Including climate into the assessment of future fish recruitment, using multiple regression models

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Background

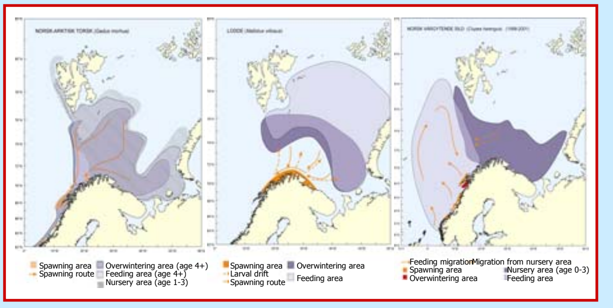
Climate variability have impact on the whole lifecycle of fish. The effect can be direct (e.g. temperature effect on metabolism) and indirect (e.g. through prey production and distribution).

Climate variability has generally not been included in the assessment of fish stocks in the Barents and Norwegian Sea. However, in recent years there has been a focus on implementing climate variability in the assessment for several stocks. A promising approach, using linear multiple regression models, has been applied for short time projections of recruitment of North-East Arctic cod, Norwegian spring spawning herring and Barents Sea capelin.

Time lags between nowcasting climate effects on the early life stage and the time the fish are recruited into the fisheries, can be used in combination with stock variables at younger ages to make models with predictive power 1-3 years ahead.

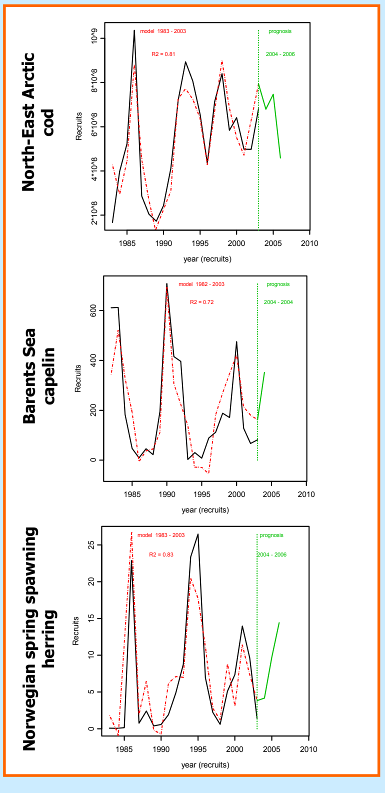
The method is easily adapted to existing assessment routines, and have already been successfully implemented in the assessment of Barents Sea capelin [1].

North-East Arctic cod | Barents Sea capelin | Norwegian spring spawning herring



Spawning, hatchery and feeding area of the three modelled species.

The recruitment models



$$Rec3_t = 3.0\times10^8 \times TempKola_{t-3} + 0.069\times 1group_{t-2} + 7.1\times10^7 \times \log(capmatbio_{t-2}) - 1.7\times10^9$$

- ***$Rec3_t$*: Modelled number of 3 year olds [2]**
- ***$TempKola_{t-3}$*: yearly average temperature in the Kola section [3]**
- ***$1group_{t-2}$*: Age 1 index of cod from the Norwegian bottom trawl survey [2]**
- ***$capmatbio_{t-2}$*: Maturing biomass (tonnes) of capelin from the survey [1]**

Subscript denotes time lag in years

$$Rec_t = -39.5\times TempskinBS_{t-1} + 0.45\times 0group_{t-1} + 0.096\times capmatbio_{t-1} - 61$$

- ***$Rec1_t$*: Modelled number of recruits (in 10^9) [1]**
- ***$TempskinBS_{t-1}$*: Winter averaged skin temperature (NCEP [4]) in Barents Sea**
- ***$0group_{t-1}$*: Capelin 0-group index [1]**
- ***$capmatbio_{t-1}$*: Capelin maturing biomass [1]**

Subscript denotes time lag in years

$$Rec_t = 6.7\times TempskinNS_{t-3} + 16\times 0group_{t-3} - 35$$

- ***$Rec3_t$*: Modelled number (in 10^9) of 3 year olds [5]**
- ***$TempskinNS_{t-3}$*: Winter average skin temperature (NCEP [4]) in Norwegian Sea**
- ***$0group_{t-3}$*: Herring 0-group log index [5]**

Subscript denotes time lag in years

Cause-effect links

It is often stated that fish doesn't eat temperature. However, temperature is one of the important controlling mechanisms (together with light and nutrients) for production in the lower part of the food web up to zooplankton. In all three models the temperature term is from the first life year of the fish. The temperature can therefore be looked at as a proxy for growth and survival of the juvenile fish through food availability.

In the Barents Sea a major component of the zooplankton biomass is advected from the Norwegian Sea. There is a close link between the inflow of warm Atlantic water masses and the temperature in the Barents Sea. The temperature is then also a proxy for advection of food.

There is also a direct effect of temperature on the growth of fish larvae, through affecting their metabolism.

The cause-effect link of an environmental factor is often a complex matter, as illustrated above. There is usually no clear single effect, but a mix of different pathways for which the environment influences fish stocks.

Conclusions

- **Multiple regression models are a useful tool, which easily incorporates climatic effects into fish assessment**
- **1-3 year recruitment prediction gives an important early warning of possible rapid changes due to climate variability**
- **Care must be made to ensure a plausible cause-effect link, not only go for the best possible statistical fit**
- **The capelin model have been successfully incorporated into last year capelin assessment**

References

[1] Anon. 2003. Report of the 2003 joint Russian-Norwegian meeting to assess the Barents Sea capelin stock, Murmansk, 3-6 October 2003.

[2] ICES (2003). Report of the Arctic Fisheries Working Group. Pasaia, Spain, 23 April - 2 May 2003. ICES CM 2003/ACFM:22.

[3] Bochkov,YA (1982) Water temperature in the 0-200m layer in the Kola-Meridian in the Barents Sea, 1900-1981. Sb. Nauchn. Trud. PINRO 46: 113-122

[4] Re-analysed data from National Centers for Environmental Predictions (NCEP), (http://wesley.wwb.noaa.gov/reanalysis.html)

[5] ICES (2003). Report of the Northern Pelagic and Blue Whitting Working Group. Copenhagen, 29 April - 8 May 2003. ICES CM 2003/ACFM:23.