# 10.0 Life Cycle Modeling I
# Eric Danner

1. Overview of Central Valley water operations and associated impacts on ESA listed salmon habitat

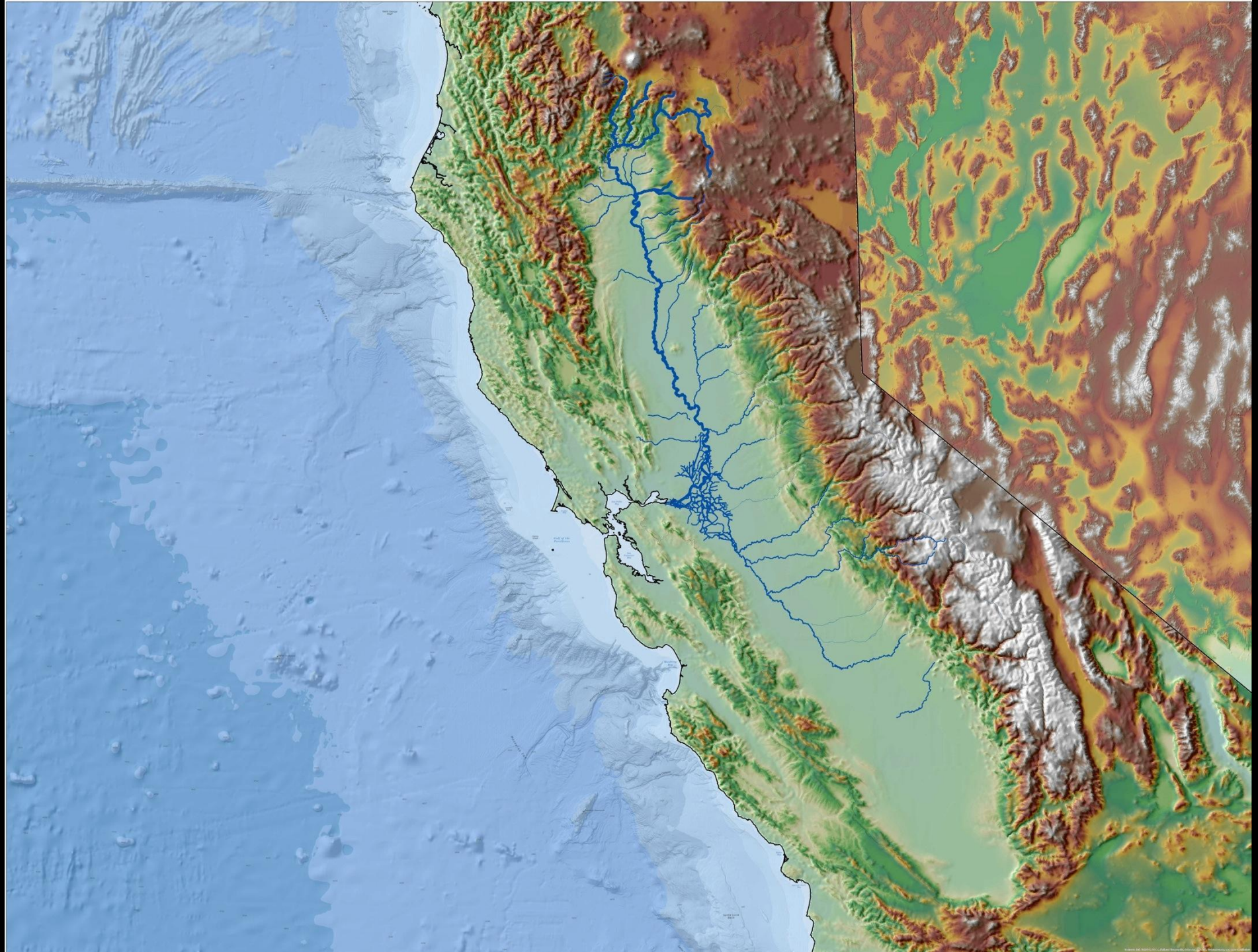
2. Water-fisheries management structure

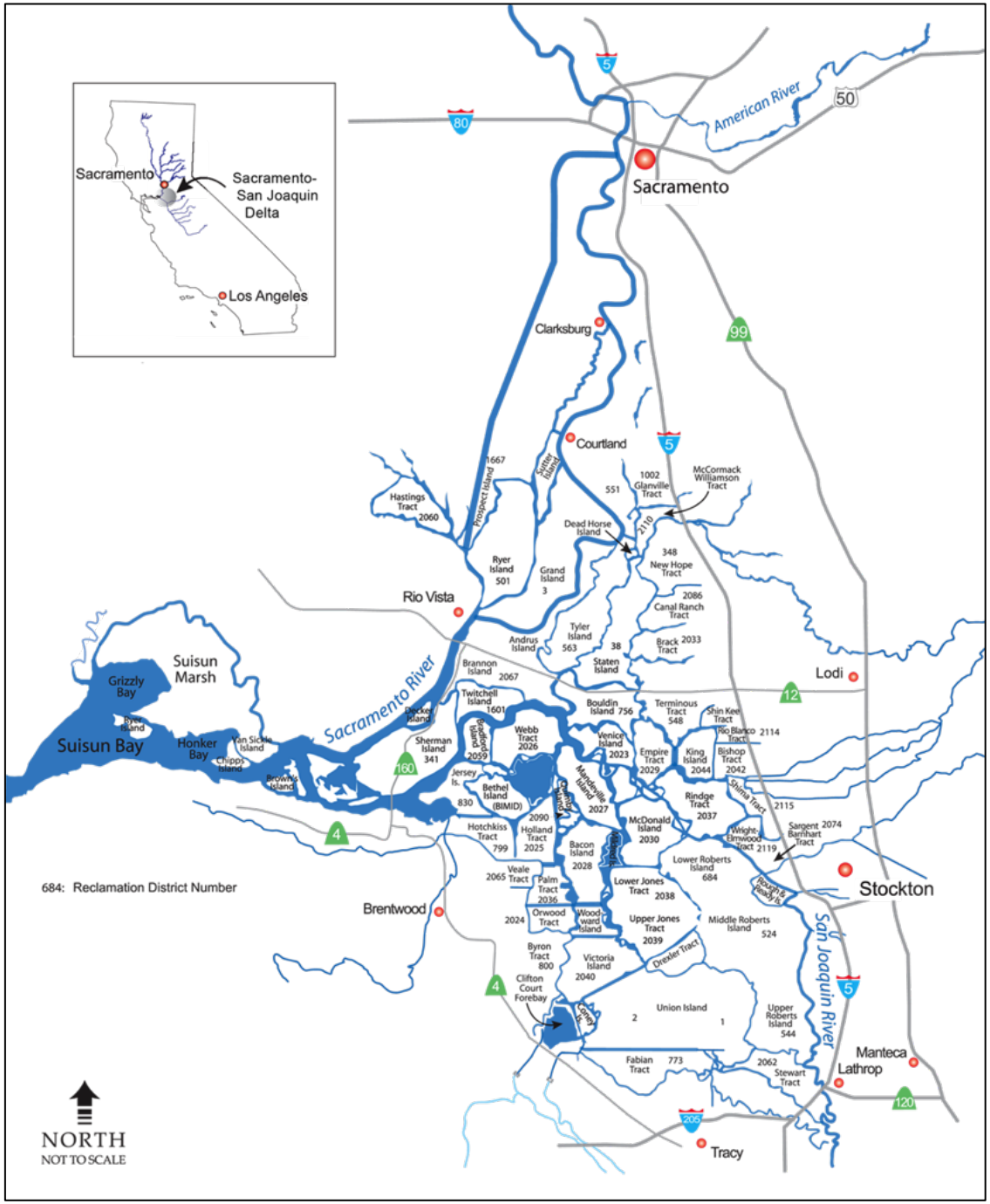
3. Management tools
   a. Life Cycle Models
      I. CVC-LCM
      II. SESAME project

4. Upper Sacramento River Decision Support Framework

5. Challenges

6. Summary




Sacramento
Sacramento-
San Joaquin
Delta
Los Angeles
American River
Sacramento
Clarksburg
Courtland
Rio Vista
Lodi
Stockton
Brentwood
Manteca
Lathrop
Tracy
Sacramento River
San Joaquin River
Suisun Marsh
Grizzly Bay
Suisun Bay
Honker Bay
Hastings Tract 2060
Prospect Island 1667
Sutter Island 551
1002 Glanville Tract
McCormack Williamson Tract
Dead Horse Island 2110
348 New Hope Tract
Ryer Island 501
Grand Island 3
2086 Canal Ranch Tract
Tyler Island 563
Andrus Island 38
Brack Tract 2033
Staten Island
Brannon Island 2067
Twitchell Island 1601
Decker Island
Sherman Island 341
Webb Tract 2026
Bouldin Island 756
Terminous Tract 548
Shin Kee Tract
Rio Blanco Tract 2114
Venice Island 2023
Empire Tract 2029
King Island 2044
Bishop Tract 2042
Jersey Is. 830
Bethel Island (BIMID)
Mandeville Island 2027
Rindge Tract 2037
Shima Tract 2115
McDonald Island 2030
Wright-Elmwood Tract 2119
Sargent Barnhart Tract 2074
Hotchkiss Tract 799
Holland Tract 2025
Bacon Island 2028
Lower Roberts Island 684
Veale Tract 2065
Palm Tract 2036
Lower Jones Tract 2038
Roberts & Beaver Is.
Orwood Tract 2024
Woodward Island
Upper Jones Tract 2039
Middle Roberts Island 524
Byron Tract 800
Victoria Island 2040
Drexler Tract
Clifton Court Forebay
Union Island 2 1
Upper Roberts Island 544
Fabian Tract 773
2062 Stewart Tract
684: Reclamation District Number
NORTH
NOT TO SCALE

# Decision Support for Central Valley Water Management

- Operations Criteria and Plan (OCAP)
- NMFS Biological Opinion (BO)
- Bay Delta Conservation Plan (BDCP)

- Determine jeopardy

- Reasonable and Prudent Alternatives (RPAs)

- NMFS must develop and deliver life-cycle models that can evaluate the cumulative effects of complex management actions

# Life Cycle Modeling

Evaluate the cumulative effects of complex management actions on salmon population dynamics, including:

- changes in water project operations
- addition or removal of barriers
- operation of tidal gates, canals or tunnels
- habitat restoration

# Specific Winter-Run Management Actions

Water Temperatures

- Maintain suitable water temperatures for winter-run
- Maintain minimum Shasta Reservoir storage

Habitat Capacity

- Restoration of floodplain rearing habitat
- Implement near-term actions at Liberty Island/Lower Cache Slough and lower Yolo Bypass

Survival

- Monitoring and alerts to trigger changes in DCC operations
- San Joaquin River inflow to export ratio
- Old and Middle River Flow Management
- Reduce the likelihood of entrainment or salvage at the export facilities

# Model Outputs

<u>Specific</u> - can provide specific relationships between population vital rates (e.g., survival or migration) and physical drivers of interest (e.g., flow or temperature)

<u>Synoptic</u> - can provide synoptic view of biological consequences of trade-offs

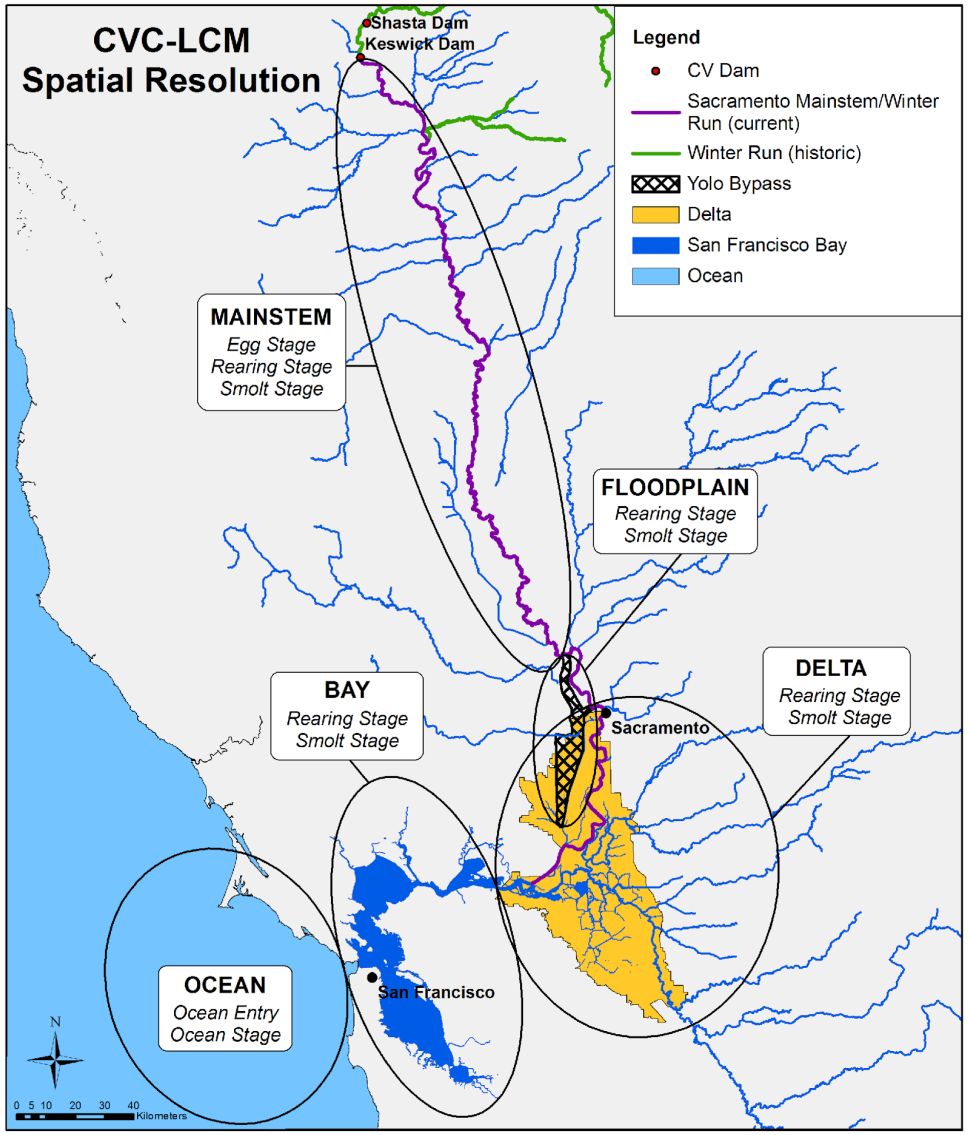
1. Seasonally – e.g., how water allocation in spring versus allocation in summer affects smolt production
2. Annually – e.g., allocation strategy across different year types affects adult abundance

# Complementary Life Cycle Modeling Approaches

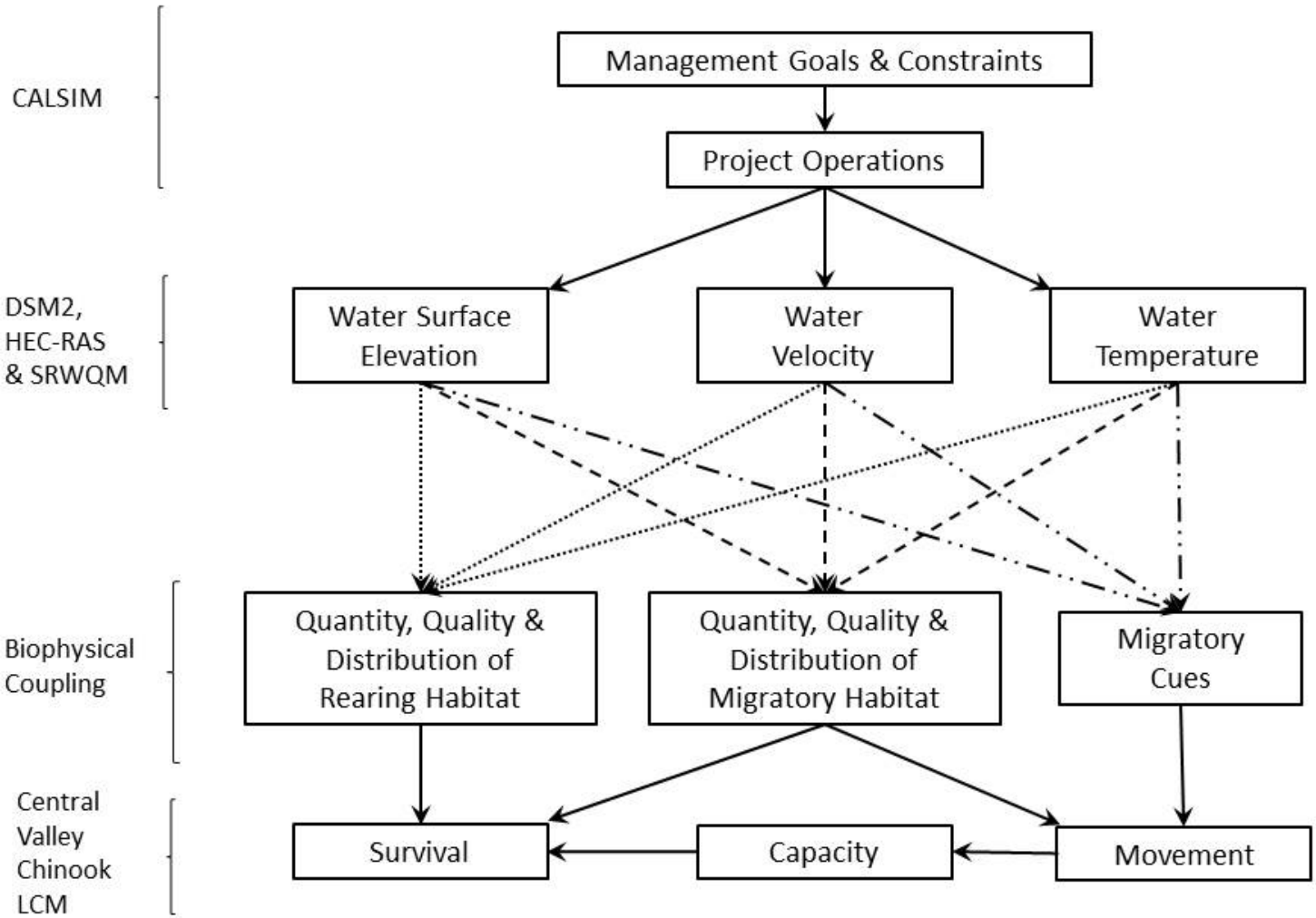
1. Link existing physical models to a population-level stage-structured life-cycle model through state-transition parameters that are a function of the environment (as described by the physical models)
   ***CVC-LCM***

2. Develop a brand-new coupled physical and individual-based biological simulation model
   ***SESAME***

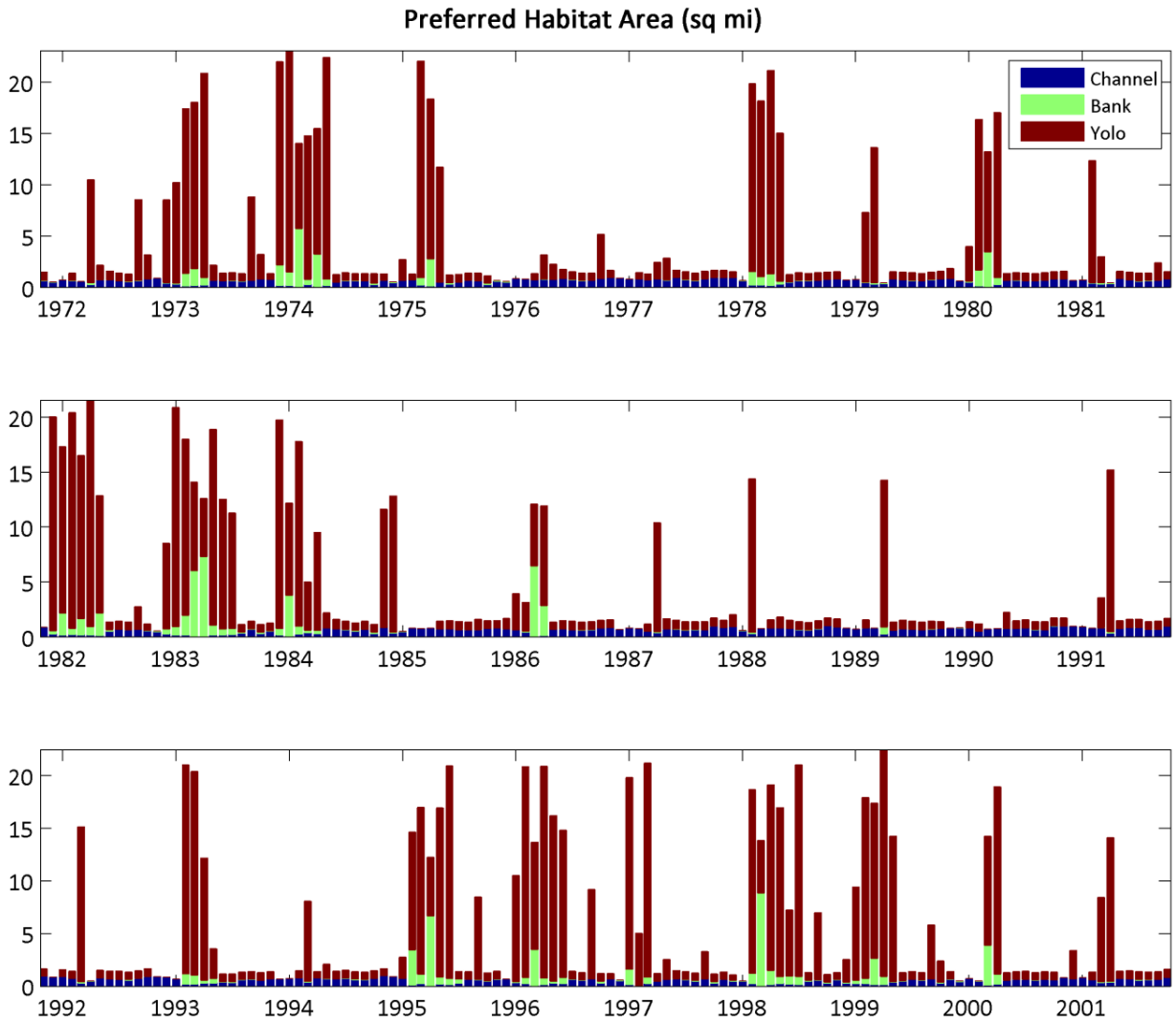
# Geographic Distribution and Life Stages CVC-LCM



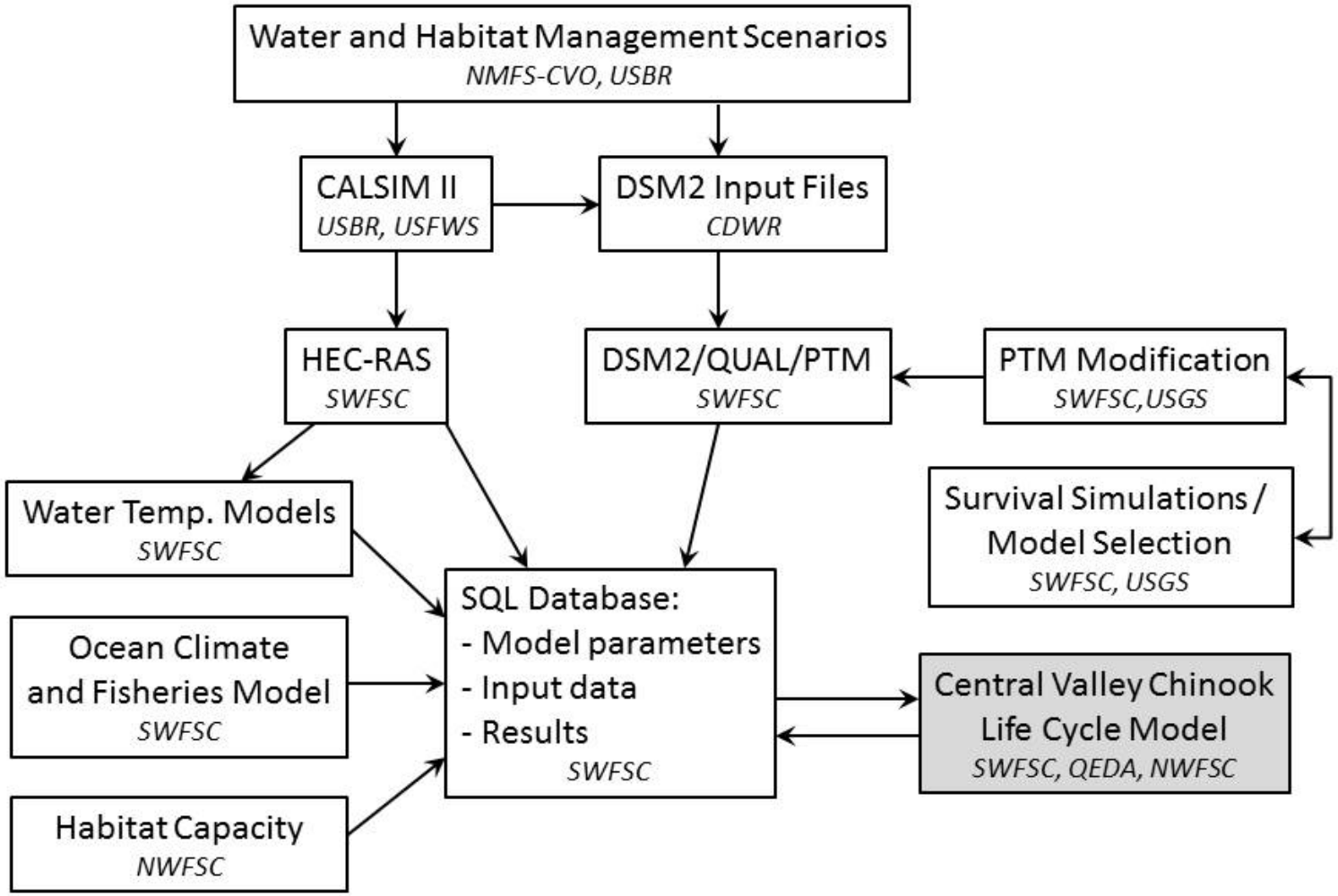
# Conceptual Model



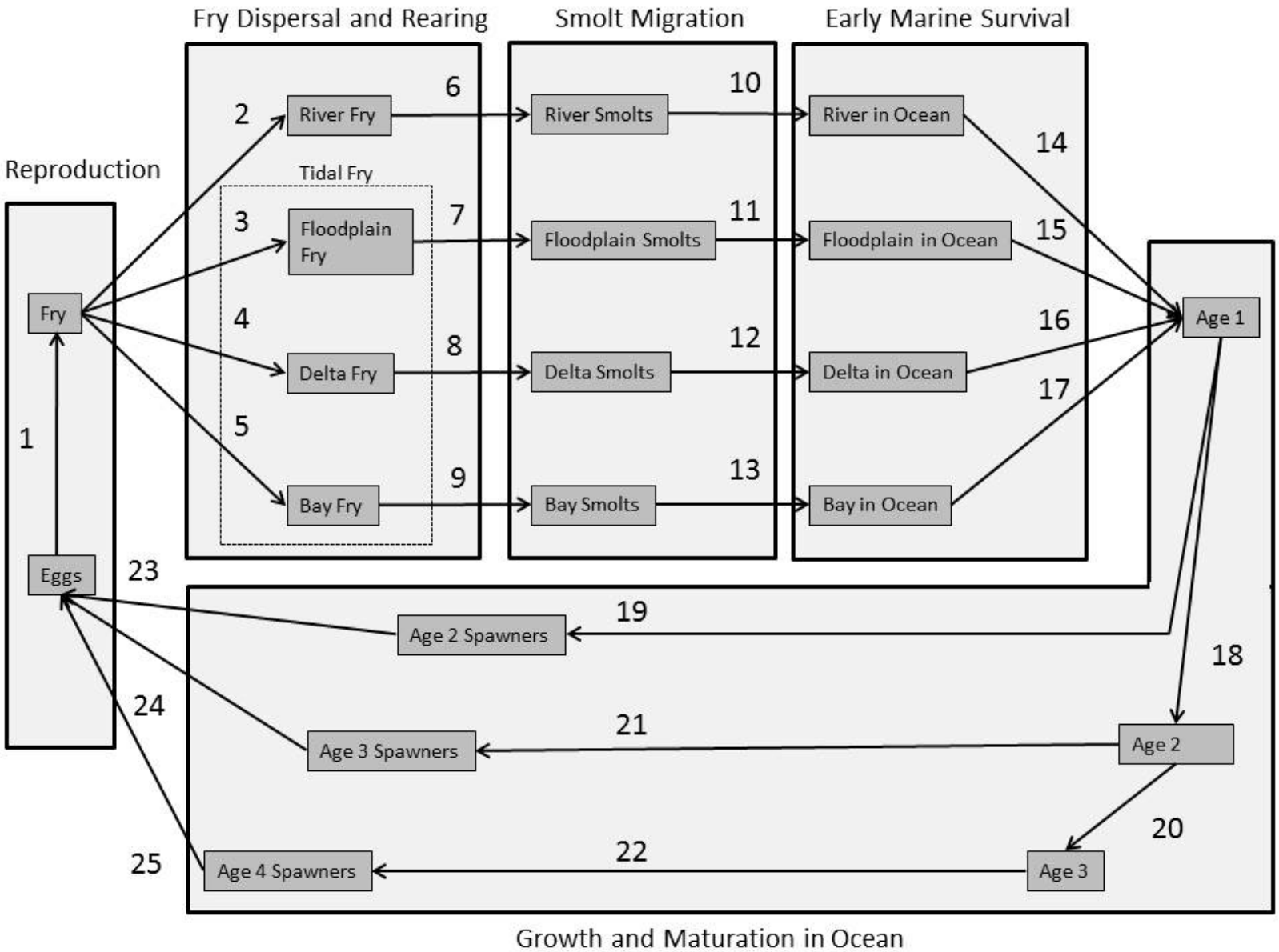
# Habitat Capacity



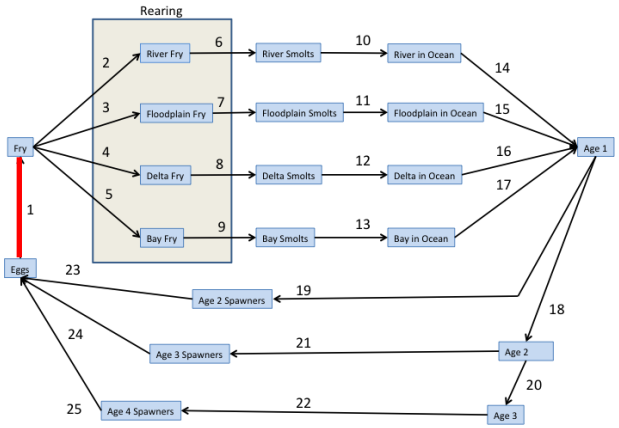
# Computational Framework



# Winter Run Model Structure



# Transition Example



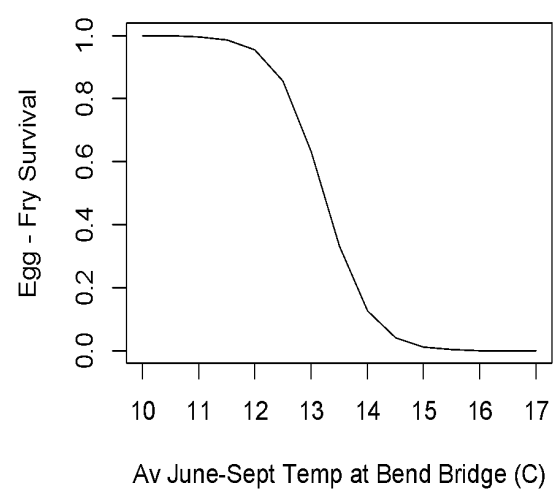

*<u>Survival to Fry stage from Egg stage</u>*

Fry = Eggs $*S_{eggs}$

$\text{logit}(S_{eggs}) = B0 + B1*\text{TEMP}$

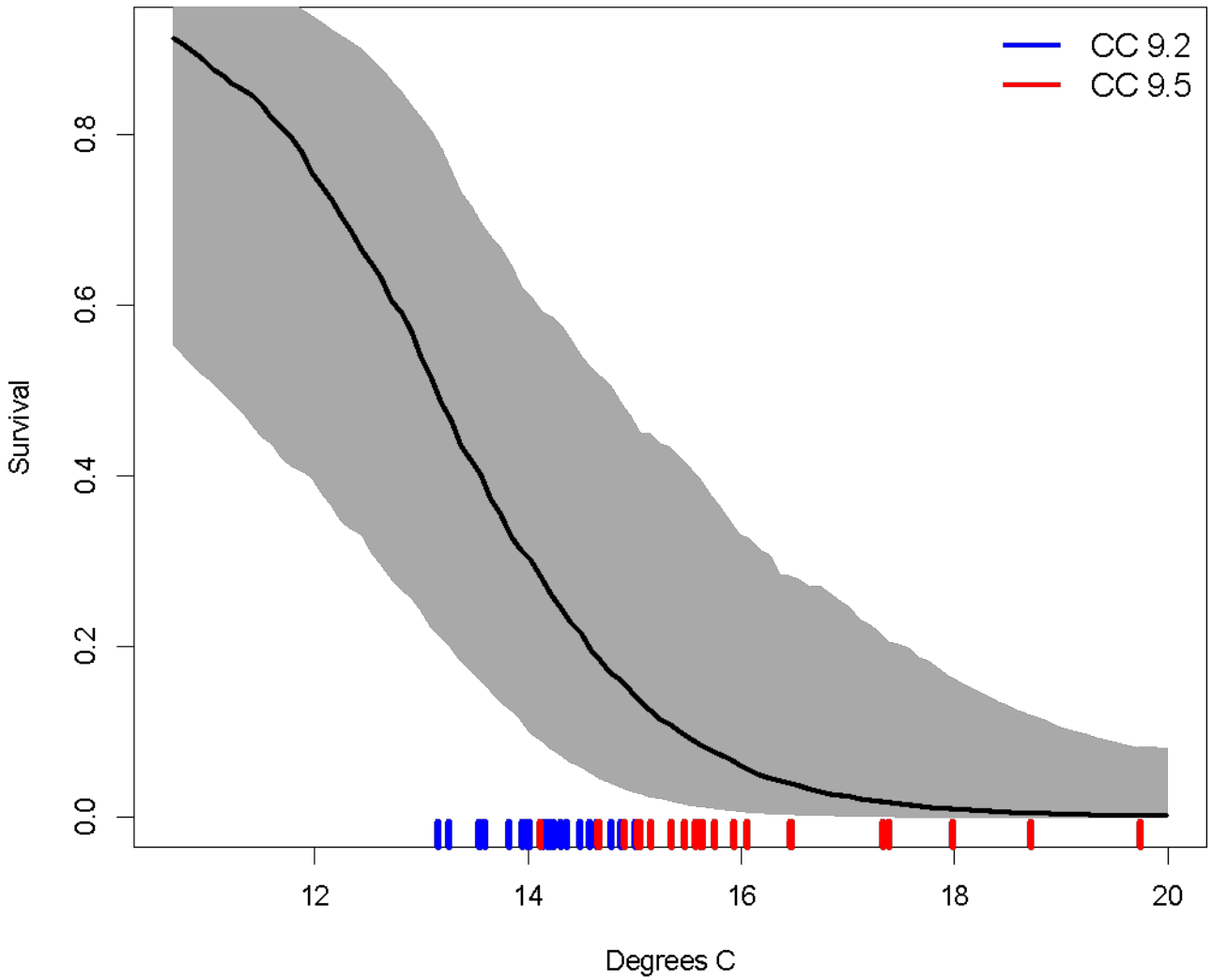
TEMP = Standardized average temperature at Bend Bridge from July to September

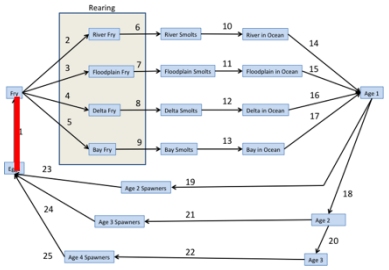
Hypothetical Relationship



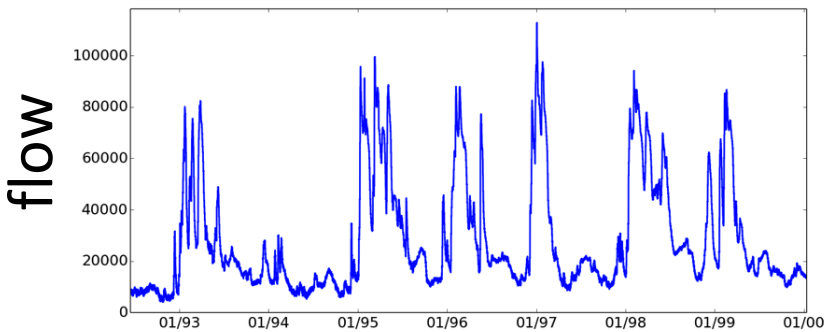
# Climate Change Scenarios 9.2 and 9.5

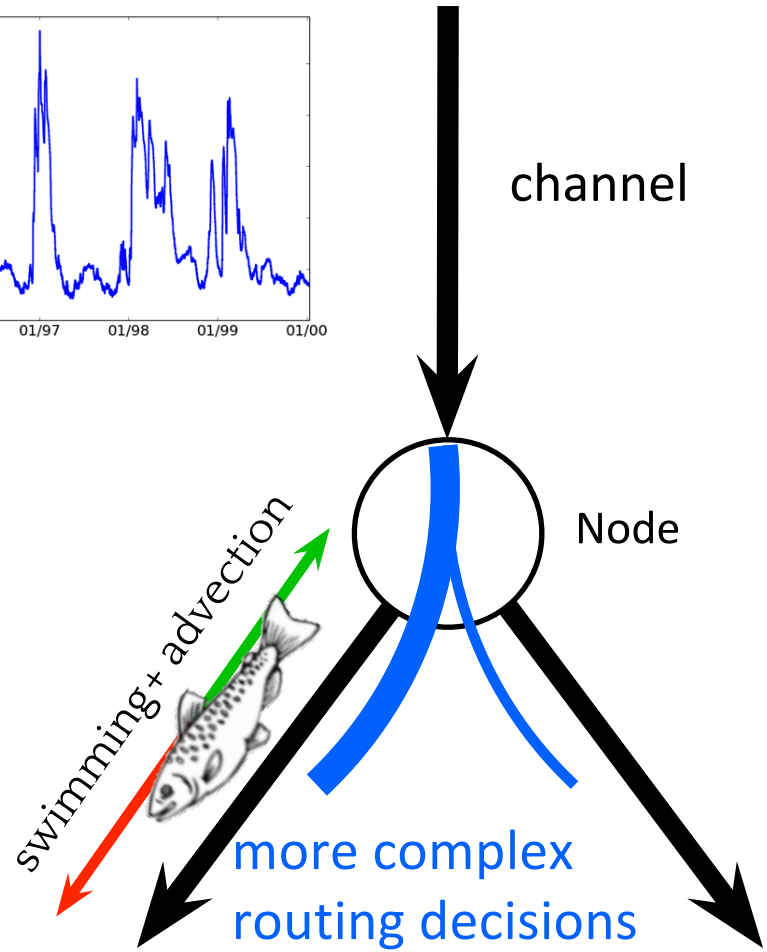
# Survival as a function of temperature

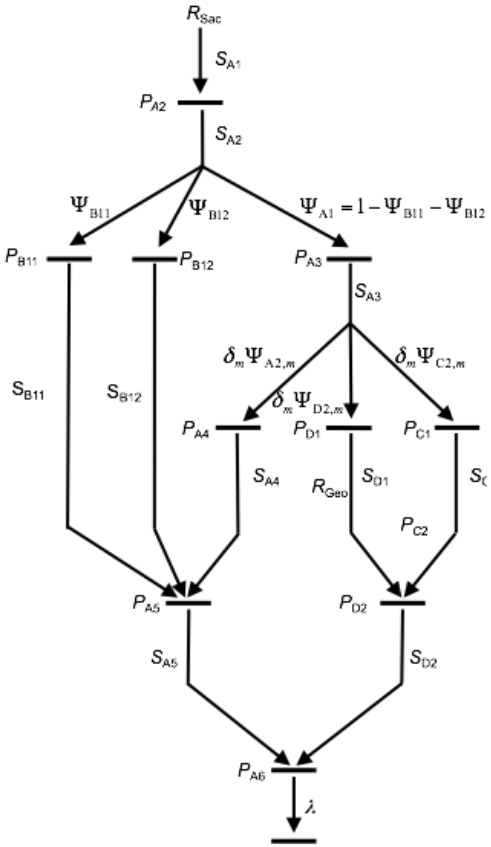


# Particle Tracking Model



# CVC-LCM Timeline

2012 - CVC-LCM project funds avail from USBR; project scope of work developed

2013 - Project team hired; work commences in earnest (4 technical workshops held, available data identified and assembled)

2014 - NOAA tech memo published describing framework for WR Life cycle model; four scenarios analyzed through version 1 of the model; results presented to USBR/NMFS leadership.

2015 - Model modified for Spring-run and Fall-run analysis; enhanced Particle Tracking Model allowing more sophisticated analysis; panel review of model; model to be used in NMFS draft Biological Assessment (August)

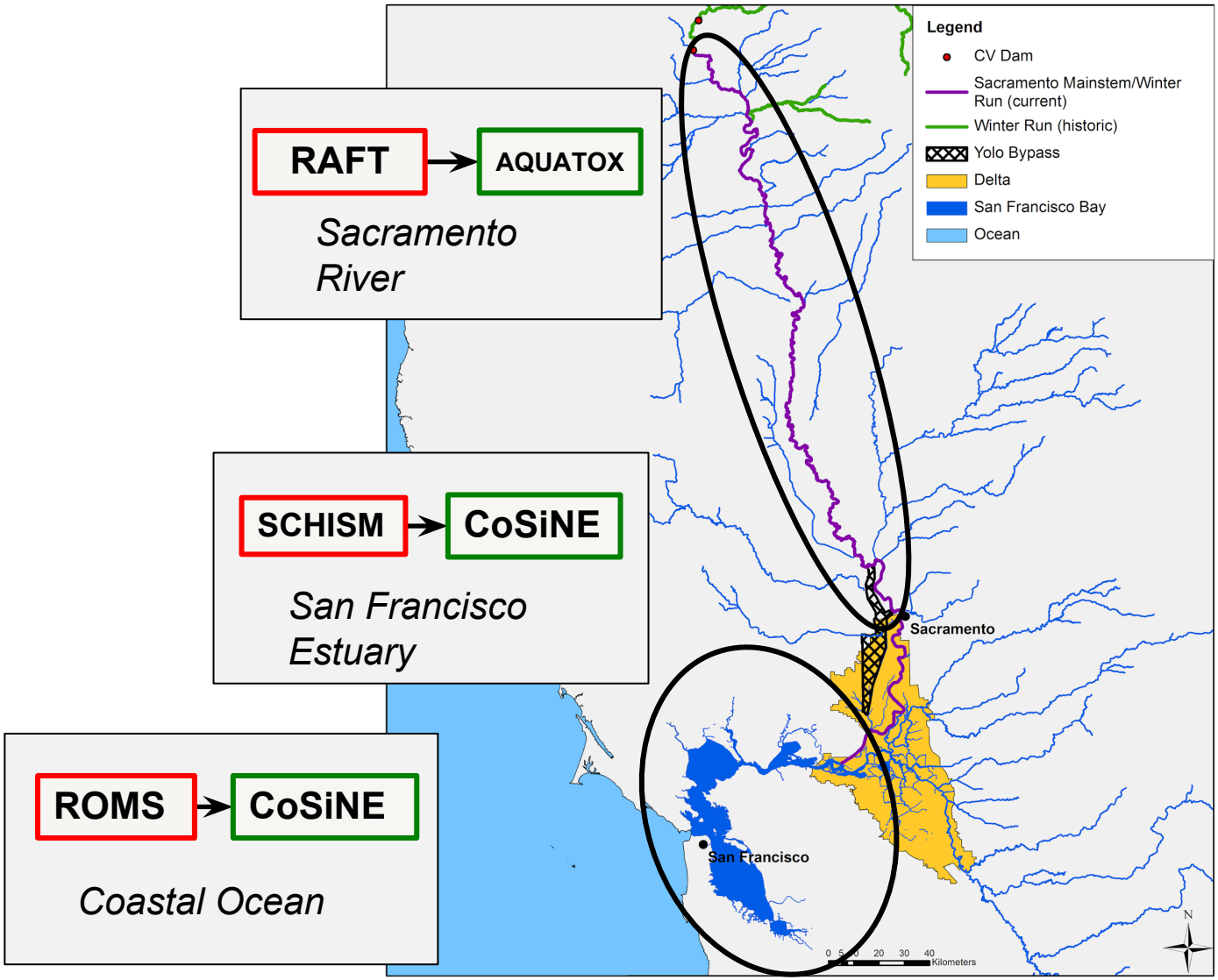
2016 - Final Biological Assessment (March)

# Individually Based Model Efforts

SESAME - Salmon Ecosystem Simulation and Management Evaluation

- Coupled physical and individual-based biological simulation model
- Dynamic energy budget (DEB) models
- Sublethal effects - growth, fecundity, reproduction
- Provides information about the sizes that fish can reach in different habitats

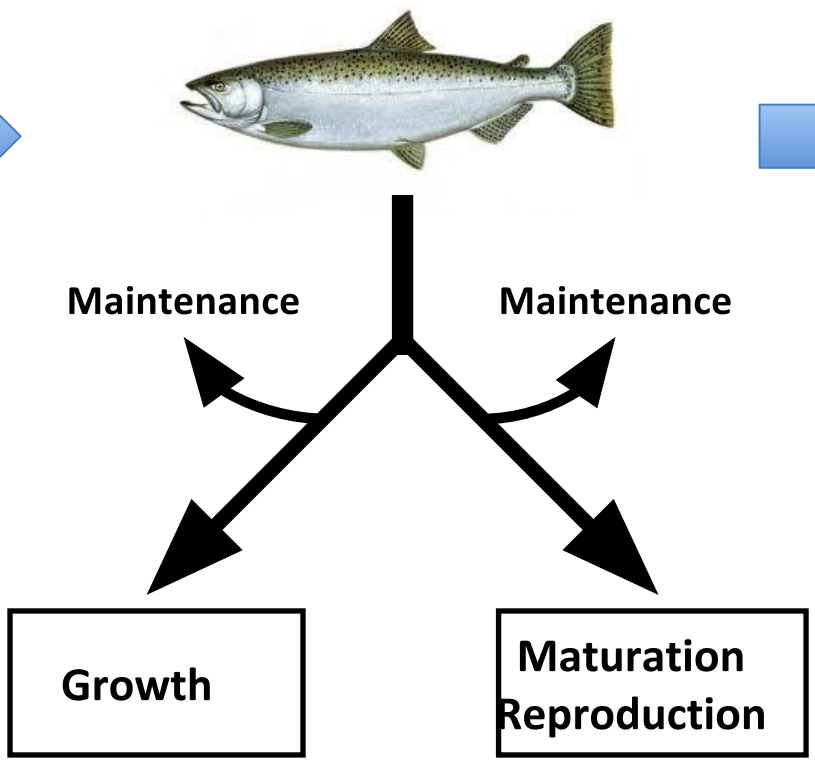
# Geographic Distribution and Sub-Models SESAME



# Dynamic Energy Budget (DEB) Models

## Input

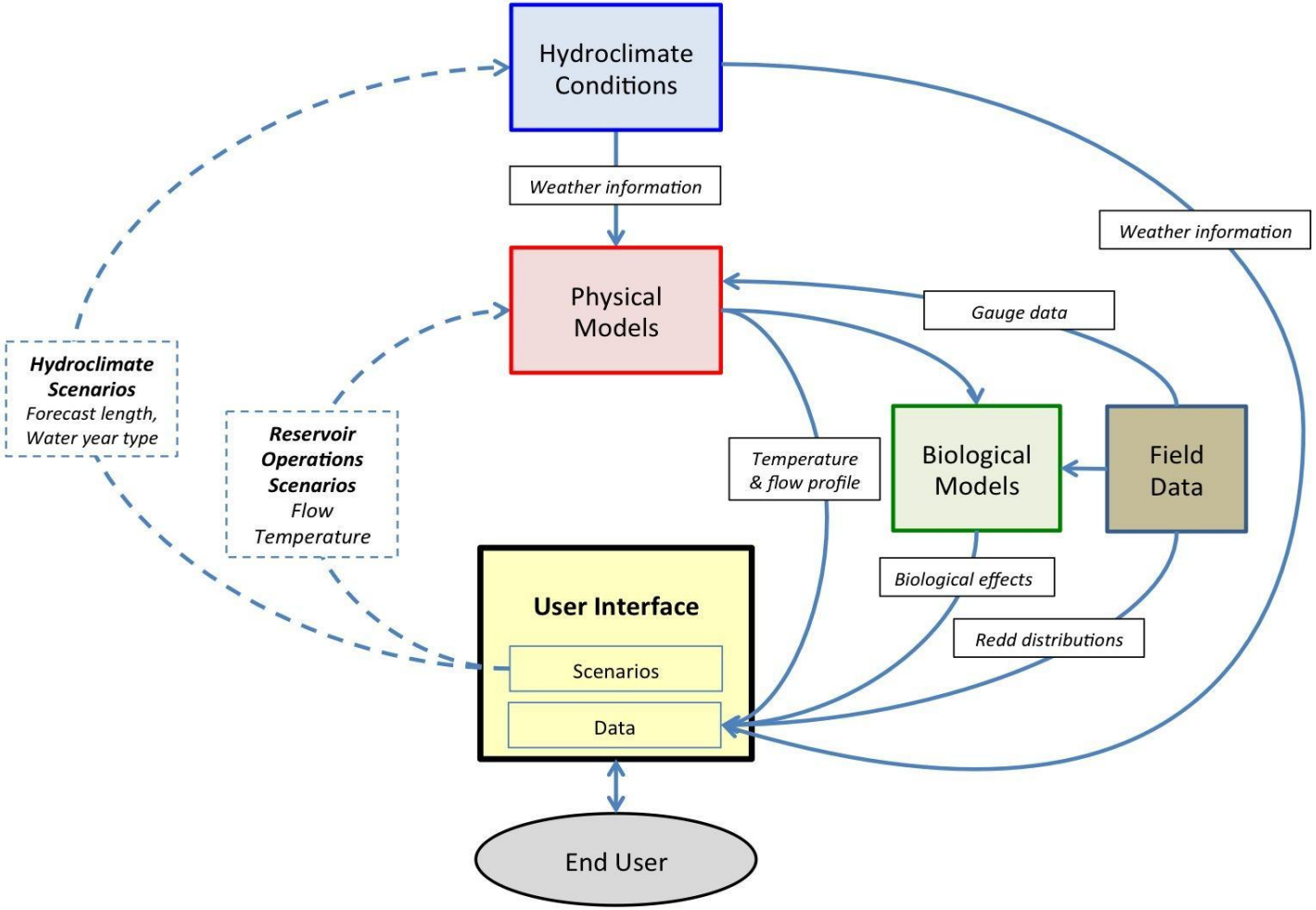
*Food*
*Temperature*
*Velocity*




## Output

Growth
Fecundity
Migration costs
Embryonic dev.
Age at maturity

# Sacramento River Decision Support Tool



# Lab Integration

Life cycle modeling

Acoustic tagging

Delta predation field studies

Ocean surveys

Delta Ecosystem modeling

# Challenges

Maintaining momentum and building capacity with contractor personnel

Drought/emergency mentality

Data gaps - fry movement/migration rates

# Summary

Funding

- CVC-LCM is from USBR
- SESAME was from NASA
- Decision support tools from USBR

Collaborators

Results and data availability