



# ICES

International Council for  
the Exploration of the Sea

# CIEM

Conseil International pour  
l'Exploration de la Mer

## **Theme Session C– Natural Mortality variation in populations and communities**

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**Conveners: Ken Haste Andersen (Denmark), Niels Hintzen (the Netherlands), and Ted Potter (UK)**

It is essential to understand natural mortality (M) variation in populations and communities to be able to construct models that will support population and ecosystem approaches for providing management advice. Community analysis has demonstrated that direct fishing mortality may be eclipsed by community trophic interactions affecting M at different life-history stages and size-classes of fish, particularly as fishing effort is reduced to aid stock recovery. The dynamics of many fish stocks is thought to be dominated by this trophic component of M. Additionally there is evidence that perturbations and changes in a range of factors, including environmental conditions, parasite loads and contaminants, have affected M and altered the food-web structure of some communities. Combinations of these different influences on M are thought to be responsible for some species declines (diadromous fish) and/or lack of recovery in others (northern and Baltic cod). Understanding these processes is therefore essential to support the development of ecosystem approaches and stock recovery plans which are now required for a large number of marine and diadromous species.

The Session addressed two particular topics within the ICES Science Plan, 'life history information in support of the EAM' and 'the impacts of fishing on marine ecosystems' and provided a forum for scientists to share experiences on a wide range of factors relating to natural mortality in fish, including methods for identifying and quantifying sources of natural mortality, and data analysis and modelling at individual, population, community and ecosystem levels. The presentations in the session may be divided into four different categories:

- 1) assessing natural mortality (empirical),
- 2) mechanisms governing natural mortality,
- 3) consequences of natural mortality (models), and
- 4) implications for management

### **Assessing natural mortality**

A number of the papers presented addressed predation on eggs, larvae or juveniles as the principal source of natural mortality, in some cases modulated by community interactions or environmental factors, such as temperature and location. The value of large-scale stomach surveys (e.g. the ICES years of the stomach) was clearly demonstrated, and such data can be greatly enhanced by the application of molecular techniques to identify stomach contents. Simple overlap in species distributions could also be used to infer predator-prey relationships, but clearly involve considerable uncertainties. Few presentations gave much consideration to variation in natural mortality of fish at later stages in their life-cycles, despite the fact that in some species, such as Atlantic salmon, it is an increase in natural mortality of the older fish once they enter the ocean that appears to be responsible for the recent decline in stocks.

### **Mechanism of natural mortality**

The mechanisms that determine natural mortality are not always very well understood. Hence, in many studies mortality is divided into two components, background mortality and predation mortality, which enable scientists to study them separately. Background mortality can be highly variable due to changing environmental factors, like food availability, and could even control community structure. However, background mortality cannot always be explained by environmental factors because these 'removals' might be also be accounted for by migration of individuals out of the study area. Including migration mechanisms in population or community modeling should result in better proxies for both natural and fishing mortality rates and almost inevitably results in consideration of spatial patterns. The inclusion of spatial dynamics in community and population modeling is receiving increasing interest as different studies have already shown that variation in spatial overlap between predators and prey plays an important role in natural mortality. Local differences in natural mortality rates can have major implications for the conclusions drawn about correlations with, for example, temperature or effects of fisheries.

Understanding predation mortality has gained a lot from recent studies on size-spectrum analyses, where predator-prey relationships are determined by predator-prey body size ratios. The effects of increasing fishing mortality on either of these groups can be evaluated and give rise to new management strategy insights as well as a better understanding of life-history characteristics and an ability to reduce the impact of environmental effects. Cannibalism, as for example when adult cod feed on juveniles, is a special example of predation mortality, and several studies have now shown that this mechanism can have a strong self-regulatory effect on populations and reduce density dependent effects in the juvenile life stage.

### **Consequences of natural mortality (models)**

The third major theme of the session was exploring the consequences of variation in natural mortality driven by predator-prey interactions. The exploration was mainly based on modeling exercises, either in a simple setting where only the predators or their prey were present (Richardson *et al*), or in the development of large food-web models (Rossberg *et al*; Ortiz and Aydin; Houle; Andersen and Berg; and Kempf *et al*). The common conclusion was that the dynamic modulation of natural mortality by predator-prey relationships resulted in quite large variation in natural mortality, leading to significantly different results from traditional single-species models. An example is the comparison between the recovery of North Sea cod as predicted by either single-species or multi-species models (see figure). Here the single-species model predicted that cod could recover to very high biomasses, while the multi-species modeling exercises predicted a much smaller potential recovery.

New methodological developments included the explicit inclusion of spatial differences into a series of coupled food-webs (Ortiz and Aydin), and the construction of a new type of unstructured food web model which may simplify multi-species modeling efforts (Rossberg *et al*).

As the focus on the session was on natural mortality the impact of varying prey concentrations on the growth of predators was not explicitly considered in the presentations, except for one example (Hinzen *et al*). This modeling exercise suggested that variations in natural mortality on a predator would be partially offset by increased growth rates of the predator when the lower abundances of the predator resulted in higher prey abundance.

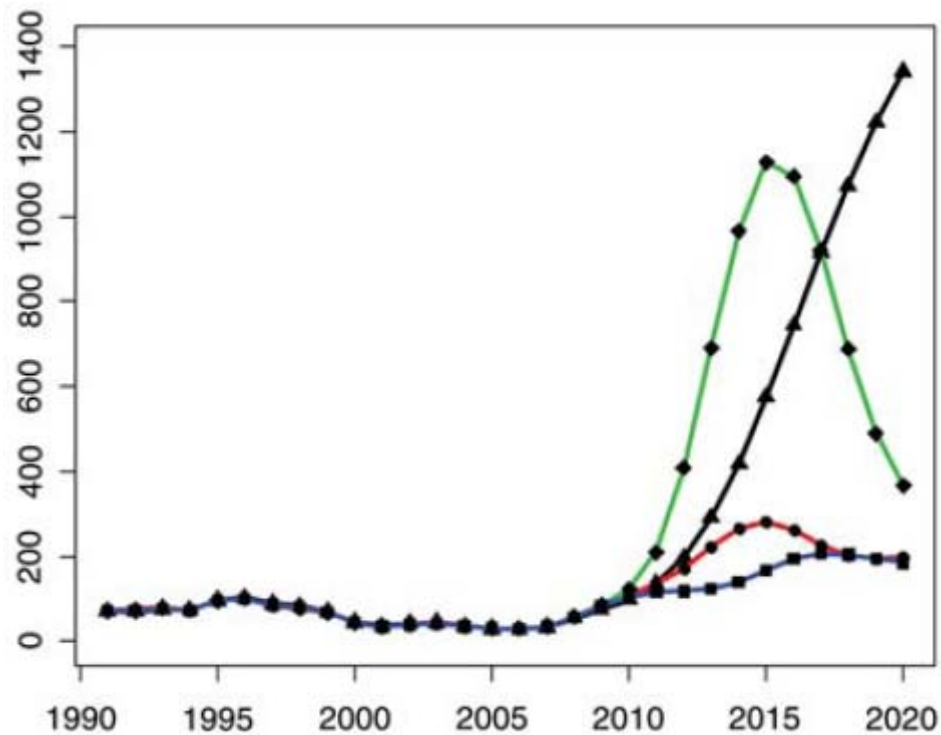


Illustration of the difference between a single-species prediction of the recovery of cod SSB in the North Sea (triangles) with various multi-species scenarios (diamonds, circles, and squares). (From presentation by Kempf *et al*).

### Implications of natural mortality for management (reference points)

The consequences of predator-prey relations for management reference points were explored in two presentations (Voss *et al* and Richardson *et al*). Voss *et al* showed how a maximum economical yield differed from the single-species maximum due to the species interactions in the Baltic Sea.

A very lucid presentation on the influence of predation by haddock on herring eggs combined all themes of the session, from identification on the magnitude of mortality, the mechanism, and the consequences for management through a structured predator-prey model (Richardson *et al*). The model illustrated how the upper limit for fishing mortality varied with the haddock stock, and demonstrated how that led to the herring stock going through alternate periods of decline and increase.

### Conclusions

The session illustrated current efforts to understand and integrate dynamic descriptions of natural mortality into fisheries management. The implications of a varying natural mortality, for example for stock recovery or tolerance to fishing mortality, have been demonstrated to be substantial. Little attention has been given on the effects of the reverse predator-prey mortality interaction, i.e. how changing natural mortality affects the growth of predators. For management purposes it is important to understand how predators affect prey densities but it is equally important to understand how prey densities affect predator abundance, this in relation to predator-prey switching and cannibalism mechanisms.