Regional and temporal variation in marine growth of Atlantic salmon (Salmo salar, L.) from North-East Atlantic populations – links to marine survival and oceanographic conditions

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Fig. 4.1.1. Image of a salmon scale, with length measurement of the freshwater zone (L1) obtained by the Measurement window, and detailed growth data (A1-A40) obtained from the marine zone by the Caliper window of the Image-Pro Plus program.
Hypothesis -
marine survival and recruitment of Atlantic salmon Salmo salar is linked to early marine growth

Hypothesis
Growth and survival of salmon are linked to specific oceanic conditions

Uses
Salmon returns can be forecast using growth and oceanic parameters
DATA
• 5 rivers - Ireland (1), Norway (1), Norway/Finland (1), Iceland (2), (Spain/France)

  • Time series data: 1930s – 2008
    mostly 70’s on but some good indices from 60’s also.

  • Growth variables of interest
    total ps growth, total no. of circuli
    average ps growth in putative months

  • Biological variables
    Marine survival
    PFA

  • Environmental variables
    SST, NAO
ANALYSES

• Temporal differences in growth over time

• Spatial differences in growth between regions

• Growth Vs Survival indices (standardised ICES Indices for the river or river close by)

• Growth Vs recruitment (ICES PFA regions North and South)

• Temporal Growth related to temperatures at sea

• Temporal Growth related to broad scale oceanic conditions (NAO)
**Figure 2.1.2.** The rivers in Iceland, Ireland and Norway (represented by flags) prioritised for assessment of marine growth from scale samples. The selected scale material from these rivers is to be analysed under WP 4 (4.2.1), and the biological information gained entered into a digital scale database for use in WP5.
Mean post smolt growth

Repparfjord
Fig. 4.1.1. Image of a salmon scale, with length measurement of the freshwater zone (L1) obtained by the Measurement window, and detailed growth data (A1-A40) obtained from the marine zone by the Caliper window of the Image-Pro Plus program.
Mean post smolt growth

<table>
<thead>
<tr>
<th>Smolt year</th>
<th>PSG (mm)</th>
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<tbody>
<tr>
<td>1928</td>
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<td>2003</td>
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<td>2008</td>
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Repparfjord  
Hofsá  
Norðurá  
Burrishoole  
Teno
Nordura

Cohort analyses

Mean Circuli

Count
Repparfjord

Cohort analyses

Mean Circuli

Count
ICES WGNAS

Standardised survival values for wild salmon stocks from Southern NEAC area (Ireland, UK, France) showing a serious declining trend for 1SW and 2SW salmon
Figure 2.1.2. The rivers in Iceland, Ireland and Norway (represented by flags) prioritised for assessment of marine growth from scale samples. The selected scale material from these rivers is to be analysed under WP 4 (4.2.1), and the biological information gained entered into a digital scale database for use in WP5.
Annual mean PSG and Circ Count Vs. Survival
Repparfjord Monthly PSG Growth Vs Survival
Burrishoole
Monthly PSG
Growth Vs
Survival

Note: no other correlations were found between monthly growth and survival indices
• General decline interrupted by a short period of increased recruitment from 1998 to 2003
• Both age components have been at full reproductive capacity prior to the commencement of distant water fisheries
• Patterns are broadly consistent with the general decline in marine survival of 1SW and 2SW salmon in most monitored stocks
Maturing 1SW stock at full reproductive capacity over most of the series
- in 2008: at risk of suffering reduced reproductive capacity
- in 2009, suffering reduced reproductive capacity
Non-maturing 1SW stock at full reproductive capacity before 1996
- at risk of suffering reduced reproductive capacity in 10 of 14 years between 1996 and 2010
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Annual mean circ. count VS Spring local SST
Monthly mean PSG for “critical months”

VS

Summer Local SST

May Growth
June growth

** Nor signif correlations for PSG July, August, September for local summer SST
**Figure 2.1.2.** The rivers in Iceland, Ireland and Norway (represented by flags) prioritised for assessment of marine growth from scale samples. The selected scale material from these rivers is to be analysed under WP 4 (4.2.1), and the biological information gained entered into a digital scale database for use in WP5.
Annual mean Circ. Count VS Broadscale SST For Southern North Atlantic
Annual mean Circ. Count VS Broadscale summer SST

For southern North Atlantic

Note: weaker correlations than with entire SSC year average
Ocean conditions

The graph shows the time series of Ocean conditions from 1940 to 2015, with data points marked for each year. The x-axis represents the years, while the y-axis shows the values ranging from -1.2 to 0.8. The data is color-coded with blue for NAO and red for AMO.
Annual mean circuli count VS Winter NAO
Summary

• Temporal differences in growth over time
  Different regional temporal signals - No big change for Repa and Teno over time, low in 1990’s, but current values are stable and at or above LTM, Nordura increasing in recent years ?, Hofsa not so obvious? Ireland declining rapidly, lowest values in time series.

• Spatial differences in growth between regions
  Highest growth for more southern origin stocks – extra months at sea ? Burrishoole high historically but now low.

• Growth Vs Survival indices
  • Annual growth indices and survival pos. correlated for Burrishoole and Nordura, but not the others
  • Monthly growth indices pos correlated for Burrishoole (Sept, Oct only)
  • Monthly growth indices pos. correlated for Repparford (July, Oct, Nov, Dec)

• Growth and recruitment
  • Growth and recruitment correlated but different signals from different regions Annual growth indices Vs recruitment negatively correlated for Hofsa, Nordura, but positively correlated for Burrishoole.
Temporal Growth is related to temperatures at sea
Annual growth indices positively correlate with local Spring SST for Repparfjord, Teno, Hofsa but negatively correlate for Burrishoole

Burrishoole growth in May was negatively correlated with summer sst, Nordura growth in June was positively correlated with growth indices for summer sst. No other months or rivers showed correlations.

Temporal Growth related to broad scale SST (annual and summer) was positively correlated for the Repparfjord, Teno, Hofsa and Nordura but not the Burrishoole

Temporal growth is related to Oceanic conditions
Positive correlations between annual growth and Winter index of NAO for Repparfjord, Teno and negatively correlated with the Burrishoole.
NASCO precautionary approach management objective:

“Stocks should be maintained above Conservation Limits by means of management targets”

Managers very keen to be able to “forecast” salmon returns to enable appropriate management actions to be taken to meet this objective – international imperative.

Currently only “lagged spawners” and year in ICES forecast model of salmon returns for North Atlantic salmon stocks used for managing mixed stocks fisheries of W. Greenland and Faroes.

Increasing possibilities to include some time series of biological and environmental data from SALSEA merge and other programmes into forecast models.