CEFAS

Fish eat fish: what are the consequences?

Predation is the driving force behind the entire North Sea ecosystem. Every year, the quantity of fish eaten by other fish, is far more than the quantity landed by fishermen.

The complex pattern of predation between species (Figure 1), and between different life-stages within species, is known as “multispecies interaction”. It is the main factor determining the growth rates, stock-recruitment relationships, and natural mortality rates seen in commercially important species.

Single-species management, as practised in Europe, deals very simply with the consequences of predation, by assuming that future patterns of recruitment, growth, and natural mortality will match those seen in the past. But if there are long-term changes in the abundance of prey and predators, then there are also likely to be changes in the recruitment, growth, and natural mortality of commercially important species. Multispecies interactions can thus have major consequences for fisheries, and raise many questions for managers. Some of the most important questions are:

- Does catching large quantities of small industrial fish, leave enough food for commercially important predators?
- What are the likely effects of technical measures? For example, if mesh size is increased to improve yields of one species, will there just be a counterproductive increase in its predators?

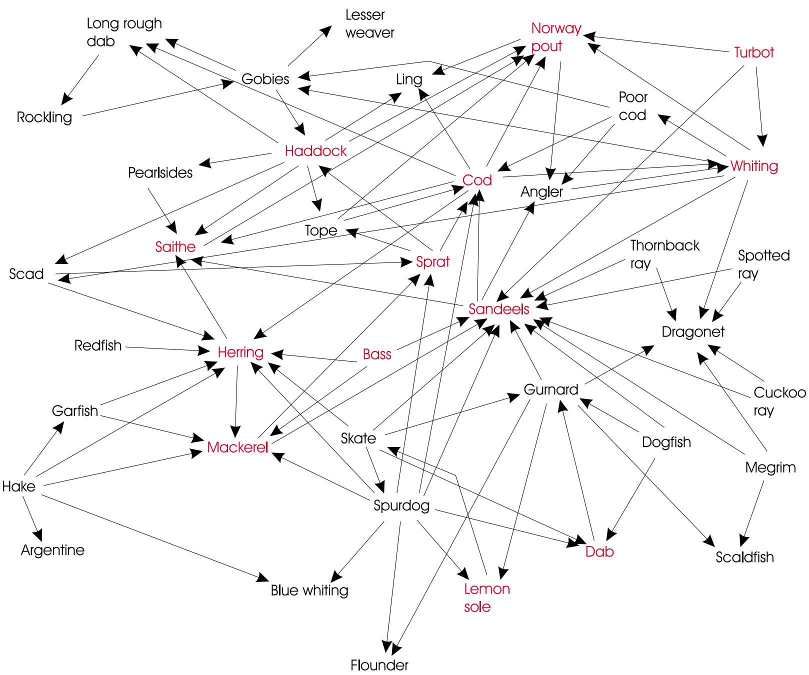

Figure 1. Schematic diagram of a simplified North Sea food web.

- Do we need to adjust single-species management policies (reference points etc.), to allow more explicitly for multispecies interactions?

Broadly speaking, there are two different scientific approaches that can help answer such questions. The first uses detailed species-by-species models, that make predictions about how much fish of each species and size will be eaten by fish of another species or size class. The second uses less detailed aggregate models that summarise the key predation processes in terms of, say, organism size, but may not involve individual species. CEFAS' multispecies research program is following both approaches, which have different strengths and weaknesses.

Figure 2 shows how a detailed species-by-species model can give different predictions from a single-species model.

In Figure 2a, a predator and a prey species do not interact and a decrease in the F on the predator only increases the biomass of the predator species while the prey biomass does not change.

Figure 2b is a model with the predator species eating the prey species. When F is decreased on the predator, the predator species biomass increases and the prey species biomass decreases as a result of the predation.

Figure 2c is a model where the predator eats the prey species and the prey eat juveniles of the predator species. The predator biomass increases and prey biomass decreases but the result is not as in 2b because the predator biomass keeps increasing and does not level out since its adults are eating the prey which in turn allows the predators juveniles to survive and join the adult population. With species-by-species models, different and sometimes unexpected results arise

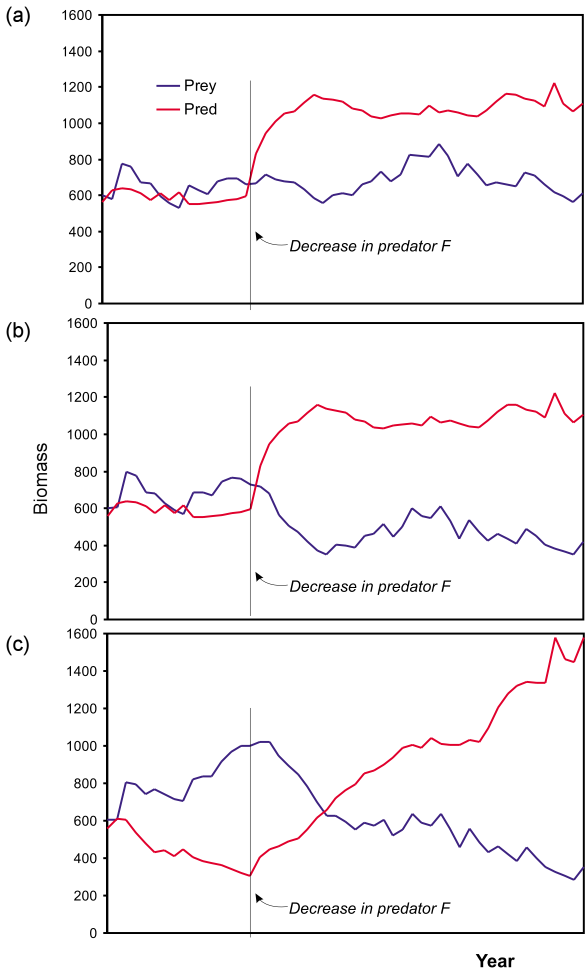

Figure 2. *Projections of models with changes in fishing effort: (a) two species with no interaction between them (b) the predator eats all prey (c) the predator eats all prey and the prey eats juveniles of the predator.*

which are not always captured in single-species models. These effects are especially important in longer term projections.

A great deal of biological data and understanding is needed to set up realistic species-by-species models.

First, we need samples of fish stomachs, to show what has been eating what and how much. Because there are so many species in the North Sea, and so many possible interactions, an enormous amount of data is needed; over 300,000 stomachs were analysed by international programmes in the 1980s and 1990s. These stomach data have already been influential in stock assessment, for instance in showing that natural mortality on young fish must be higher than previously thought.

Second, we need to know how consumption changes when prey abundance changes. For example, if the amount of food available to a predator is doubled, how much more will the predator actually eat, and how much faster will it grow? This requires data on growth, spatial distribution, and fish behaviour.

Third, we need a better understanding of the potential for fish predation on very young fish, when natural mortality is extremely high. This can be studied by looking at hydrographic models, to figure out whether the right predators are likely to be in the right place at the right time.

Although it is tempting to try to develop ever more complex species-by-species models, in order to make the models as "realistic" as possible, there is inevitably a limit at which we run out of data.

Another approach is to develop aggregate models that involve fewer hard-to-test assumptions. Although a number of aggregate models have been developed worldwide, to date they are primarily theoretical. The challenge is to develop practical aggregate models that better reflect how changes in fishing affect the ecosystem, and how changes in the ecosystem affect the variables that matter to management, such as overall yields and species composition.

The North Sea is so large and complex that we may never arrive at a final "best" model to predict the future consequences of multispecies interactions. Fortunately good management does not always depend on having just one best model. If there are several plausible models but they all give similar answers (as they do for example for the impact of reductions in fishing effort), then there is a good scientific basis for making decisions. Problems only set in when the range of answers is very wide. By researching and testing different types of model, and by collecting data on the fundamental ecological processes underlying the models, CEFAS is narrowing down the range of plausible multispecies models, to provide a more robust basis for management.

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