Interplay between ocean climate, adult condition factor, run-timing and smolt quality in Scotland

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Outline of presentation:

- Focus is on quality of individuals (condition factor), not abundances
- Time-series changes in condition factor in 1SW, summer 2SW and spring 2SW fish (a concern?)
- Time-series changes in age-structure of emigrant smolts (FW climate?)
- Time-series changes in run-timing of return adult 1SW salmon (Ocean climate: management implications?)
- Possible “carry-over” effects of adult marine experience on quality of offspring (a concern?)
Why is it important to monitor wild salmon from commercial net catches?

- Data largely belong to FRS/Marine Scotland

- Crucial to maintain existing time series
  - River North Esk 1963 – 2011 Season start delayed until 1 May for conservation
  - River Tweed 1968 – 2011 Season start delayed until 1 May for conservation
  - Strathy/Armadale 1993 – 2011 June-August only

- Numerous possibilities of extending the science-base to provide informed management advice based on reliable, consistent and comprehensive empirical evidence

- Otherwise “stabbing in the dark”? (MSW ‘Spring’ salmon the major concern here)
Female, 51.5 cm, 1.16 kg, $W_R = 0.71$ (26% under-weight)

Male, 65.0 cm, 3.10 kg, $W_R = 0.93$ (4% under-weight)
Changes in Condition Factor ("skinniness") of 1SW Atlantic salmon: driven by an INDIRECT effect of ocean climate change?
Atlantic sea surface temperature and the distribution of Atlantic salmon: fortunately, salmon largely forage at the ocean surface, so satellite telemetry is ecologically valid.
A significant decline in frequency of S3 smolts ($r = -0.422$, $p = 0.01$), and a corresponding increase in S2; evidence of warming/improved growth conditions of the freshwater environment?
Size threshold for smoltification? Decrease in proportional abundance of S3 emigrants indicates freshwater growth conditions have improved and more now smolt at 2 years. But freshwater “improvement” (climate warming?) is insufficient to increase the frequencies of S1.
River age-groupings included in analysis ONLY if >50 fish and predicted modal date is within the sampled date range.

River North Esk. Predicted modal return date for 1SW adult fish of river ages 1-4 (S1-S4)
Rivers Spey, North Esk, Tay, Tweed. Modal dates of return of 1SW adults of river age 2 (S2)
Is run-timing influenced by the seasonal pattern of river flow height?
Specifically, do major spate events determine the timing of river entry?
Multiple regression analysis of Modal Date of Return of 1SW adult salmon of river ages S2 and S3

Dependent variable - Modal date of return (predicted by computer model) of S1, S2 and S3 adults for each available Year and River

(Possible) explanatory factors - River; Median river Flow; Variability of flow (5-95% range); Condition Factor of adult fish

OUTCOME:

• 1SW adults of older river ages return earlier in the summer

• Neither median river height, nor variability of flow explain a significant proportion of the variability in modal return dates

• A significant proportion (r2 adjusted = 0.26) of the variation in return date is explained by Condition Factor. “Skinny” grilse remain at sea longer. Management implications? (mean sizes AND vulnerability)
Comparison including a separate fixed value for each age-class in each river; adjusted $r^2 = 0.26$
River North Esk, 1975-2010. Emigrant smolt sizes

River North Esk, mean lengths S1-S3 emigrant smolts

- S3 Mean 12.5 cm
- S2 Mean 12.2 cm
- S1 Mean 11.5 cm
Evidence of a “maternal effect” of parental quality on offspring quality

River North Esk emigrant smolt size difference. S2 Mean length - S3 Mean length versus Parental Condition Factor (Mean pooled 1SW/Summer 2SW; lagged -3 Years)

\[ y = 3.8614x - 3.8836 \]

\[ R^2 = 0.1856 \]
Ocean climate impacts on wild salmon in Scotland

Summary messages from the foregoing:

- Recent ocean warming is a real phenomenon, and has marked INDIRECT effects on individual wild salmon and entire annual cohorts (1SW and 2SW)
- Ocean warming is having a continuing detrimental effect on 1SW grilse/2SW summer salmon in the Norwegian Sea
- But a positive influence of ocean warming on MSW salmon migrating to West Greenland. Should we restart sampling of spring 2SW fish?
- Current poor condition (driven by climate) is changing run-timing of return adults
- Current poor condition (driven by climate) may be affecting emigrant smolt quality