"IMPRESS"

The impact of sandeel stock density on seabird foraging success and breeding performance

The industrial sandeel fishery is the largest single species fishery in the North Sea. Sandeels are a major food source for a long list of top-predators, including predatory fish, seals, and many species of seabirds and cetaceans. Because of this, severe ecosystem effects of sand eel stock collapses have occurred. In ecologically important sea areas, the industrial fishery might or indeed does have an effect on these natural sandeel predators, but the fishing industry generally contests this view.

Earlier studies have focused on the geographical overlap between feeding areas of seabirds and prey stock, but the relationship between stock size and prey availability to predators is poorly understood. As a result, current knowledge does not suffice to give fishery managers high-quality advice with respect to allowable levels of exploitation.

The **IMPRESS** project aimed at **tackling a specific part of the conflict: the effect of overfishing on breeding success of seabirds and the risk of overfishing in an ecologically important area such as the Wee Bankie/Marr Bank complex off the Scottish east coast**.

The overall objective of IMPRESS was **to determine the relationship between sandeel population characteristics (i.e. patterns in abundance and age- and size-distributions), hydrography (influencing prey availability), and the foraging success and breeding performance of four species of seabirds**. A key part of the IMPRESS project was to develop and use sophisticated bird-borne loggers suitable for North Sea species in order to collect high quality data on foraging locations, diving depth, and prey capture rates, relative to the physical characteristics of the areas used by these birds for foraging. This information was then combined with data on seabird distribution and foraging behaviour collected at sea, with information on prey stock characteristics, hydrography, and data on breeding performance and population trends at colonies on land. Selected predator species under IMPRESS were **Northern Gannet (*Morus bassanus*), European Shag (*Phalacrocorax aristotelis*), Black-legged Kittiwake (*Rissa tridactyla*), and Common Guillemot (*Uria aalge*)**; all with different foraging strategies, feeding capacities and prey preferences.

The Wee Bankie/Marr Bank sandbank complex of the Fifth of Forth in south east Scotland was used as study site. Industrial fisheries for sandeels commenced here in the early 1990s. Coincident with the increase in the removal of sandeels from areas close to the Scottish east coast, seabird breeding success at colonies along that coast started to decline. Concerned that the fishery was affecting an ecologically sensitive area, fisheries managers prohibited fishing for sandeels close to the coast, from the Farne Islands to Rattray Head, and eastwards to longitude 1°E in 2000 for a period of three years. In 2003, the decision was taken to maintain the fishery closure.

Foraging seabirds are constrained by a delicate balance between the time they can allocate towards food acquisition, the energy demands associated with their activities and the food they are able to acquire. Confronted with a decline in availability of a particular prey species (e.g. sandeel), seabirds have a number of potential options. For some it might be possible to switch to

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Interactions between the marine environment, predators, and prey: Implications for sustainable sandeel fisheries.

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"COMBINING INFORMATION ON AT-SEA DISTRIBUTION AND ACTIVITY WITH OCEANOGRAPHIC DATA HAS HIGHLIGHTED THE COMPLEX INTERPLAY BETWEEN SEABIRD FORAGING SUCCESS, FEEDING LOCATION AND INTER-SPECIFIC COMPETITION AND FACILITATION"

other prey, or they may be able to increase their foraging effort in a number of ways. Dietary information acquired during IMPRESS, suggested that Kittiwakes and Shags were least able to switch to alternative prey. For Kittiwakes, this might be exacerbated by its surface feeding habit that limits its foraging abilities to prey items close to the sea surface. Shags and Guillemots were estimated to have sufficient time and energy to allow them to increase their foraging effort considerably, while Kittiwakes and Gannets appeared more constrained by time and energy respectively.

Sandeel biomass was significantly higher in 2000-2003 than it was in the three years prior to the project and the reproductive success of Shags and Kittiwakes was relatively high in these years, albeit variable in Kittiwakes. For the Guillemot, however, the reproductive success declined and relatively few sandeels were brought into the colony in recent years.

No clear absolute relationship between the density of any seabird species and the density of either sandeels, Herring or Sprats could be determined. However, foraging success depended to a large degree on fish density, while fish behaviour (shoaling or not) had important consequences for predator performance.

Estimates of breeding populations, daily energy requirements, and energy contents of prey fish, revealed a total consumption for June-July of about 16 thousand tonnes for the four seabird species within the study area. Estimates based on numbers seen foraging at sea in the principal study area yielded a total of >8 thousand tonnes. **Both estimates are low compared to the total prey stock estimate averaged over the years - circa 197 thousand tonnes -, but form a significant part of the minimum prey fish stock found between 1997 and 2003 of 27 thousand tonnes, which is only about 2 to 3 times larger than the estimated consumption of these four top-predator species alone.**

Combining information on at-sea distribution and activity (both from visual observations and from data collected with instrumented individuals) with oceanographic data has highlighted the complex interplay between seabird foraging success, feeding location and inter-specific competition and facilitation. Thanks to multi-disciplinary projects such as IMPRESS, do we begin to understand the functional links between marine predators, their prey and the marine climate and may we thus come closer to ecosystem-based fisheries management.