

# Identification of potential target levels for Central Baltic Sea fishing mortalities, taking multispecies interactions into account

Extended abstract

**Vinther, Morten; Neuenfeldt, Stefan; Eero, Margit; Casini, Michele; Sparholt, Henrik**

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TITLE

**Identification of potential target levels for Central Baltic Sea fishing mortalities taking multispecies interactions into account**

AUTHORS

Morten Vinther, Stefan Neuenfeldt, Margit Eero, Michele Casini, Henrik Sparholt & Anna Rindorf.

EXENDED ABSTRACT

Management of fisheries for cod can have an impact on fishing opportunities for sprat and herring, and vice versa. Cod are predatory, and their main prey is sprat and, to a lesser extent, herring and also juvenile cod (cannibalism). In addition, herring and sprat sometimes feed on the eggs of cod. Furthermore, growth of herring and sprat has been density-dependent, and growth of cod has, to some extent, been dependent on herring and sprat biomass. Finally, the relative distributions of predator (cod) and prey (herring and sprat, possibly juvenile cod) have changed substantially during the last years, and for the time being much herring and sprat are outside the predatory reach of cod

Candidates for $F_{MSY}$ were identified using deterministic forecasts with no stochastic variability in recruitment based on a high number of combinations of F-values for the three species, cod, herring and sprat. Based on the estimated yields from these runs, the range of F values giving high yield by species was identified (taking the F-level and stock sizes on the other stocks into account simultaneously). In the simulations a wide range of F values, and probably unrealistic low and high values, can be used initially to identify the higher yield region of F and thereby to allow selection of a narrower range of F-values.

Figure 1 presents the results for the default one-are, no-growth run of the deterministic forecasts. The highest yield of the individual species, without seriously impairing the stock sizes of other species, is obtained for an F around 0.60-0.65 for cod, 0.26 for herring and 0.46 for sprat.

Yield within this narrow near $F_{msy}$ range of F presented is rather constant for three species. For cod, the median yield is almost constant (in the range 70-73 kt), while SSB ranges 140-210 kt for F in the

range of 0.4-0.7. The yields of herring of sprat vary by around 5% and 10% within the presented range of F, while SSB by species varies between 550 kt and 850 kt. The variation in yield of herring and sprat due to the stock size of cod and associated predation is at the same scale as the variation in yield due to the F range shown. As the modelling for Fmsy does not include any structural uncertainty, risks of stock decline and impaired cod recruitment will be higher than those estimated.

The combination of an increasing cod stock and low abundance of sprat and herring in SD 25 (in the main distribution area of cod) has resulted in the lowest biomass of clupeids per cod currently available in this area since the 1970s (Eero et al. 2012). In line with low biomass of clupeids in the area, the mean weight of older cod (age-groups 4-7) in SD 25 has sharply declined since 2007.

While the effects of spatial distributions of predator and prey can be assessed in the retrospective runs of the SMS model (Vinther & Levy 2004), for forecast there is a limited knowledge on the processes that lead to changes in spatial distributions. Moreover, when taking clupeid density-dependent growth in consideration, the $F_{msy}$ estimated by SMS are very high for both herring and sprat, and the reason for this should be further investigated.

All the multispecies $F_{msy}$ values for Eastern Baltic cod, Central Baltic herring and Baltic sprat are higher than the single species values. Particularly for cod and sprat higher Fs give very similar yields on the long term and will give lower SSBs and in some cases risks of stock decline to the "lower biomass" reference points (that is a first suggestion for a lower SSB to avoid impaired recruitment). Model results indicate that although higher F on Eastern Baltic cod give little increase in cod yield, a higher cod F gives higher yields from Baltic sprat and Central Baltic herring.

The present distribution pattern, with a limited distribution range for cod (concentrated in the southern area) and basin wide distribution for herring and sprat (but mainly concentrated in the northern areas, at least in some seasons), implies that an increase in F on cod, not necessarily will result in increasing Baltic wide clupeid stock sizes. Conversely a decrease in F on cod will not necessarily result in a decrease of the Baltic clupeid stock size if it will not be accompanied by a cod expansion to northern areas. However, cod cannibalism will be higher and limited growth of cod due to food deprivation will become a bigger problem. On the other hand, a reduction of clupeid F in Sub-division 25 will likely improve growth and condition of cod as well as reduce cannibalism. An increase in clupeid F in northern areas (SDs 27-32) will likely not have a negative

effect on cod, since this will not affect the stock component distributed in southern areas (SD 25-26). Further, a higher F on clupeids in northern areas would likely reduce density dependence and improve the growth and condition of clupeid stocks.

Higher $F_{msy}$ proxies for herring and sprat are also obtained when density dependent growth is assumed for the two species, as the stocks compensate by a higher growth at lower stock densities due to either higher fishing mortalities or predation.

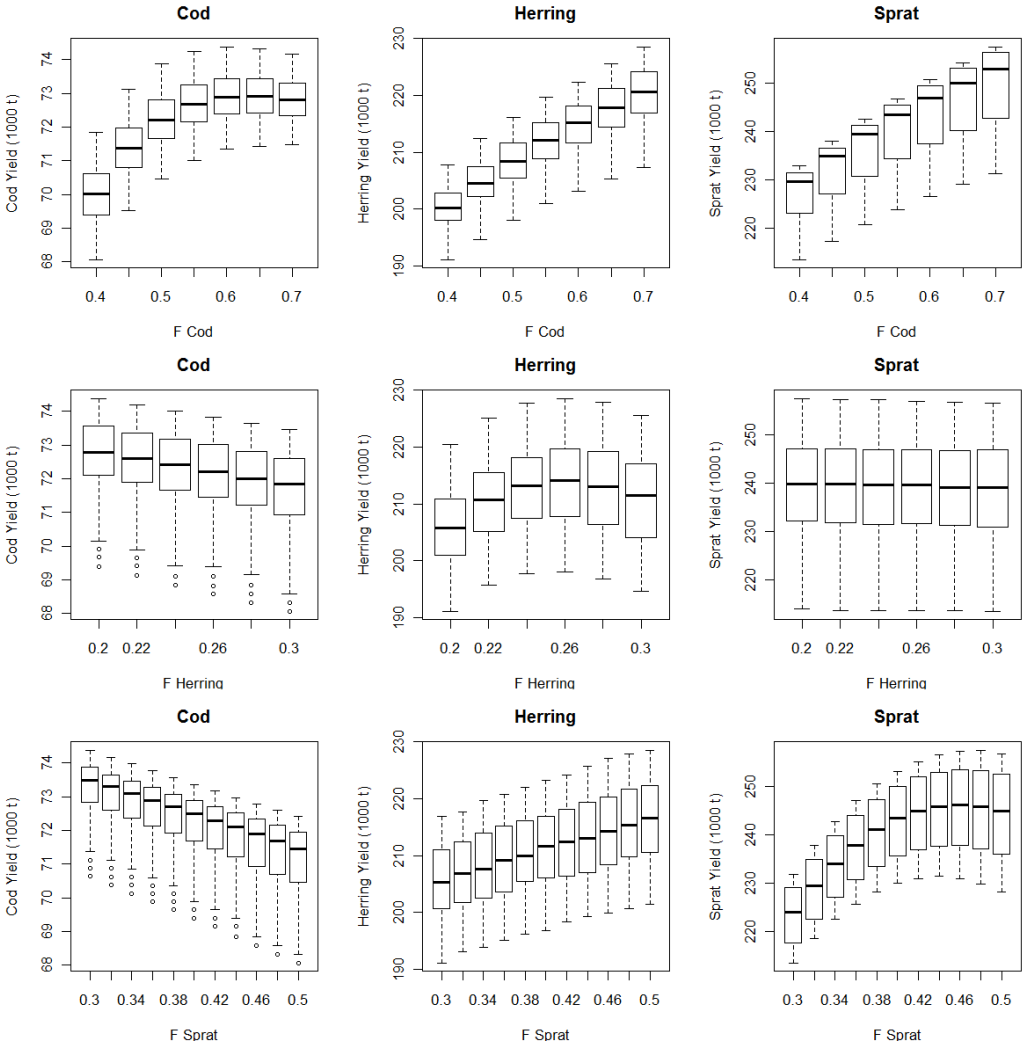


**Figure 1.** Equilibrium yield predicted for various levels of fishing mortality for cod (0.4 to 0.7 step 0.05), herring F (0.2 to 0.3 by 0.02) and sprat F (0.3 to 0.5 by 0.02). The boxplot by species shows the distribution of yields for the given F level shown on the X-axis taking into account to the range of F-levels for the other species. E.g. the yield of cod (upper left panel) has a median yield at 70 kt for cod F at 0.4. The variation in yield for F=0.4 is due to the varying F on sprat and herring and thereby the level of available food and related cod-cannibalism which affect the yield of cod.

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