Juvenile salmon survival in coastal waters of the Northeast Pacific Ocean: top-down or bottom-up control?

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Why juveniles?
Early ocean life is the most “critical” time for a year class
Juvenile Salmon

Upper Trophic Levels

Lower Trophic Levels

Top-down

Bottom-up
Research objectives

• Summarize knowledge on juvenile salmon interactions in coastal oceanic waters

• Develop a mathematical model of juvenile salmon dynamics

• Identify processes controlling the survival of juvenile salmon
Number of Fish \( N(t) \) \[ \rightarrow \] Total Biomass \( B(t) \) \[ \rightarrow \] Fish Weight \( W(t) \)
Initial number, $N_0$

Natural mortality

Stochastic elimination

Temporal migrations

Cannibalism

Predation

Temperature

Salinity

Light

Dissolved oxygen

Anthropogenic effect

Initial weight, $W_0$

Maximum weight, $W_{max}$

Resources

Food availability

Competition

Trophic demands

Trophic coefficient, $k_T$

$W(t)$

$N(t)$

$Y$

B(t)

Top-down

Bottom-up
Modeling individual growth

\[ W(t) = \frac{W_{\max}}{1 + \left( \frac{W_{\max} - W_0}{W_0} \right) \cdot e^{-Q_1 k_T t}} \]

- \( W_0 \) – initial weight of fish
- \( W_{\max} \) – maximal weight of fish
- \( Q_1 \) – buffer coefficient
- \( k_T \) – trophic coefficient
- \( t \) – time

Juvenile stage
Modeling fish abundance

\[ N(t) = N_0 \cdot \exp(-Q_2 \cdot Y \cdot t) \]

- \( N_0 \) – initial number of fish
- \( Y \) – additive loss
- \( Q_2 \) – buffer coefficient
- \( t \) – time
Coho salmon

1999 – 2002
May, June, September

• Fish abundance
• Fish weight

• Temperature
• Salinity

• Trophic demands
• Abiotic preferences
Model simulations

<table>
<thead>
<tr>
<th>Days</th>
<th>Number of fish</th>
<th>Total biomass</th>
<th>Individual weight</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>45</td>
<td>37000.00</td>
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<tr>
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<td>0</td>
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<td>0</td>
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<td>2</td>
<td>180</td>
<td>19127.95</td>
</tr>
<tr>
<td>180</td>
<td>2</td>
<td>225</td>
<td>1255.90</td>
</tr>
</tbody>
</table>
Sensitivity analysis

- Vary the values of different parameters
- Record the response of the juvenile salmon
- Determine the most important factors
Model predictions

effect of variations in predation on total biomass

Total Biomass

1: Predation = 0.03
2: Predation = 0.035
3: Predation = 0.04
4: Predation = 0.045
5: Predation = 0.05
Model predictions

effect of variations in trophic coefficient on total biomass

Total Biomass

150000

75627

1255

0  45  90  135  180

Days

1:Trophic coefficient=1
2:Trophic coefficient=0.95
3:Trophic coefficient=0.9
4:Trophic coefficient=0.85
5:Trophic coefficient=0.8
Growth of juvenile coho salmon

![Graph showing growth of juvenile coho salmon over months and years.

- X-axis: Months (May, Jun, Sep)
- Y-axis: Fish Weight (g)

The graph indicates a significant increase in fish weight from May to Sep, especially noticeable in 2001 and 2002.]
Abundance of juvenile coho salmon

The graph shows the number of fish caught per day in May, June, and September over the years 1999, 2000, 2001, and 2002. The percentage of fish caught each year is also indicated:

- 1999: 3.5%
- 2000: 2.5%
- 2001: 4%
- 2002: 2%
Conclusions

- Juvenile salmon biomass in the coastal waters is primarily defined by variations in activity at upper trophic levels rather than lower ones.

- Juvenile salmon survival is primarily controlled by a top-down, but not a bottom-up mechanism in the nearshore oceanic ecosystem.
Theoretical implications

- Provides a theoretical insight into complicated relationships between juvenile salmon and their environment
- Enables a simultaneous study of both upper and lower trophic level effects
- Sets the range of data necessary for studying the survival of juvenile salmon
- Defines future research priorities
Research priority

Study predators
- Abundance
- Food habits
- Feeding rates