

A multispecies approach to fish management in the North Sea

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As fish overexploitation becomes more and more of a concern, stakeholders are constantly looking for novel resource management strategies and more accurate forecasting techniques. The GADCAP project has made an important contribution by test-driving the multispecies approach to fisheries management in the Flemish Cap.

Pinpointed by the likes of the Food and Agriculture Organisation (FAO) of the United Nations, the limitations of a single-species approach to fisheries management have resulted in attempts to replace it with a wider ecosystem approach to fisheries assessment and management.

The main shortcoming of the single-species approach to fisheries management lies in the fact that it considers species in isolation from their ecosystem and uses the resulting data to establish management procedures.

The effects of interactions with other species on population dynamics are disregarded, which is where a multispecies approach can prove useful.

The EU-funded GADCAP (Implementation of a multispecies model GADGET to the ecosystem of Flemish Cap and incorporation to the fisheries stock assessment of NAFO; a case study) team, led by Prof. Dr Perez-Rodriguez Alfonso, spent the past two years applying such an approach to the Flemish Cap. The relative simplicity of this area—where 85 % of the total biomass is made up of cod, redfish and shrimp, its

relatively high level of isolation, the strong connections between species and the vast amount of quality data available from commercial and scientific surveys conducted made it an ideal test environment.

In this exclusive interview with the research*eu results magazine, Prof. Dr Rodriguez expands on the results of the project and how it will eventually contribute to disentangling the interconnected drivers determining the dynamic of cod, redfish and shrimp stocks in the Flemish Cap.

What are, according to you, the main shortcomings of the single-species approach to fisheries management?

Well, this approach can be valid for commercial species that are not preyed upon (or not so much in comparison to other causes of mortality) and feed on ecosystem components that are not currently commercially exploited (like zooplankton or phytoplankton). However, these are in fact rare cases and most commercial species are subjected to strong species interactions which include not just predation, but also competition for food resources. In these cases, disregarding species interaction may lead to an overestimation of population productivity and eventually to short- and long-term forecasts of stock biomass that are way above real values. This may in turn result in the overexploitation of resources, and if this failure is maintained in the long term it may favour declines and even a collapse in exploited populations.

How can the multispecies approach lead to better results?

The multispecies approach, as opposed to the single-species approach, takes into consideration the main interactions with other commercial species in the ecosystem. While the description and modelling of past

time (hindcast) is not necessarily better in the multispecies than in the single-species approach, the short and long-term forecast is expected to be more reliable in the multispecies approach. The reason is that when running projections, the trophic interactions and the complex interactions resulting from predation and competition can be explicitly considered to predict the dynamics of commercial population.

In some areas, the evaluations of predation-related mortality coming from multispecies models are considered in single-species models. Although this is already progress, it is not enough: single-species models cannot properly represent the complex feedbacks resulting from predatory interactions, and this is especially important in the evaluation of management strategies.

Why did you choose the GADGET tool for your project?

The intention of GADCAP was to develop a model that was simple enough to be of use for scientific advice in the Northwest Atlantic Fisheries Organisation (NAFO) area, but still with the highest level of information related to species interactions and other elements related to population productivity.

GADGET meets these requirements. It is a flexible tool that allows the user to create everything from the simplest to the most complex models, taking into account various characteristics of the ecosystem: one or more species, each of which may be split into multiple components; multiple areas with migration between areas; predation between and within species; growth; maturation; reproduction and recruitment; and multiple commercial and survey fleets taking samples from the populations. It is a process-based model and it allows for modelling different biological and ecological processes for each population, setting the parameters for sub-

models of predation, growth, maturation, length-weight relationship or change of sex. It has been recognised by the FAO as one of the ecosystem models with the best performance for practical scientific advice in fisheries management. It is currently utilised in different areas like Icelandic seas, the Barents Sea and the Gulf of Biscay.

What have you learned from your research on the dynamics of Flemish Cap cod, redfish and shrimp populations?

Overfishing, predation and cannibalism, as well as variable recruitment success, were found to be the main drivers behind strong swings in the biomass of all three stocks over the study period. In shrimp, both predation by redfish and fishing have worked together to cause the stock collapse, along with predation by cod. The proportion of large cod in the stock, especially since 2010, raised predation-related mortality in redfish and seems to be the main factor inducing their decline. The model has also made it clear that cannibalism has been the main source of mortality in both juvenile cod and redfish, and has significantly jeopardised the chances of increasing the stock. Additionally, it has revealed the relevance of external prey groups like hyperiids and euphausiids for immature, small mature cod and redfish, the genus *Anarhichas* sp for large mature cod, and copepods for redfish. These results suggest that the potential decline of some of these alternative prey groups may have important consequences for the dynamics of the commercial species by changing predatory (and cannibalism) interactions.

For the long-term forecast, the overall values of biomass and the estimated 'Maximum sustainable yield' (MSY) for each species obtained with different fishing pressure levels showed marked patterns resulting from the negative effect of fishing mortality on prey or predator stocks. In this regard, the expected patterns of decrease in biomass as a result of

increasing fishing pressure were observed in all three stocks. But other than these trivial fishing-stock reactions, which can also be estimated with single-species models, more interesting secondary feedback was only observable with multispecies models. Among these was the negative effect on total production and MSY for cod as a result of higher fishing mortality among redfish and shrimp. This negative impact was the result of the increased cannibalism in cod, as their main prey became more difficult to find. It was also of interest to observe the positive effect on redfish biomass and MSY of increasing cod fishing mortality as a result of the released predation mortality. The same is observed in shrimp biomass and MSY in relation to redfish and cod fishing pressure.

What would you say are GADCAP's main contributions to the development of the multispecies approach?

GADCAP's main contribution so far is the fact that it provides a clear example of the usefulness of considering trophic interactions when trying to explain and forecast population dynamics. However, soon we expect to be able to expand the scope of the multispecies approach by applying the GADCAP model in multispecies management strategy evaluation.

How do you think your project results will help to better manage fisheries in the Flemish Cap area?

GADCAP is the first multispecies model that has been developed for the NAFO area. The results clearly indicate that disregarding species interactions in the assessment of the Flemish Cap cod, redfish and shrimp would lead to serious underestimations of both the magnitude and the variability of natural mortality. This would entail an overestimation of the exploitable biomass in the short-term projections

supporting management decisions, due to excessive positivism.

Meanwhile, it has also been shown that, due to the prey-predator size relationship and the dynamic of prey-predator stock populations induced by variable recruitment, trophic interactions have a high degree of plasticity and are beyond being only species interactions; they are also size-modulated specific interactions. This should be seriously considered when evaluating the effect of a predator on a prey stock, otherwise the assessment of predation mortality could be misleading. Hence, GADCAP is representing the first step towards the implementation of a multispecies and ecosystem approach to fisheries management in the NAFO area.

What are your plans now that the project has been completed?

The development of GADCAP has been a breakthrough in my expertise in matters related to modelling of population dynamics, stock assessment and management aspects. This has added to my background as a biologist and marine ecologist. Now I am ready to take on projects and integrative tasks in terms of their environmental content and management, where knowledge about the marine ecosystem and its modelling are of great importance.

Therefore, I am particularly interested in continuing with projects applying knowledge of ecosystem management of fisheries resources. One possibility would be the continuation of the work initiated in the Flemish Cap with the development of a Management Strategy Evaluation framework where the multispecies models developed in GADCAP would be a central element of the operative model.

What about other fishing grounds? Do you have any

plans to pursue your work elsewhere in Europe?

Yes, the multi-species approach to [fisheries management](#) is relatively new and has only been applied to a small number of systems. As mentioned above, in those systems where the interactions between species are important, especially predatory interactions, the multispecies approach provides an insight into the dynamics of the community which the single-species approach lacks. This can lead to serious errors in management decisions. Therefore, in those systems with suitable databases, it will always be interesting to develop this approach and I will be glad to contribute, both directly and indirectly. These ecosystems might be located both within European waters as well as in international areas where the EU, as a contracting party, is highly interested and has an outstanding role in defining management approaches and decisions (as is the case for NAFO).

More information: Project page: cordis.europa.eu/project/rcn/110232

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