Somass Sockeye Salmon
Responses to
Climate Variation & Change
in Freshwater Ecosystems

Kim D. Hyatt,
Howard Stiff,
Diana Dobson

Fisheries & Oceans Canada

Stamp River – Kevin Pellett
1. Freshwater Conditions Affecting Migrant Sockeye
   • Temperature & Discharge

2. Marine Conditions Affecting Holding Sockeye
   • Temperature and Oxygen
**Study Area**

Nuu-chah-nulth
“along the mountains and the sea”

Alberni Inlet, Vancouver Island, B.C.

Catalyst Paper Mill – Port Alberni, B.C.

Aboriginal Multi-Media Society
Study Area

Nuu-chah-nulth
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Alberni Drainage

Catalyst Paper Mill – Port Alberni, B.C.
Study Area

Nuu-chah-nulth “along the mountains and the sea”

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Economic value: Comm + Rec = $5 – $10M

Alan H Brown – “West Coast Fisherman”
Study Area

Nuu-chah-nulth
“along the mountains and the sea”

Tseshahnt & Hupacaseth Community Fishing, Somass River

Annual economic value: Comm + Rec: $5 – $10M

Alberni Inlet, Vancouver Island, B.C.
Catalyst Paper Mill – Port Alberni, B.C.

Alan H Brown – “West Coast Fisherman”
Study Area

Great Central Lake

Sproat Lake

GCL Dam

Stamp Falls

Andrew Campbell

Taylor River

Sproat River

Port Alberni
Study Area

Great Central Lake

Sproat Lake

Somass River

GCL Dam

Stamp Falls

Port Alberni Inlet
Regional Climate Change

Summer Air Temperatures, 1920-2012, Somass Region

Environment Canada

<table>
<thead>
<tr>
<th>REGIONAL CHANGES</th>
<th>1900 - 2000</th>
<th>2000 - 2100</th>
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</thead>
<tbody>
<tr>
<td>Mean Air Temperatures*</td>
<td>↑ 0.8°C - 1.1°C</td>
<td>↑ 1.4°C - 3.9°C</td>
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<tr>
<td>Summer Water Temperatures</td>
<td>↑ 0.5°C - 1.5°C</td>
<td>↑ 1.3°C - 2.5°C</td>
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<tr>
<td>Snowpack*</td>
<td>↓ 0 - 10%</td>
<td>↓ 35% - 68%</td>
</tr>
<tr>
<td>Summer stream flows*</td>
<td>↓ 0 - 10%</td>
<td>↓ 10% - 20%</td>
</tr>
</tbody>
</table>

* Pacific Climate Impacts Consortium
Sockeye “Temp-Oxy Rules”

Temperature and Oxygen affect Sockeye physiology and behaviour

- Pre-spawn mortality
- Gamete viability, egg-to-fry survival
- Migration delays (“thermal barrier”)
- Disease, parasites; decreased speed
- Physiological stress
- Optimal for adult migration

**Sockeye mortalities - Sproat River - 2015**

**Temperature and Oxygen**

<table>
<thead>
<tr>
<th>O₂</th>
<th>T °C</th>
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<tr>
<td>1</td>
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<td>7</td>
<td>16</td>
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<tr>
<td>8</td>
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**Stress**

- Optimal for adult migration
River Conditions & Migration

2012

"Cool"

20°C

40 days

Early entrants > 75% of the run

No mortalities

No late entry events

May Jun Jul Aug Sep Oct

Migration Rate (%) and Water Temp (°C)

Discharge (cm³)
River Conditions & Migration

1990 Mortalities:
~100,000 fish
~$5 million
(Stucchi et al. 1990).
River Conditions - Temperature

Somass - Thermal Barrier Frequency – 20th Century
(Days where Water Temp > 19°C)

# DAYS

<table>
<thead>
<tr>
<th>DECADE</th>
<th>JUL</th>
<th>AUG</th>
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<td>4.5</td>
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<tr>
<td>2000s</td>
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<td>37.9</td>
<td>6.4</td>
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River Conditions - Temperature

Somass - Thermal Barrier Frequency – 20th Century
(Days where Water Temp > 19°C)

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Mean 28 days / year (30%)

42 days / year (46%)
**River – Future Temperature**

**Somass – Thermal Barrier Frequency**
(#Days where Water Temp > 19°C)

![Bar chart showing thermal barrier frequency for Somass River.](chart.png)

**GCM Emissions Scenarios**

- **RCP 4.5** – ‘moderate scenario’ – emissions decline after 2040
- **RCP 8.5** – ‘business-as-usual’ scenario – emissions rise throughout 21st century

Ensemble means: 10 GCMs x 2 RCPs (Stiff, Hyatt & Cannon 2018)
River – Future Temperature

**Somass – Thermal Barrier Duration**
(Avg Length of Thermal Barrier Events, in Days)

<table>
<thead>
<tr>
<th># DAYS</th>
<th>14 days</th>
<th>20 days</th>
<th>28-33 days</th>
<th>30-50 days</th>
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<td>1971-2000</td>
<td>RCP45</td>
<td>RCP45</td>
<td>RCP45</td>
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<td>2041-2070</td>
<td>RCP45</td>
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<td>2071-2100</td>
<td>RCP45</td>
<td>RCP85</td>
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**EMISSIONS SCENARIOS**

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(Stiff, Hyatt & Cannon 2018)
River Conditions - Discharge

Stamp Falls Fishway – 1927, upgraded 1954

Sproat Falls Fishway completed 1951

Photos: Kevin Pellett
Low Flow Events

SPROAT RIVER - ANNUAL FREQUENCY (days < 5 cms)

STAMP RIVER - ANNUAL FREQUENCY (days < 25 cms)
**Holding Zone:**

- Low mixing rates
- + Pulp-mill effluents
- = Poor marine water quality
  - (high temps, low oxygen)

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**Somass River:**

Water temperatures >19-20°C act as a “thermal barrier” to Sockeye migration.

(Hyatt et al., 2015)
Alberni Inlet – “Temp-Oxy Squeeze”

1999 (Cool Year)

1998 (Warm Year)

Depth (m)

°C Isotherm

O₂ Isopleth

Substrate

Somass

Somass
1. Somass water temperature >19-20ºC present thermal barriers to Sockeye migration in freshwater.

2. Outlook: near-doubling of baseline (1971-2000) thermal barrier impacts by the 2050s due to climate change:
   - Average frequency up from 38% of migratory season to 70%.
   - Average duration of delays increase from 14 to 30 days.

3. Low flow events will likely occur more frequently during peak Sockeye migration periods (added stressor).

4. Temp/oxy conditions at the head of Alberni Inlet tend to provide poor holding conditions when upstream migration conditions are also poor.

5. Sockeye holding in the marine environment prefer temperatures of 9-10°C, even if oxygen concentrations are detrimental (< 4 ppm).
Project funding provided by NR-CAN and the DFO ACCASP program.

Depth profile data for this analysis were largely sourced from ENVIRONMENT CANADA’s Environmental Effluent Monitoring Program c/o Catalyst Paper Corporation which collected weekly or bi-weekly CTD sampling of the head end of the inlet. EEMP (Catalyst Paper Corp) 1991-present (Janice Boyd (EC); Larry Cross (Catalyst;); Hatfield Consultants (maps).

Other depth profile data were retrieved from various cruise reports and the DFO-IOS CTD database, and SAFE & South Coast StAD also teamed up to obtain depth profiles at other seaward locations from Stamp Narrows to Uchucklesit Inlet (2015).

Alex Cannon (ECCC) and Trevor Murdock (PCIC) assisted in the projection of future air temperature conditions in the Somass watershed.

Photos: Kevin Pellett; Andrew Campbell; Philip Pereboom; Neil de Boer; Lorne Collicutt