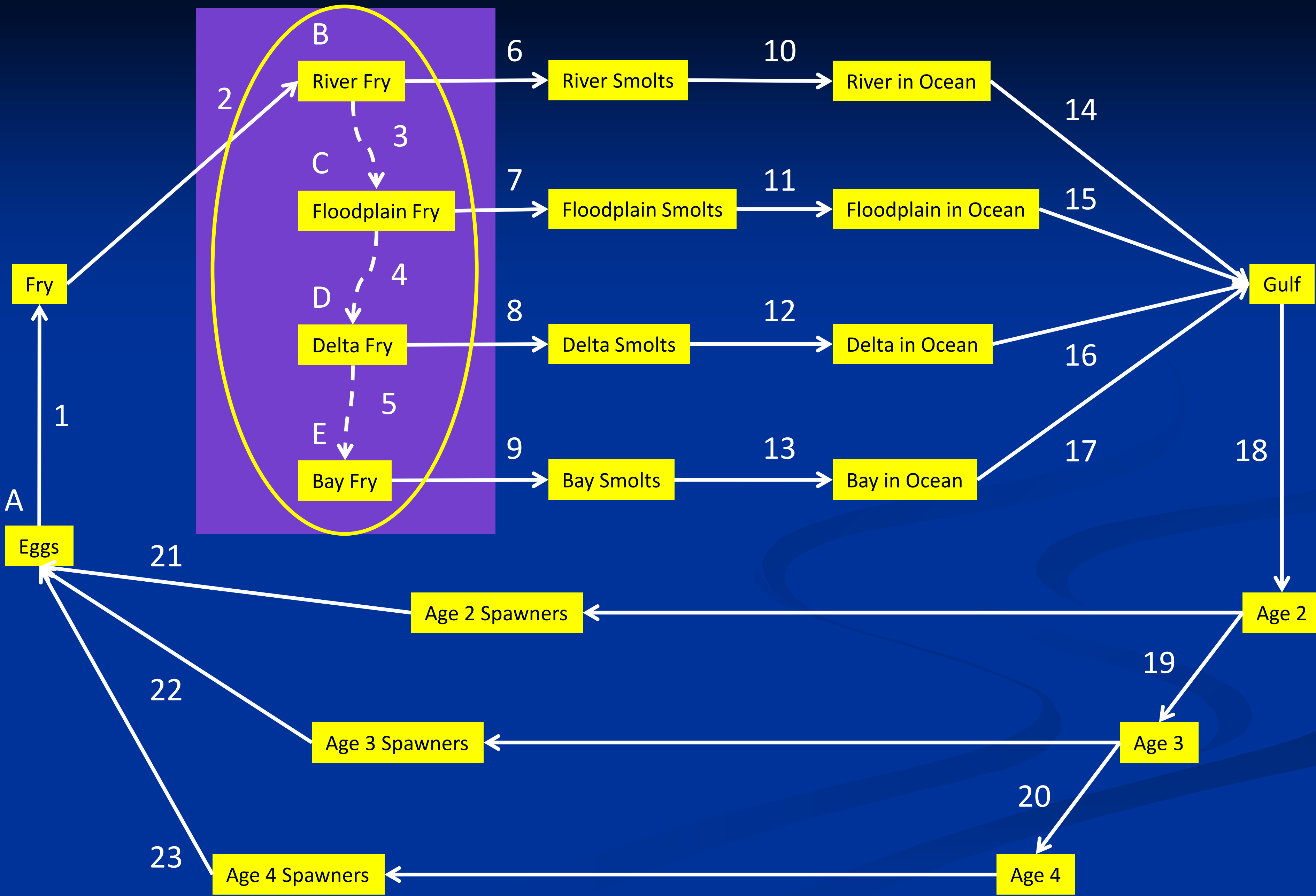
Egg Stage



- Capacity
  - Depth
  - Velocity
  - Manning's n (bottom roughness)
- Survival
  - Water Temperature



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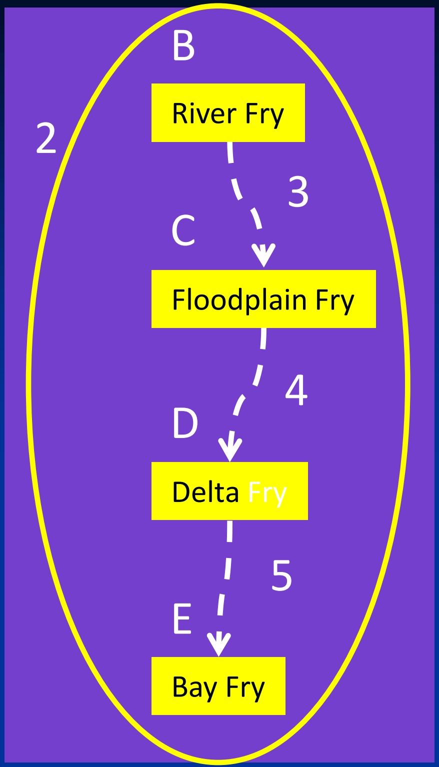

Rearing Stage

- Movement
  - Flow-Dependent
  - Flow-Independent
- Capacity (River and Floodplain)
  - Depth
  - Velocity
  - Manning's n
- Capacity (Delta and Bay)
  - Depth
  - Channel Type
  - Levees
  - Bank Characteristics
- Survival
  - Water Temperature

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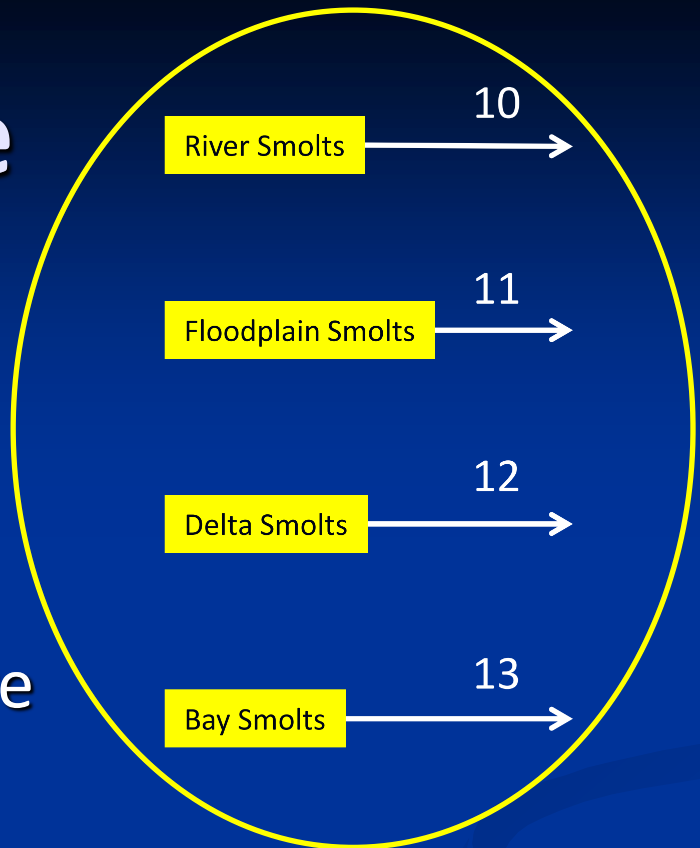
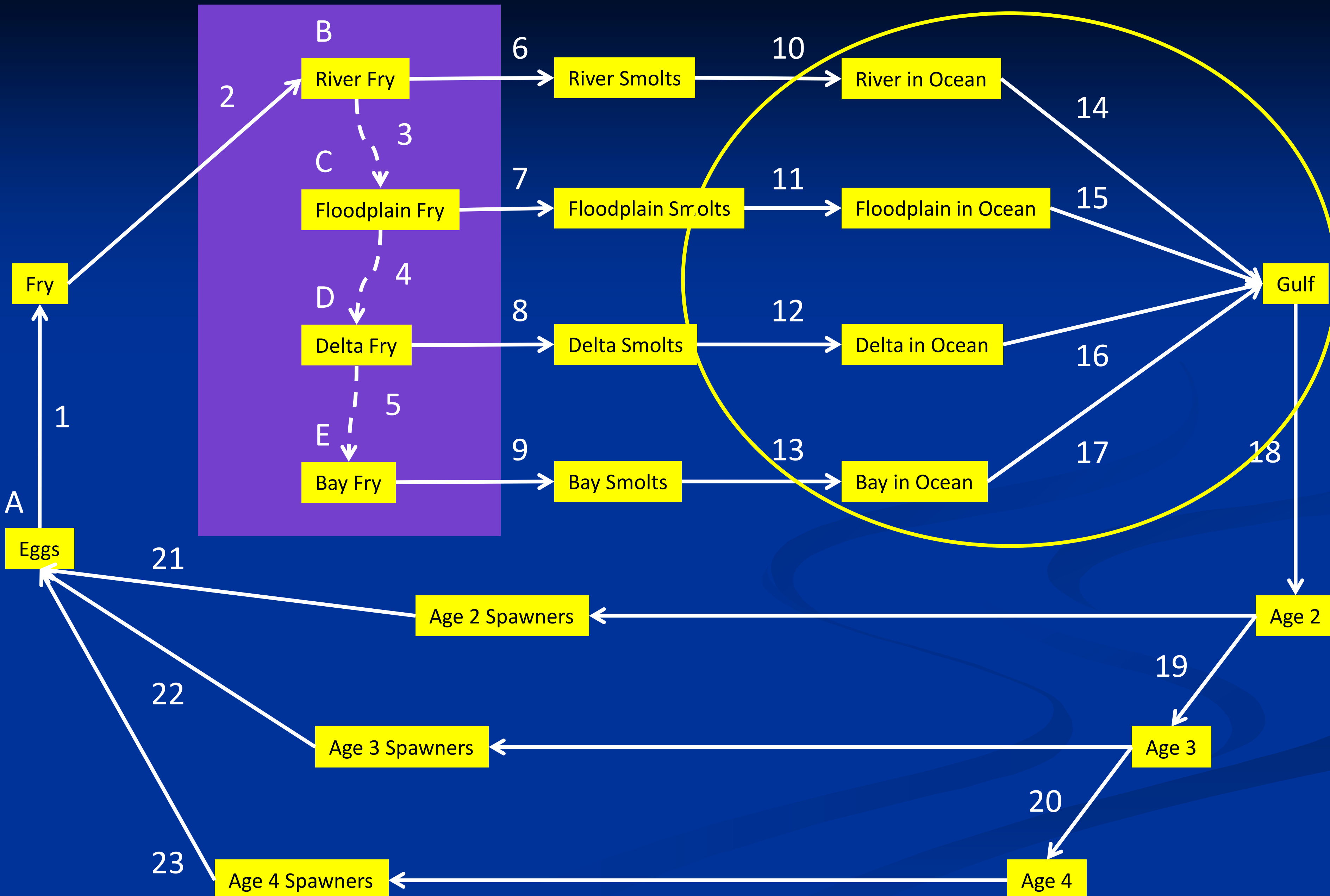
Smolt Stage

- Survival
  - Flow
  - Exports
  - Temperature





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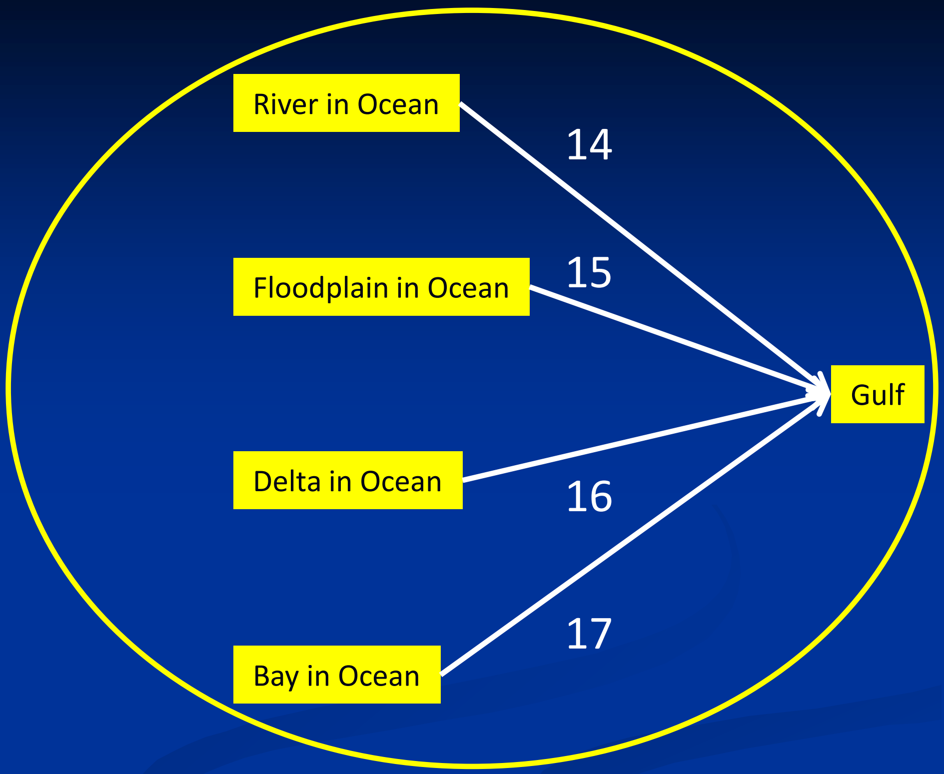
Ocean Entry

- Survival
  - Climate-Dependent
  - Habitat-of-Origin-Dependent



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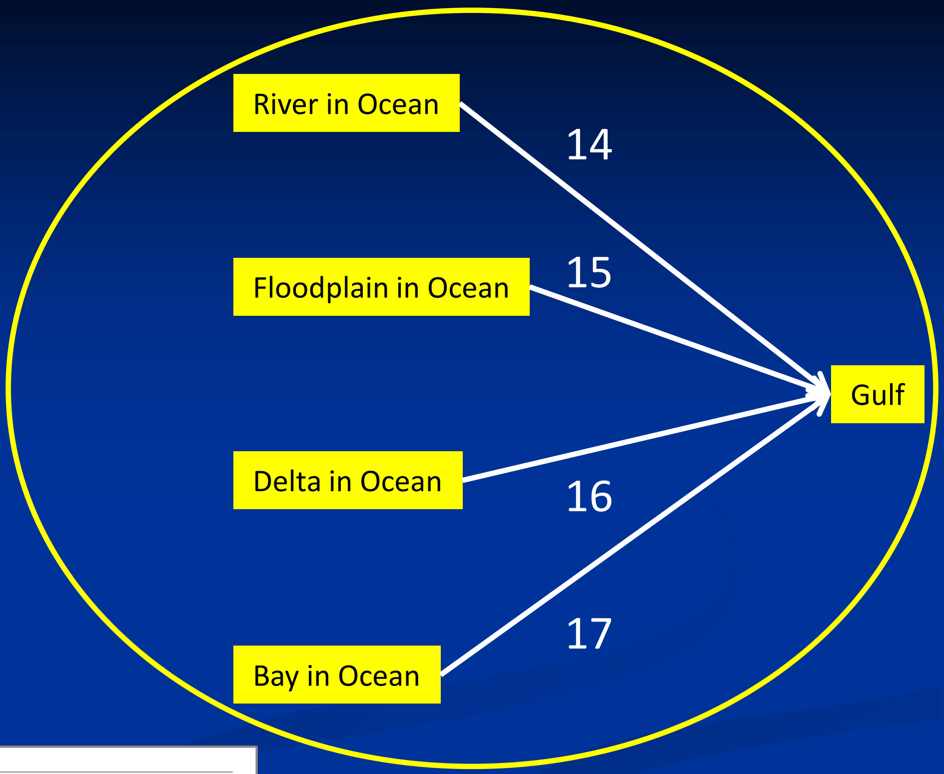

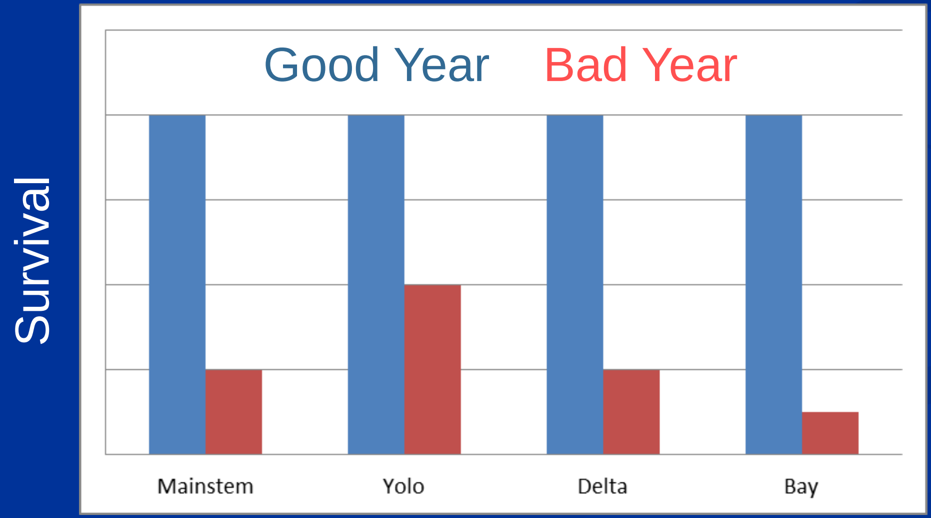

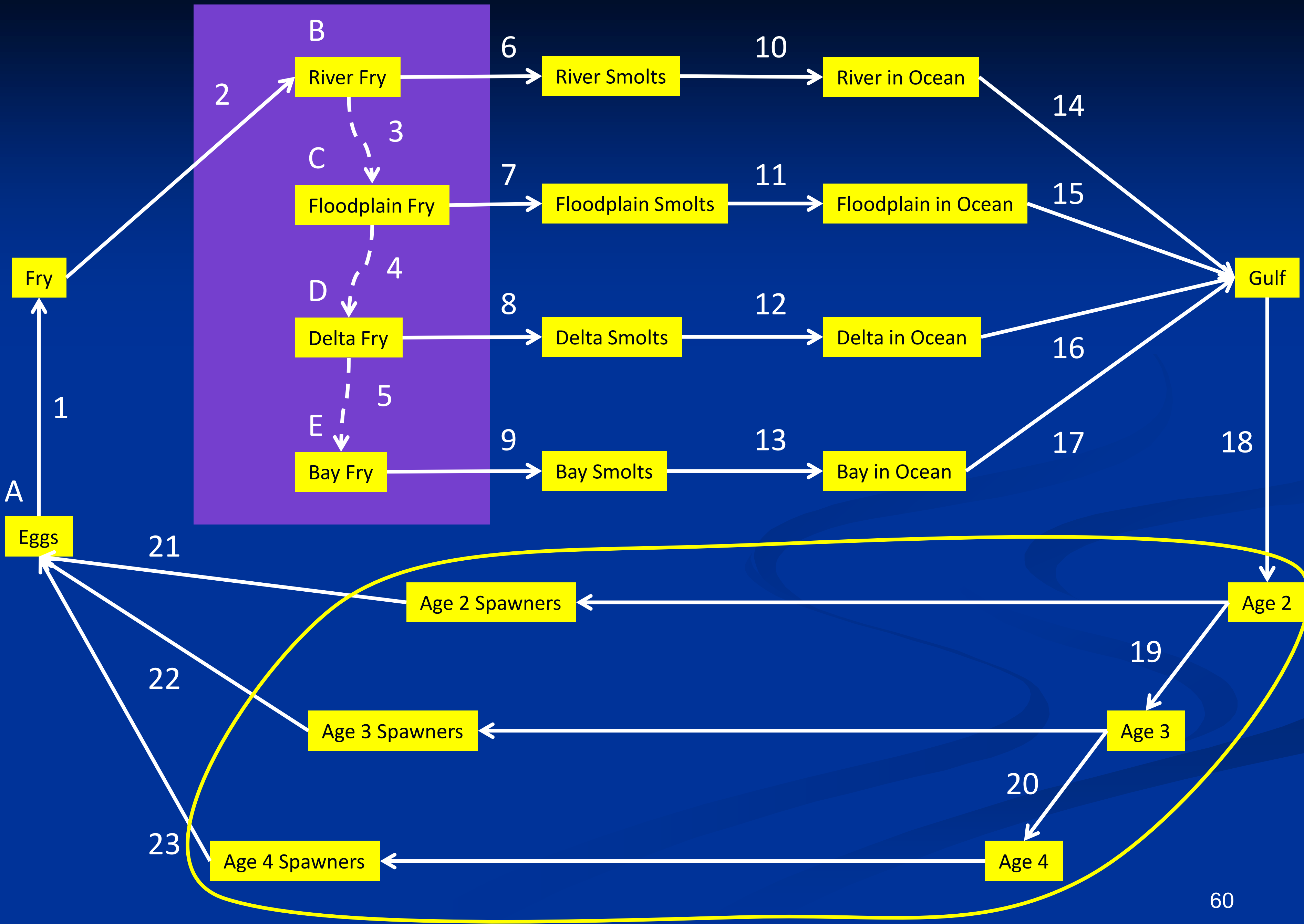
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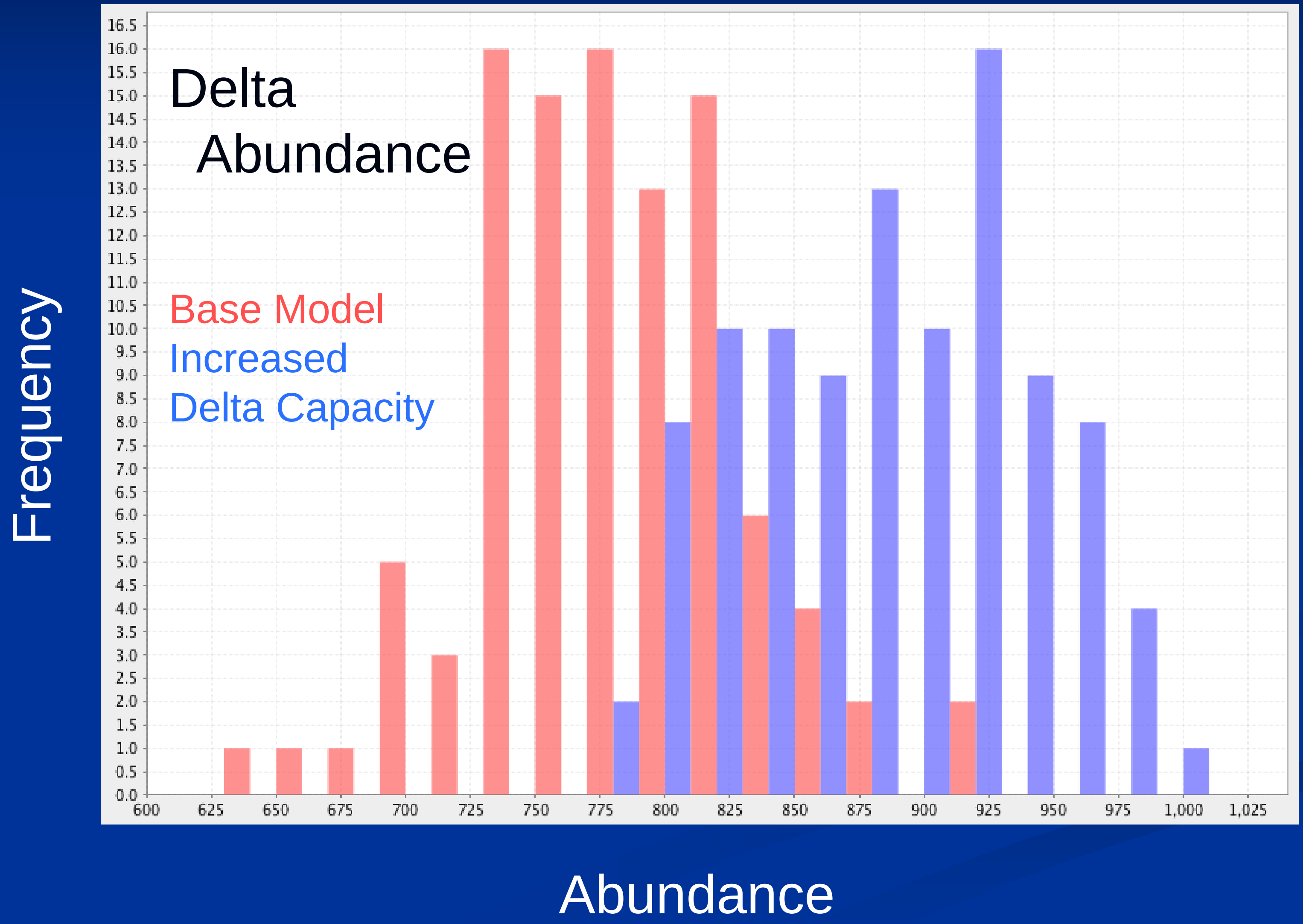
Ocean Stage

- Survival
  - Year-to-Year Variation
  - Age-Dependent
- Maturation Rates
  - Year-to-Year Variation

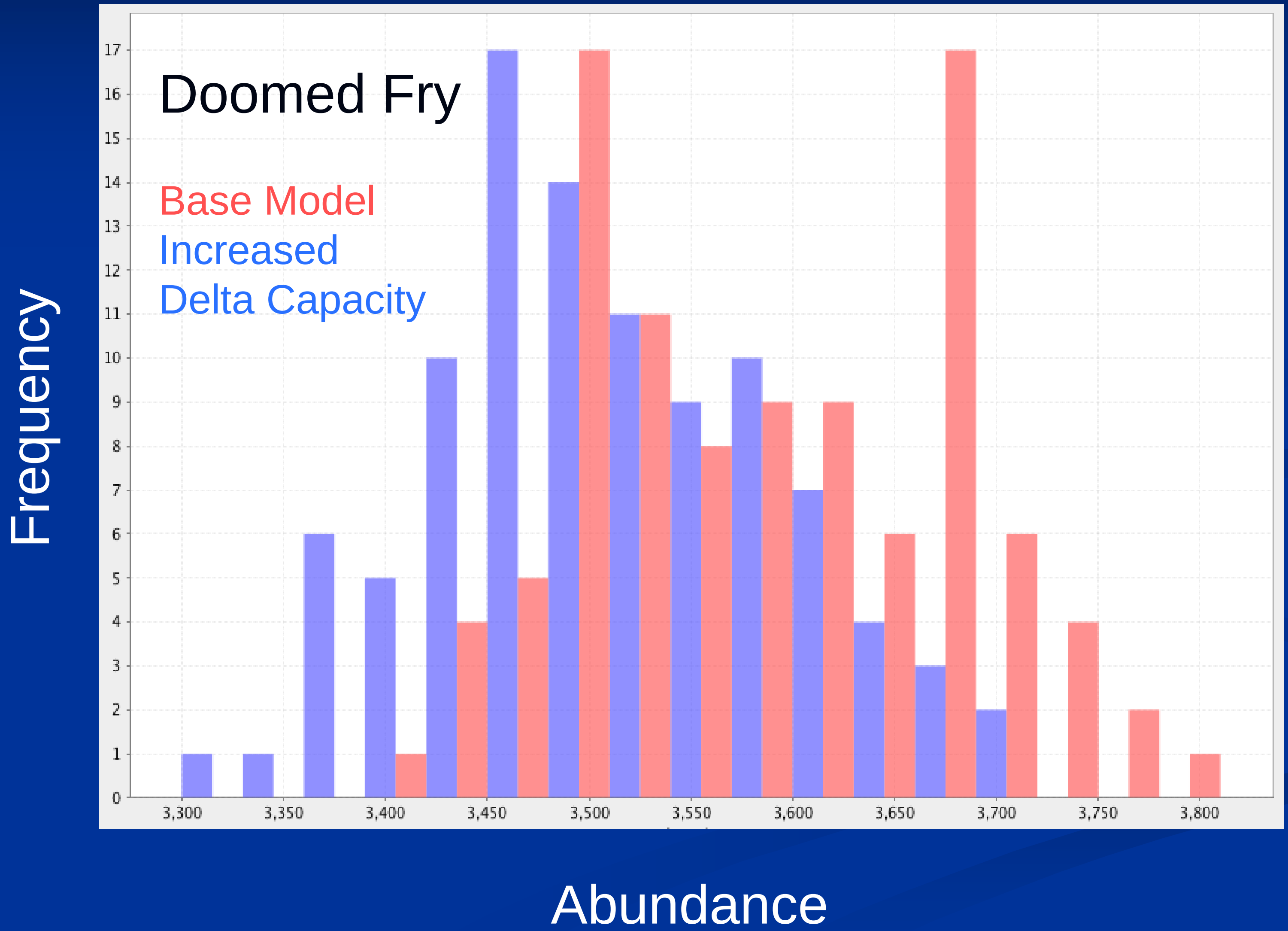
Model Application

- How do management actions intended to increase Delta capacity affect Chinook?
  - Direct Effects
  - Indirect Effects

Direct Effect



Indirect Effect



Current Model

- To be completed by end of 2012
- Robust, but can be improved
  - Manning's n values ≈ habitat suitabilty
  - Bank Type GIS layer imprecise
  - Migration survival estimates limited

Next Steps (version 2)

- By late Fall 2013
- Better estimates of habitat suitability
  - bathymetric data based on sonar
  - bank type data based on LiDAR
- More precise estimates of migration survival
  - XT model (theoretical foundation)
  - modified PTM in DSM2
  - empirically-calibrated

Acknowledgements

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Using Structured Decision Making to manage uncertainty and improve management outcomes

U.S. Fish and Wildlife Service

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Key points

1. SDM should be used to develop a decision support framework, evaluate trade-offs among alternatives
2. Efficient, strategic monitoring –reducing uncertainty could influence decisions
3. incorporate monitoring data into decision-making to achieve adaptive management
4. examine consequences of alternative management scenarios

What is Structured Decision Making?

"A formal application of common sense for situations too complex for the informal use of common sense."

R. Keeney

What makes decisions hard?

- May not know all the possible actions
- Objectives may be complex or contradictory
- System dynamics may be poorly known
- Even knowing all the other components, the solution (optimization) may be difficult to figure out

- Science alone cannot make the decision about water quality objectives; the decision is informed by science but ultimately value based

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Key Elements

- Problem decomposition
  - Break the problem into components
  - Complete relevant analyses
  - Recompose parts to make a decision
- Values-focused
  - Objectives (values) discussed first, drive rest of analysis
  - Contrasts with intuitive decision-making, which usually jumps straight to the alternatives
- Defensible, transparent, efficient decisions

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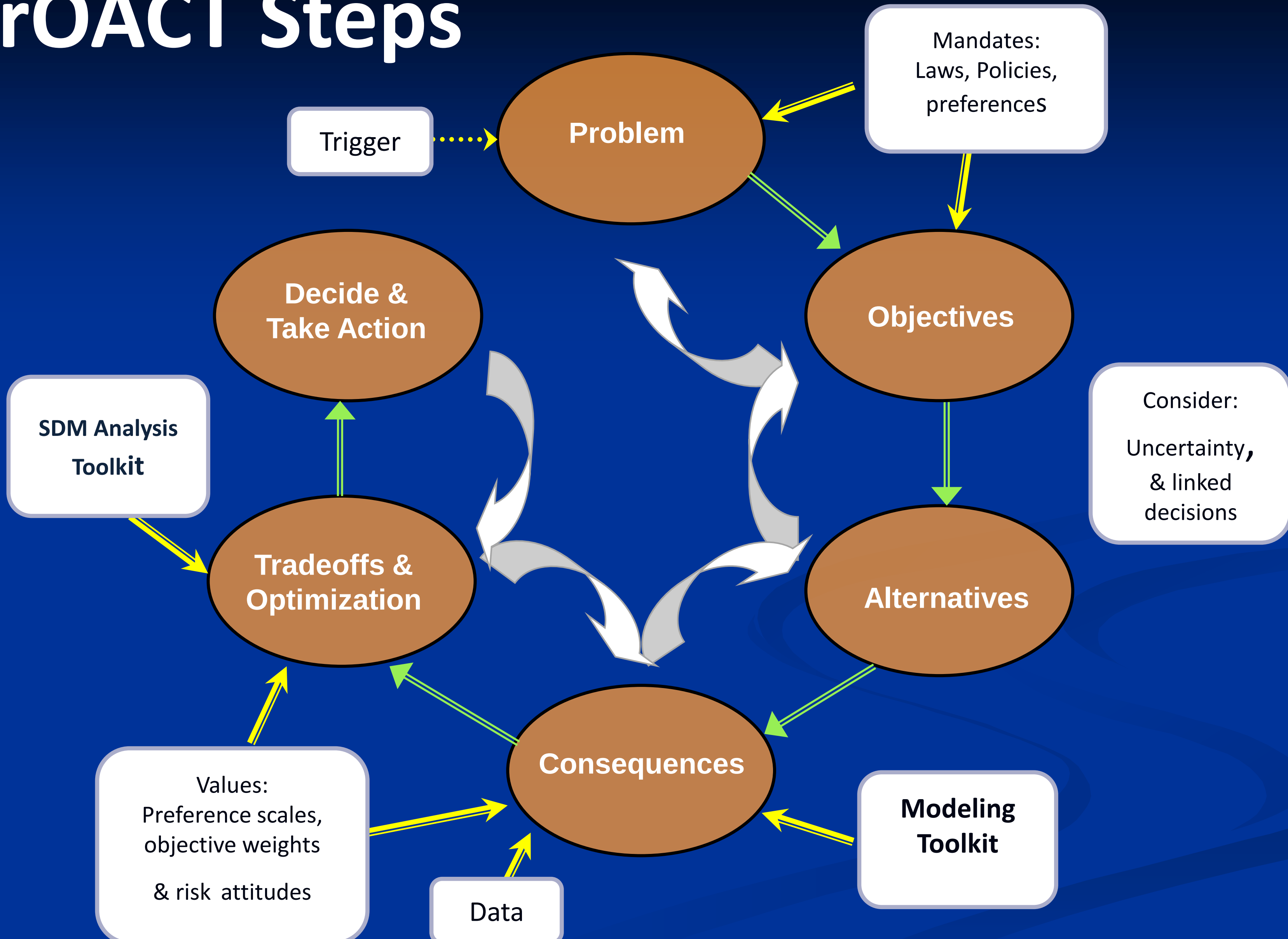
PrOACT Steps



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Framing the Problem

- The hardest skill of all and the first step
  - Need to anticipate all the elements of the decision
  - Requires getting a glimpse of the core decision problem
- Use the PrOACT+ framework
  - And continually revisit the question

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Objectives

- Explicit statement allows focused discussion, negotiation, and evaluation
- Should capture implied trade-offs
- The objective drives everything else
- Focus on setting objectives first, before discussing alternatives

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Potential actions

- Sometimes the list of potential actions is clear
  - But often generating list is fundamental challenge
  - Options initially discussed is often unnecessarily narrow
- Ask, how can the objectives be achieved?
  - Fundamental objectives generate alternative actions
  - Challenge apparent constraints
  - Don't anchor on initial set of options
  - Develop creative & unique alternatives before assessing feasibility and efficacy

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The Role of Modeling

- Models link actions to outcomes that are relevant to the objectives
  - Models make predictions (consequences)
  - Examine relative differences between alternatives
  - Sensitivity analyses determine where additional information could change a decision (monitoring)
  - Decision context provides guidance about how to construct the model
- There is a wide range of types of models

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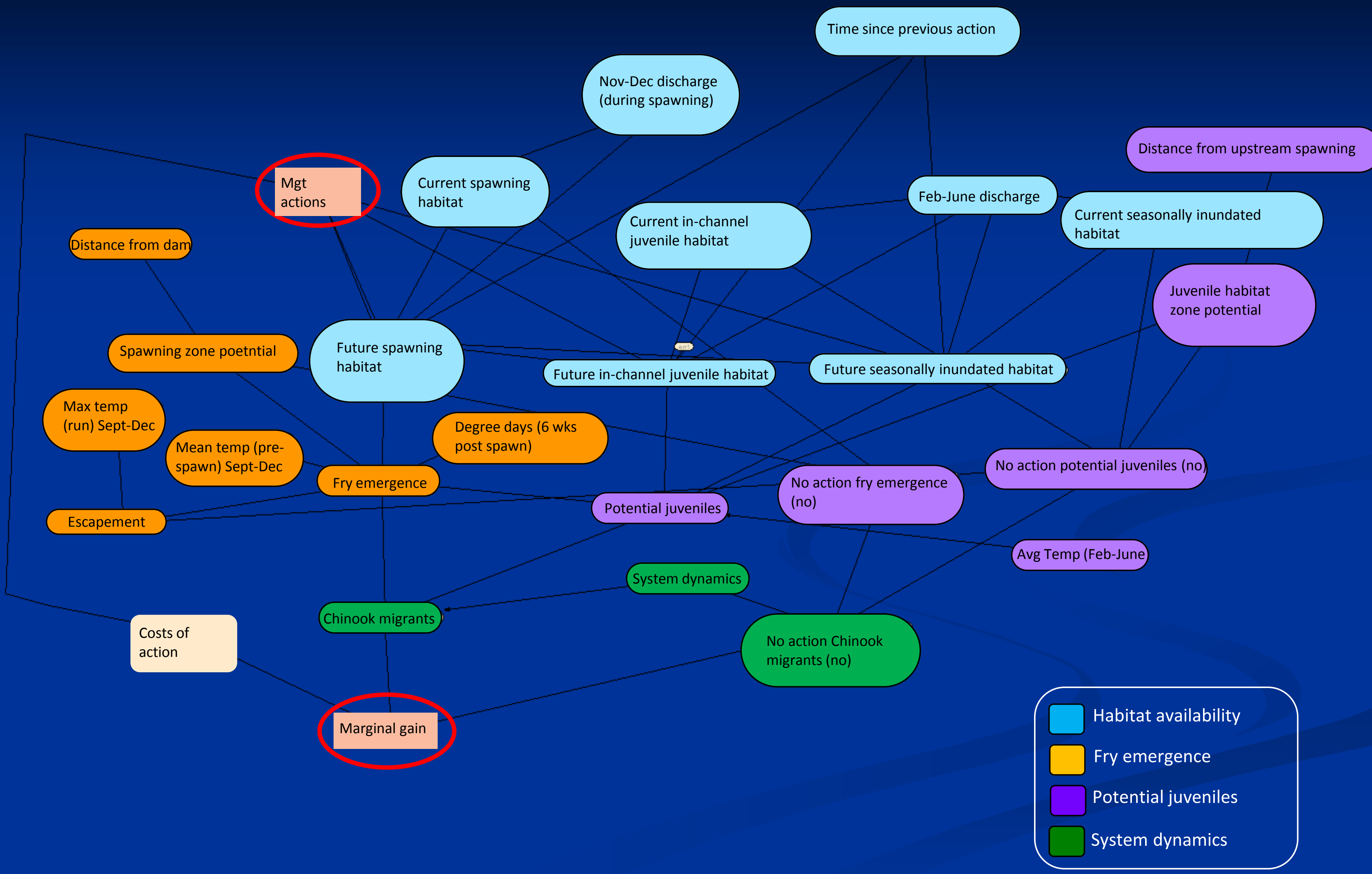
American River habitat restoration



Best Practices

- Restoration problems are multi-objective decisions
- Include all relevant objectives
- Do not expect experimental results alone to lead to clear restoration choices
- Implement adaptive management within a structured decision-making framework
- Long-term experimental programs need to be responsive to changing information and values

Getting started

- Assemble small working group with technical and policy experts
- Use an expert “coach” with experience in SDM
  - ensure the right people are involved
  - lead the working group through SDM framework
  - act as objective voice
- Design decision-making framework to address multiple competing objectives