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Evaluation of potential impacts of hake (*Merluccius merluccius*) emergence in the North Sea on saithe (*Pollachius virens*) stock growth.

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In a context of global warming, and based on the assumptions highlighted in a previous study concerning the importance of Norway pout (*Trisopterus esmarkii*) for the spatial distribution of saithe (*Pollachius virens*) and hake (*Merluccius merluccius*), we investigated the impact of a reduction of prey availability on the saithe stock as a potential consequence of hake recent emergence in the North Sea. As first step, the evaluation of bottom-up processes was done studying environment influence on saithe growth using ICES survey data. The environment was defined by temperature, saithe spawning stock biomass (SSB) and Norway pout total biomass. Estimation of the influence of the environment on saithe weight-at-age was done using generalized linear models. Von Bertalanffy growth function (VBGF), and another related method, were used to estimate growth parameters from VBGF which were, in a second time, put in relation with the environment. In a next step, the results concerning the influence of Norway pout biomass on saithe weight-at-age and/or growth parameters will be implemented in the the stochastic multispecies model (SMS) to assess hake direct effects on Norway pout stock and indirect effects on saithe population growth and stock dynamics.

Introduction

European hake (*Merluccius merluccius*) is a top-predator species which shows since few years an increase of biomass and an expansion of its distribution in the North Sea (Baudron and Fernandes, 2014; Cormon *et al*., 2014). Cormon *et al*. (2014) highlighted positive effects of temperature and potential prey occurrences on hake probability of presence relating hake changes in distribution to climate and trophic changes. Baudron and Fernandes (2014) reported potential issues for mixed demersal fisheries but there is currently no study about the potential ecological impacts of hake emergence on other commercial species. The emergence of a predator can lead to direct impacts through predation (Floeter *et al*., 2005). These effects are generally accounted in multispecies stock assessments while indirect effects through potential reduction of forage fishes availability induced by the emergence of a spatially overlapping potential competitor are less studied.

The increasing overlap between hake and saithe (*Pollachius virens*) in the North Sea, the common importance of Norway pout presence for both species probable habitat (Cormon *et al*., 2014) and diet (Bergstad, 1991; Cormon *et al*., in prep.), and the decreasing biomass and weight-at-age of saithe in this area (ICES2013), lead to the assumption of competition. This study investigates saithe growth in relation to temperature, saithe spawning stock biomass, and Norway pout biomass in order to increases our understanding of the environmentally-induced changes of saithe growth and quantitatively estimate bottom-up processes applied to North Sea saithe.

Materials and Methods

Age 3 to 10 saithe weight-at-age data (1987-2012), and age 1 to 10 age-length-key (ALK) data (1991-2012), were respectively extracted from ICES (2013) and from ICES database DATRAS. ALK data were averaged to obtained mean length-at-age for each year and growth increments were calculated within years for length data. Temperatures were extracted from ICES database OCEAN and saithe SSB and Norway pout total biomass from ICES (2013).

We used generalised linear models to study the global relationships between mean weight-at-age and environmental variables (M1). We obtained eight models (from age 3 to age10) with different coefficients and significance for each set of descriptors. To study growth processes, Von Bertalanffy growth function (VBGF) equation was used in order to estimate by non-linear regression the growth parameters K for each year between 1991 and 2012 using the ALK dataset. Simple regressions of estimated parameters against environmental variables followed (M2). Length increments were used to apply the Gulland-Holt plot method. This method, related to VBGF, allows a linear estimation of K and L_{inf} which are then put in relation with the environment through simple regressions (M3).

Results and Discussion

The global approach (M1, Table 1) reveals a positive influence of prey availability (Norway pout biomass) on weight-at-age of younger age classes (age 3 to age 5) while interspecific density-dependence (saithe SSB) negatively affects the older ones (age 6 to age 10). The regression of the yearly estimated growth rates K against the different environmental variables (M2, Table 1) confirms the results previously obtained with a negative intraspecific density-dependence effect and a positive prey availability one. In the North Sea, the current maturity ogive indicates that 15, 70 and 90% of the population are mature at age 4, 5 and 6, respectively (ICES, 2013). Consequently, the results obtained in M1 are consistent with the fact that most part of somatic growth generally occurs before maturation. The Gulland-Holt plot method (M3) could not be applied to the ALK dataset because of survey related bias *e.g.* low catchability of younger (under 3 years old) and older fishes (over 6 years old).

Table 1: Signs of relationships between estimated variables and environmental variables using different methods. Description of the different methods in Materials and Methods section. X: not significant. t.b.c.: to be continued.
(a) Jennings *et al*., 1998.

Methods	M1	M2	M3
Estimated variables	Weight-at-age	K	K and $L\infty$
Fixed variables		$L\infty$ = 177.1 cm (a)	
Norway pout biomass	Age 3 to age 5 (+)	(+)	NA
Saithe biomass	Age 6 to age 10 (–)	(–)	NA
Annual mean temperature	X	X	NA

We showed that when Norway pout biomass increases, saithe young individuals weight-at-age as well as saithe growth rate increases. The coefficients obtained provide a first step toward the study of hake emergence in the North Sea impacts, particularly on saithe population through a potential reduction of Norway pout biomass. However, they need to be validated *e.g.* by the analysis of commercial data. Also an estimation of growth parameters directly including the environment could be of interest (Millar and Myers, 1990). In a second step, these results will be implemented in the multispecific stock assessment model SMS in order to understand potential competitive interactions between saithe and hake in the North Sea.

References

Baudron, A. R. and P. G. Fernandes (2014). Adverse consequences of stock recovery: European hake, a new "choke" species under a discard ban? Fish and Fisheries, doi:10.1111/faf.12079.

Bergstad, O. A. (1991). Distribution and Trophic Ecology of Some Gadoid Fish of the Norwegian Deep .2. Food-Web Linkages and Comparisons of Diets and Distributions. Sarsia, 75(4): 315-325.

Cormon, X., Loots, C., Vaz, S., Vermard, Y. and P. Marchal (2014). Spatial interactions between saithe (*Pollachius virens*) and hake (*Merluccius merluccius*) in the North Sea. ICES Journal of Marine Sciences, doi:10.1093/icesjms/fsu120.

Cormon, X., Vermard, Y. and P. Marchal (in prep). Diet overlap between saithe (*Pollachius virens*) and hake (*Merluccius merluccius*) around the Shetland Islands.

Floeter, J., Kempf, A., Vinther, M., Schrum, C. and A. Temming (2005). Grey gurnard (Eutrigla gurnadus) in the North Sea: an emerging key predator? Canadian Journal of Fisheries and Aquatic Sciences, 62(8): 1853-1864.

ICES (2013). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) ICES CM/ACOM:13. 1392 pp.

Jennings S, Reynolds J.D and S.C. Mills (1998). Life history correlates of responses to fisheries exploitation. Proc. R. Soc. B. 265, 333–339.

Millar, R. B. and R.A. Myers (1990). "Modelling environmentally induced change in growth for Atlantic Canada cod stocks." ICES CM/G:24: 1-13.