Atlantic salmon index rivers: their contribution to management
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What is an Index River?

- Salmon population abundance (biological traits) monitored
  - (Anadromous) Adult (returns + catches), parr, smolts...
  - Survival rates (freshwater, marine)

- Over long term
  - Several decades

- Used by ICES NASWG to assess the status A. Salmon stocks
  - Both sides of the Atlantic Ocean

- For providing scientific management advice

- ~ 30 Index Rivers: 50/50 each side of the Atlantic
  - In Europe: From France → Iceland
  - Morfish Rivers (Scorff, Oir, Frome): members of the club...
Why are Index Rivers useful?

- Abundance data series from Index Rivers are used to derive Biological Reference Points
  - Abundance benchmarks against which population status can be assessed
- Conservation Limits: abundance level above which population should be maintained
  - If falling below, remedial management action should be taken
- NASCO Conservation Limit: spawning escapement producing MSY
  - Derived from Stock-Recruitment analysis
- An illustration using the Nivelle R. data series
The Nivelle R.: the southernmost Index River in Europe

Uxondoa trapping station
Redd counts
Olha trapping station

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The egg-to-egg Stock/Recruitment series of the Nivelle R.
The egg-to-egg Stock/Recruitment series of the Nivelle R.

Median recruitment curve

Recruitment -> returning eggs (m² RR eq.) vs. Stock -> spawned eggs (m² RR eq.)
The egg-to-egg Stock/Recruitment series of the Nivelle R.

Median recruitment curve

Plateau = carrying capacity
The egg-to-egg Stock/Recruitment series of the Nivelle R.

Median recruitment curve
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Gain -> sustainable yield

Stock -> spawned eggs (m² RR eq.)

Recruitment -> retuming eggs
The egg-to-egg Stock/Recruitment series of the Nivelle R.

Maximum Sustainable Yield
NASCO CL -> 1.8 egg/m² (RR eq.)
What about non-Index Rivers?

- A handful of Index Rivers but several 100's salmon rivers
- How can we transfer our knowledge about CLs from data-rich Index Rivers to data-poor non-Index Rivers?
- Modern statistical modeling techniques (Bayesian Hierarchical Analysis): a formal and rigorous framework for carrying out this extrapolation (Prévost et al. 2001)
  - Accounting of the associated uncertainty
  - Taking into account environmental variables explaining variations in productivity and carrying capacity between salmon rivers
- A brief illustration from the EU Salmodel project (Prévost et al. 2003)
  - Also conducted for the rivers of Atlantic Canada (Québec, Maritime Provinces and Newfoundland)
SALMODEL: a joint SR analysis of 13 Index Rivers

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SALMODEL: estimation of NASCO CL for any salmon river in Western Europe

Grey: NACSO CL estimates for Index Rivers
SALMODEL: estimation of NASCO CL for any salmon river in Western Europe

Latitudinal Gradient
SALMODEL: estimation of NASCO CL for any salmon river in Western Europe

Latitudinal Gradient

White: NACSO CL prediction based on latitude
Troubles with NASCO CL definition

- Assume catches (at sea and in rivers) are well known or negligible
  - Generally not true
    - E.g. in the Nivelle: significant but unknown coastal exploitation

- Spawning stock producing MSY: is this relevant to conservation?
  - Rather aims at fisheries exploitation optimization

- What if survival (e.g. at sea) drops?
Evolution of NASCO CL if sea survival drops

Nivelle current conditions
NACSO CL: 1.8 egg/m²

Sea survival drops by 25%

Recruitment curve flattens
→ NACSO CL decreases

Nivelle new conditions
NACSO CL: 1.4 egg/m²
CL definition: time for a change?

- NASCO CL: based on fisheries optimization principle
  - when times become harder for salmon CL should be revised downward
- Fisheries optimization ≠ Conservation
- But how can we define Conservation?
- An operational (and partial) proposal: conservation should ensure that wild juvenile recruitment does not fall too low
- Associated CL definition: spawning escapement threshold that ensure wild juvenile recruitment does not fall too low
The Nivelle R.: the southernmost Index River in Europe

- Uxondoa trapping station
- Olha trapping station
- Spawning
- Redd counts
- Escapement
- Juvenile (0+ parr in the fall) recruitment
- Electrofishing

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The egg-to-0+ parr Stock/Recruitment series of the Nivelle R.
The egg-to-0+ parr Stock/Recruitment series of the Nivelle R.

Max median recruitment: R_{max} = 0.13 \text{ 0+}/m^2
The egg-to-0+ parr Stock/Recruitment series of the Nivelle R.

Stochasticity: Wide ranging fluctuations

Carrying capacity: $R_{\text{max}} = 0.13\ 0+/m^2$
CL definition: time for a change?

- Acknowledge recruitment stochasticity (uncertainty)
- Modified CL definition: spawning escapement threshold that ensure a low probability of wild juvenile recruitment falling too low
  - Conservation aims at controlling the risk of low recruitment
- But what is low recruitment?
  - A management decision
  - An operational proposal: set as a proportion of the carrying capacity (Rmax)
- And what is low probability?
  - A management decision
- Scientific advice: produce (risk) plots that help management decision
Risk plot for 3 options of low recruitment level

Risk: Proba(Recruitment < X% of Rmax)

Stock -> spawned eggs (/m² RR eq.)
Risk plot: an example of management decision

Risk: \( \text{Proba(Recruitment < X\% of Rmax)} \)

Low recruitment: 50% Rmax
Low probability: 25%

CL: 2.8 egg/m²
Risk plot: being too risk averse is not realistic

Risk: Proba(Recruitment < X% of Rmax)

Low recruitment: 90% Rmax

Unrealistic!

Low probability: 10%
New CL approach: pros & cons

• PROs
  – Based on a conservation principle/definition in a risk control context
  – Identify the risk of low recruitment level as a management decision
    • Easier to communicate to management stakeholders (?)
  – Uses scientific and fisheries independent data only
  – Not sensitive to changes in density independent mortality (e.g. at sea)
  – Transferable from Index Rivers to non-Index Rivers (as NASCO CL)

• CONs
  – CL estimation sensitive to recruitment rate at low spawning escapement
    • A quantity usually difficult to estimate from SR data
  – Do not take into account potential density dependence of survival after the juvenile recruitment stage considered
Atlantic Salmon Index Rivers: Their contribution to management

- Major contribution: provide the scientific data basis for ecological research and innovation applied to management of Atlantic salmon.
Thanks for your attention