Overview: status of Atlantic salmon (*Salmo salar*) in the North Atlantic and trends in marine mortality

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Overview: status of Atlantic salmon (*Salmo salar*) in the North Atlantic and trends in marine mortality

Content of the presentation
1 – the fish itself (refresher)

2 – measures of abundance

3 – abundance and dynamics at the stock complex level

4 – evidence of factors that affect salmon abundance are acting

5 – cautions about stock complex assessments

6 – conclusions
Family Salmonidae
*Salmo salar* Linneaus

- Broadly distributed in North Atlantic, in over 2000 rivers
- Obligate freshwater spawner, with anadromous option
- Iteroparous (repeat) spawner although repeat spawners are less common in the southern portion of the range

http://www.asf.ca/about_salmon.php
Family Salmonidae  
*Salmo salar* Linneaus

- Short-lived species, age at first spawning as young as two years, and oldest salmon generally less than ten years old, oldest animals in the northern areas

- Fast growth at sea compared to most marine fish, including Pacific salmon

<table>
<thead>
<tr>
<th></th>
<th>Atlantic salmon</th>
<th>Sockeye salmon</th>
<th>Chinook salmon</th>
<th>Bluefin tuna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smolts</td>
<td>10 – 20 cm</td>
<td>6 – 13 cm</td>
<td>6 – 13 cm</td>
<td>45 – 60 cm</td>
</tr>
<tr>
<td>(1-6 yrs)</td>
<td>(1-2 yrs)</td>
<td>(0 – 1 yr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One year at sea</td>
<td>45 – 65 cm</td>
<td>35 – 40 cm</td>
<td>30 – 45 cm</td>
<td>45 – 60 cm</td>
</tr>
<tr>
<td>2 years at sea</td>
<td>60 – 90 cm</td>
<td>45 – 55 cm</td>
<td>50 – 65 cm</td>
<td>65 – 90 cm</td>
</tr>
<tr>
<td>3 years at sea</td>
<td>80 – 100 cm</td>
<td>50 – 60 cm</td>
<td>65 – 80 cm</td>
<td>85 – 120 cm</td>
</tr>
<tr>
<td>4 years at sea</td>
<td></td>
<td>80 – 95 cm</td>
<td>100 - 150 cm</td>
<td></td>
</tr>
</tbody>
</table>

- Recruit at 2 to 3 distinct adult ages/sizes (1SW, 2SW, 3SW)
Family Salmonidae

*Salmo salar* Linneaus

Stock-specific characteristics include:

- sea age at maturity (grilse stocks; multi-sea-winter stocks), sex bias in age-at-maturity, fecundity increases with body size

![Graph showing average stock characteristics by sea age maturity group and country in northeast Atlantic](image)
Family Salmonidae
Salmo salar Linneaus

• Few (2000 to 12000) and large eggs (5 – 7 mm diameter) per female, deposited in redds (protected)

• Very good juvenile survival in freshwater (upwards of 3% egg to smolt survival)

• Generally high natural mortality (M) at sea
  • for many marine fish (assumed) 16% to 30% per year
  • for Atlantic salmon, as high as 95% per year
Indicators of abundance

• Short term view of salmon abundance (pristine state)
• Reliable catches which can be an index of abundance go back to 1960, further back for some jurisdictions,
  • reliability of catch data is questionable prior to 1960
• Peak catch of < 12 000 mt (< 4 million fish) around 1970s

- Catch $\neq$ abundance due to incompleteness, changes in management, variable exploitation rates, ...
Estimates of absolute abundance and trends

- **River**
- **Ocean**
- **Coast**

**Eggs** → **Smolts** → **Pre-Fishery Abundance** → **Returns** → **Spawners**

- **River** → **Eggs** → **Smolts** → **Pre-Fishery Abundance** → **Returns** → **Spawners**

Greenland: North America, Northeast Atlantic
Faroes: Northeast Atlantic
Newfoundland/Labrador: North America

**Catch**
- Coastal waters
- Inriver

by river, by region, **by stock complex**
by sea age group (**1SW, MSW**), by smolt cohort (**1970 to 2009**)
<table>
<thead>
<tr>
<th>North America (NAC)</th>
<th>Southern NEAC</th>
<th>Northern NEAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Iceland (south/west region)</td>
<td>Iceland (north/east region)</td>
</tr>
<tr>
<td>Scotia-Fundy</td>
<td>France</td>
<td>Sweden</td>
</tr>
<tr>
<td>Gulf</td>
<td>Ireland</td>
<td>Norway</td>
</tr>
<tr>
<td>Quebec</td>
<td>UK (N. Ireland)</td>
<td>Finland</td>
</tr>
<tr>
<td>Newfoundland</td>
<td>UK (England &amp; Wales)</td>
<td>Russia</td>
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<tr>
<td>Labrador</td>
<td>UK (Scotland)</td>
<td></td>
</tr>
</tbody>
</table>
Lagged Eggs = \( \Sigma_{\text{region}} \Sigma_{\text{age}} \Sigma_{\text{eggs}} y-(\text{sm.age}+2) \)

Productivity

Prop. Mat.

PFA

PFAm

PFAnm

Catch 1SWm

Returns 1SW

Spawners 1SW

Eggs 1SW

Catch 1SWnm

Catch MSW

Returns MSW

Spawners MSW

Eggs MSW

By stock complex

things we estimate by models but can never measure

things we calculate

things we assume

things we know
**PFA (at Jan. 1 of first sea winter)**

**Northern NEAC:**
- approx. 1.2 million (avg. 2005-2009)
- small salmon: 49% decline
- large salmon: 54% decline

**Southern NEAC:**
- approx. 1.5 million (avg. 2005-2009)
- small salmon: 66% decline
- large salmon: 81% decline

**North America**
- approx. 0.9 million (avg. 2005-2009)
- small salmon: 40% decline
- large salmon: 88% decline
Separating freshwater effects from marine survival effects

- Increased estimated lagged eggs for N-NEAC but a decline of 43% in PFA

- Decrease of 33% for lagged eggs but decline of 66% in PFA

- Increased lagged eggs for NAC but decline of 61% in PFA
Separating freshwater effects from marine survival effects

Return rate of Imsa (Norway) smolts declined 68% from 1982 to 2007

Return rate of Corrib (Ireland) smolts declined 61% from 1981 to 2003

Declines in return rates of 81% for wild smolts (Quebec) and 88% for hatchery smolts (Saint John), for the time series
• Estimated declines in PFA are in opposing sign to the trends in spawning escapements but consistent with increased marine mortality
• Based on the assumptions for the PFA reconstruction (M is constant in the second year at sea), declines in PFA are attributed to decreased productivity between the spawning stage and the PFA stage (freshwater and first year-at-sea effects)

Productivity = PFA / Eggs
Trends in productivity

Northern-NEAC:
- shorter time series, begins 1991
- max. productivity of 1.2 fish per 1000 eggs
- declined beginning in 2004
- reached lowest level in 2007 at 0.5

Southern-NEAC:
- max. of 1.2 fish per 1000 eggs
- fell abruptly in 1990
- remained low since at 0.5

Productivity highest for NAC
- max. of 1.7 fish per 1000 eggs
- declined continually since 1989 to lowest value of 0.45 in 2001
Trends in productivity

Rapid decline in Southern-NEAC and rapid and sustained declined in NAC began in 1989 to 1990 PFA years
- the two stock complexes that migrate to Greenland for their second year at sea

Similar decline may have occurred in Northern-NEAC
- recent decline beginning in 2004 not observed in S-NEAC and NAC
Indicators of ecosystem changes in the North Atlantic

North Sea copepod and decapod larvae.

Northwest Atlantic (Gulf of Maine, Georges Bank) copepod


In Southern-NEAC and NAC

- spawner abundance in some regions has declined by more than 80%, and spawning escapements are substantially below the region specific conservation requirements.

Large numbers of assessed rivers are not meeting their spawning requirements.

% of rivers above CL (2009, 2010)
- UK (England & Wales): 59% (of 64)
- Ireland: 43% (of 141)
- France: 12% (of 17)
- Canada: 41% (of 76)
- USA: 0% (of 6)
What constitutes a “healthy” population?
• interpretation based on the abundance of salmon over the past half century at best
• in some portions of its range, Atlantic salmon was extirpated as early as the late 1800s (MacCrimmon and Gots, 1979)
• in the past four decades, adult-sized anadromous Atlantic salmon totaled less than 10 million animals annually, minor component, by number and biomass, of the pelagic ecosystem in the North Atlantic

Changes in the marine ecosystem of the North Atlantic have been noted
• there appears to be a North Atlantic wide factor(s) that is constraining productivity at sea at the stock complex level in both the northwest and northeast Atlantic areas
• reduced productivity is expressed in terms of increased mortality
Conclusions

Stock complex assessments that provide catch advice for mixed stock fisheries mask the regional and river-specific situations of Atlantic salmon populations

- this poses particular threats to stocks that are at low abundance and subject to other threats unrelated to fishing, such as freshwater habitat degradation

- still a number of mixed stock fisheries on salmon in the North Atlantic

Ideally, stock assessments would be conducted for every stock and fisheries would be prosecuted on stocks that are meeting their conservation requirements.

- reality is that annual river specific stock assessments are only available on about 25% of the 2000 river populations
Conclusions

Abundant river-specific scale assessments are crucial to improving our knowledge of Atlantic salmon population abundance and regulation as they provide the foundation upon which to test hypotheses of factors that define salmon survival both in freshwater and in the ocean.

Must maintain and expand diverse river-specific monitoring and assessment programs

- monitoring programs are not scientifically glamorous
- require long term engagement and investment of resources
• Members of the ICES Working Group on North Atlantic Salmon from more than 13 countries over the past three decades
• Countless individuals involved in the monitoring of stocks, compilation of catch data and biological characteristics from national governments, NGOs and aboriginal communities