



What's got you down?

Declining Longfin Smelt abundance and the search for environmental factors that affect vital rates

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Methods

We developed a state-space model of Longfin Smelt population dynamics. Variables were considered for inclusion via stochastic search variable selection. Data for age-specific abundances came from Bay Study indices for both gear types.

State Equations

Age-0 Survival (S_0)

Survival from age-0 to age-1 (S_0) was formulated as a logit model for the ratio of the log of age-1 abundance the next year to log of age-0 abundance from the current year with a normally-distributed error term.

$$\text{logit}(S_{0,t}) = \frac{\log(N_{1,t+1})}{\log(N_{0,t})} + \epsilon_{S0,t}$$

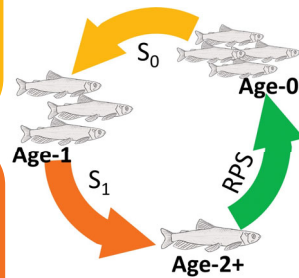
$$\epsilon_{S0,t} \sim N(\mu_{S0}, \sigma_{S0,t})$$

Age-1 Survival (S_1)

Survival from age-1 to age-2 (S_1) was formulated as a logit model for the ratio of the log of age-2 abundance the next year to log of age-1 abundance from the current year with a normally-distributed error term.

$$\text{logit}(S_{1,t}) = \frac{\log(N_{2,t+1})}{\log(N_{1,t})} + \epsilon_{S1,t}$$

$$\epsilon_{S1,t} \sim N(\mu_{S1}, \sigma_{S1,t})$$



Recruits per Spawner (RPS)

Recruits per spawner was modeled using the Beverton-Holt equation to represent a density dependent relationship between age-2 abundance and age-0 abundance. In this equation, a describes density-independent recruitment (intrinsic productivity) which is proportional to fecundity, i.e., recruitment when densities are low, and b describes the degree of density-dependence.

$$\log(N_{0,t}) = \log\left(\frac{N_{2,t}}{a_t' + b_t' \cdot N_{2,t}}\right) + \epsilon_{N0,t}$$

$$\epsilon_{N0,t} \sim N(\mu_{N0}, \sigma_{N0,t})$$

where $a' = 1/a$ and $b' = b/a$

Several variables were considered for inclusion in the model to explain patterns in vital rates. Below, the variables are grouped by categories of environmental factors that are hypothesized to affect Longfin Smelt abundance, growth, and survival⁴.

Variables Considered for Inclusion

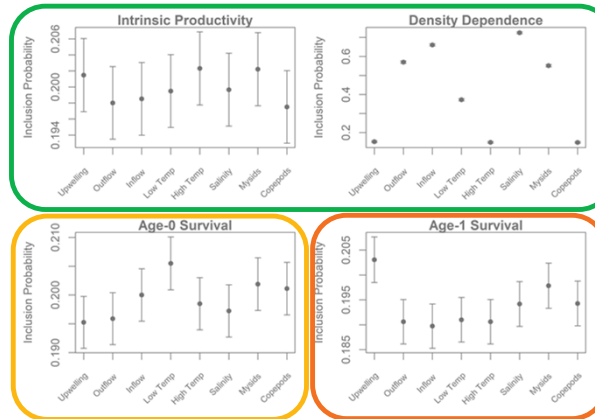
Category	Variable	Details
Hydrology	Outflow	Median annual outflow
	Inflow	Median annual inflow
Water Quality	Low Temperatures	Days < 15° at Martinez (MRZ)
	High Temperatures	Days > 20° at Martinez (MRZ)
	Salinity	Days < 2 PSU at Martinez (MRZ)
Prey Availability	Copepods	Eurytemora (gC/m ³) in Suisun Bay (NZ048) in March
	Mysids	Mysid CPUE in Suisun Bay (NZ048) in November
Ocean Temperature	Upwelling Index	Mean upwelling index August

The observation equations in the state-space model incorporate data from both gear types, with separate observation errors for each combination of gear and age class and a scaling factor that accounts for large-scale differences in observations between the two gear types for each age class.

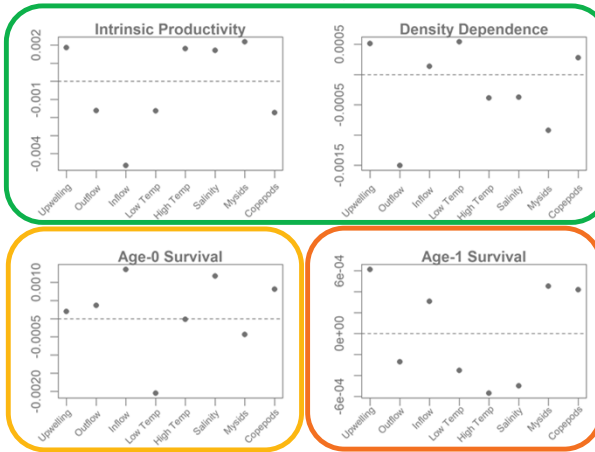
Results

No single variable stood out as the best explanation for any of the vital rates we modeled. The estimates of vital rates varied over time, but the pattern in intrinsic productivity was overwhelmed by the variation around the estimates.

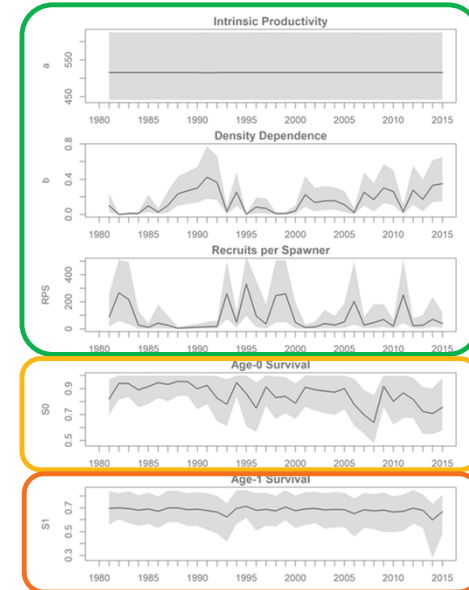
Variable Inclusion Probabilities



Estimated Slopes



Estimated Parameters over Time



Discussion

- Several environmental factors may have contributed to the observed decline in Longfin Smelt abundance in the San Francisco Estuary. Among variables considered, temperature and prey availability were identified as the most probable variables affecting survival.
- There have been substantial changes in recruits per spawner and survival over time.
- Future development of a Longfin Smelt population dynamics model may include additional environmental variables or reformulating the model to include length information.

Acknowledgements

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⁴CDWR, CDFW, SWC, & USFWS. 2020. Longfin Smelt Science Plan 2020 – 2030.