The Delta Passage Model: a tool for investigating juvenile salmonid migration and predation mortality in the Delta

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Presentation Overview

1. Briefly explain the DPM
2. Introduce and describe the IB-DPM
3. Predation related IB-DPM applications
Delta Passage Model (DPM)

Integrates and applies available empirical data from analyses of acoustic and coded wire tag studies in the Delta.
Operates on a daily time step, using daily average flows (DSM2 Hydro) for primary migration routes.

Most functional relationships structured as probability distributions.

IOS = JPE + DPM + Ocean

Limitations of the DPM

1. Long reaches, poor spatial and hydro resolution
2. Mortality independent of migration speed
3. Predation mortality not specifically represented
4. Interior Delta “black box”
IB-DPM
(Individual Based- Delta Passage Model)

- 192 DSM2 Hydro channels
  - No pre-defined reaches, detailed hydrodynamic resolution
- 14 junctions, including DCC and HORB
- Predation mortality is directly represented
- Individual fish navigate a more realistic Delta
Sacramento River routes
San Joaquin River routes
IB-DPM: Key Functions

• Junction routing probabilities based upon daily flow proportion
  – change as a function of inflows, barriers and exports
IB-DPM: Key Functions

• Junction routing probabilities based upon daily flow proportion
  – Routing changes as function of exports, inflows, barriers

• Residence time \((t)\) is a function of hydrodynamic conditions in each channel

• Survival is a function of residence time \((t)\) and a predation intensity parameter \((\omega/\lambda)\).

\[
S = \exp \left( -\frac{\omega}{\lambda} t \right)
\]

From Anderson et al. (2005)
IB-DPM: Residence time-hydrodynamics

• The influence of hydrodynamics on residence time key for modeling predation mortality

• Hydrodynamic metrics relevant to migrating juvenile salmonids
  – “net” flow and % positive flow
San Joaquin River Inflow: 1,500 cfs
OMR: -2,500 cfs
OMR: -5,000 cfs

% positive flow
daily average flow
IB-DPM: Residence time-hydrodynamics

- The influence of hydrodynamics on residence time is a key scientific uncertainty.
- Example flow metric-relationships
IB-DPM: Key Functions

• Entrainment modeled for CVP and SWP facilities
  – Pre-screen mortality, louver efficiency, trucking represented
  – Through-Delta survival via salvage tracked as a result
IB-DPM
Demonstration
IB-DPM: Demonstration

Flow scenario: HORB
Barrier effect: out
SJR inflow: 1500
OMR: -2500
Scenario date: 2007-05-15

Flow measure: Daily average flow
IB-DPM: Example Results

= 50% reduction in predation intensity parameter ($\omega/\lambda$).
IB-DPM: Predation Applications

- Explore relative influence of operations, hydrodynamics and predation

- What management actions can change predation intensity ($\omega/\lambda$)?
  - Where and by how much?
Where to make habitat or change predators?

Cavallo et al. 2012. “Effects of predator and flow manipulation on Chinook salmon….” Environmental Biology of Fishes
IB-DPM: What next?

- Identify hydro-residence time hypotheses for testing
- Use hundreds of previous CWT experiments to calibrate
  - estimate parameters
  - test alternative hydro-residence hypotheses
- CWT study responses to be used:
  - Arrival timing at salvage facilities and Chipps Isl.
  - “Loss” at SWP and CVP
  - Estimated number of fish reaching Chipps Isl.
Extra Slides
Delta Juvenile Salmonid Conceptual Model (fry, parr or smolt)

Migrating

Behavior
Alternating (minutes to months)

Holding or Rearing

LOCATION SPECIFIC:

Hydrodynamics
Inflow
Exports
Tides

Turbidity
Precipitation
Bank type
Channel morph
Inflow, Wind

Predation Risk
Predator habitat
Food
Temperature

Salmonid Habitat and Food Availability

Survival

Growth

- +
Flow results (Sacramento)

K-W test: $\chi^2 = 100.120, p < 0.001$

1st significant difference
San Joaquin flow

San Joaquin 2 wet

San Joaquin 2 above normal

San Joaquin 2 dry

San Joaquin 2 critical
Flow results (San Joaquin)

K-W test: $\chi^2 = 76.824, p < 0.001$

1st significant difference
More on residence time-hydrodynamics

Percent Positive Flow

- \(a = 25\)
- \(c = 0.05\)
- \(b = 5\)

- \(a = 25\)
- \(c = 0.00012\)
- \(b = 42\)

- \(a = 25\)
- \(c = 0.05\)
- \(b = 100\)

Average Flow

- \(a = 25\)
- \(c = 0.00012\)
- \(b = 5\)

- \(a = 25\)
- \(c = 0.00012\)
- \(b = 100\)
Sensitivity Analysis: Life Stage Functions

Change in Spawners: “Wet” Water Year
Sensitivity Analysis: Life Stage Functions

Change in Spawners: “Dry” Water Year

- Smolt-age 2 survival
- Ocean productivity
- Age 3 harvest
- Egg survival
- Delta survival
- Fry-smolt survival
- Age 4 harvest
Export Results (Sacramento River)

K-W test: $\chi^2 = 15.15$, $p = 0.056$
Sensitivity Analysis: Delta Survival

- Survive to Bay: 68%
- Mortality due to predation or other non-project stressors: 30%
- Mortality attributable to indirect and direct export effects: 2%
DPM Conceptual Model

River

Fish Proportion

Survival Proportion

Flow Proportion

B1

Survival Proportion

Migration Speed

Flow Proportion

B2

Survival Proportion

Migration Speed

Flow

C

Survival Proportion

Exports

Bay

Survival Proportion

Exports

Inflows

Survival

Migration Speed

Migration Route

f(Inflows, Exports, Barriers)