Identifying freshwater and oceanic environmental signals from decadal and centennial Atlantic salmon catches off North East Atlantic

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1. Background on harvested population dynamics: main effects on time series’ fluctuations.

2. Brief background on Atlantic salmon dynamics: influence of broad environmental forcing.

3. Objective and Hypotheses

4. Description of the material and methods used in this working project.

5. Results so far of multidecadal and centennial (Norwegian) time series analyses.

6. What we’ve learnt.

7. Flaws and next steps.
Variability in fisheries time series is mainly an interplay between:

1. Internal (species) population dynamics.

2. The stochastic environmental forcing that also modulates the signal depending on the geographic location and local properties.

3. Finally exploitation patterns also contribute to shape the observed fisheries time series.
Variability in Atlantic salmon (catch) time series:

1. Studies tend to relate time series with oceanic temperature in both sides of the Atlantic. Other variables explored are NAOw, AMO, GSNW, rainfall, air temp…

2. The majority of these studies are focused on analysing few stocks at once or a given long time series (e.g. PFA in west Atlantic, nominal catches in East Atlantic, specific stocks from Iceland, Scotland, Norway, Ireland etc).

3. But there is few systematic analyses on multiple time series of Atlantic salmon catches at a broad scale compared to the abundance of regional studies.
2. Environmental effects on Atlantic salmon dynamics

Beaugrand & Reid (2003) GCB 9:801


Condron et al (2005) GRL 32:L23703


The main objective of this ongoing project is to expand the ideas developed in a previous work.

Divergent trends in anadromous salmonid populations in Norwegian and Scottish rivers
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... which basically shows that temporal trends in catches between pairs of rivers are correlated with geographical distance largely due to long-term rather than short-term fluctuations.
Broad working hypotheses of this ongoing project:

1. Are time series within countries more similar in the short or the long term? On the long term is expected if there is a common climate signal, otherwise, short term similarities might occur on closely located series due to local effects.

2. If any grouping on the low frequencies, it is expected a relationship with broad climate environmental fluctuations off the North Atlantic, otherwise, similarities on the high frequencies should be related with the local climate.

3. Are time series grouped according to their geographical proximity? If not, are they grouped to their association to the environment?
Material

1. Atlantic salmon fisheries

• Iceland: Time series of total rod catches (i.e. nº grilse + 2SW) for 6 rivers from 1949 to 2010 from 3 major regions (SW, NW, NE).

• Scotland: Time series of total wild catches (i.e. nº grilse + MSW) for 37 districts from 1950 to 2008 from 3 major regions (Atlantic, North Sea, Irish Sea).

• Norway: Time series of total rod catches (i.e. kg grilse + MSW) for 52 rivers from 1969 to 2007 from 4 major regions (Skagerrak, Western, Central, Northern).

2. Environmental variables

• SST: HadSST2 (5º × 5º cell: 55º-75ºN, 30ºW-40ºE) from NOAA/ESRL.

• NAO: winter NAO from NCAR/CGD (J. Hurrell’s index).

Methods

1. Wavelet analysis were used to decompose the signals of the noisy and non-stationary fisheries and environmental time series [technical details in Cazelles et al. (2008) Oecologia 156:287; Rouyer et al. (2008) PNAS 105:5420].

2. We computed distance matrices among the fisheries time series’ decomposed frequencies, and then used cluster analyses to identify the “best” grouping.

3. Finally, Spearman correlations between fisheries time series and environmental parameters (SST, NAO & AMO) were used to analyse the coherence of the signals. Degrees of freedom (autocorrelation) were corrected following Pyper & Peterman (1998) CJFAS 55:2127.
Working with the time series: Ellidaar as an example
5. Results: Icelandic time series

Relationships between frequencies’ distance matrices in Iceland

Cluster dendrogram - Iceland

- Ellidaar SW
- Laxa NE
- Nordura SW
- Hofsa NE
- Midjardara NW
- Viddalsa NW
5. Results: Icelandic time series

Cluster dendrogram - Iceland

Catches (n° caught)

Ellidaar

Laxa

AMO

Ellidaar

Laxa
5. Results: Scottish time series

Cluster dendrogram of Low Frequencies in Scottish Time series

Group 1  Group 2  Group 3  Group 4
Boxplots of Spearman $r$ of LF of catches vs. AMO
Cluster dendrogram of Low Frequencies in Norwegian Time series

Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
Boxplots of Spearman $r$ of LF of catches vs. AMO
5. Results: Norwegian short time series

Map showing various data points across Norway, labeled with different colors representing various groups.
5. Results: Norwegian long time series
• Similarities on long term trends? Yes

• Identified any environmental signal at Low Frequencies: Yes

• Which index plays a relevant role? AMO (NAO & SST were not important)

• What drives the grouping? AMO does, but strongly contrasted with -/+ relationships

• Geographical relevance? Yes (W Scotland - AMO related, E Scotland + AMO related, S & W Norway - AMO related), while not in the rest of Norway & Iceland

• Why contrasting effects, & why not always geographically structured? Not clear at all, but guessing: climate affects local dynamics differently, and probably has contrasting effects on life stages and/or age groups…
Any flaws of the present ongoing project?

- Time series of catches, though not expected changes in effort on the long term.
- Catch series contain various age-groups.
- Index of SST over a broad geographical scale.

What are the coherent steps to progress with this analyses?

- Downsizing the geographical scale might help to interpret results, that is shifts in AMO relationships might be due to different spatial responses of SST to AMO.
- Local (freshwater & oceanic) forcing must be included.
- Differentiation between age groups might help interpreting the clustering and relationships (different migration routes?)
THANKS FOR YOUR ATTENTION!!

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