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Good environmental status for cephalopods in UK waters?

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<u>Summary</u>: Under Descriptor 1 of the EU's Marine Strategy Framework Directive, indicators are required for abundance, range, distribution patterns and demography of marine taxa, along with community level indices. The status of most cephalopods in UK and adjacent waters is not well known, although survey and fishery data, and project databases are available for some species. As key ecosystem components, it is important to consider whether suitable indicators could be developed for cephalopods. We describe results from a recent UK-Defra funded project to develop and evaluate indicators for cephalopods in UK waters. Spatiotemporal patterns of abundance were modelled and potential indicators developed. Since cephalopods are sensitive to environmental variation, it is important to quantify environmental effects on distribution and abundance, which could provide a moving baseline, improving the likelihood of detecting effects of anthropogenic stressors such as fishing. Analyses focused on the best studied species, namely *Sepia officinalis*, *Loligo forbesii* and *Eledone cirrhosa*. We also obtained new age data to test the consistency of growth curves across seasons and years in *Loligo forbesii,* and reviewed other sources of relevant information on cephalopods. The feasibility of monitoring cephalopods under the MSFD is discussed.

<u>Keywords</u>: squid, octopus, cuttlefish, baselines, environmental relationships, MSFD

Introduction: Although most EU Member States have not specifically included cephalopods as indicators under the MSFD, there are several reasons why their status should be monitored. Several species are important fishery resources but are not routinely assessed and fishing is largely unregulated (Pierce et al., 2010). Cephalopods have important trophic roles as both predators and prey, can be the main food of some protected cetaceans (e.g. MacLeod et al. 2012) and some may be keystone species (Gasalla et al. 2010). In addition, cephalopods could be good indicators of the status of marine ecosystems due to their well-documented sensitivity to variation in ocean climate (Pierce et al. 2011) and their relatively high public profile. In the context of the MSFD, cephalopods could provide indicators for several descriptors, in particular descriptors 1 (biodiversity), 3 (exploited species) and 4 (food webs). In the UK, data on cephalopods are routinely collected as part of ongoing fishery monitoring: landings are well-documented (in Scotland at least, for over 100 years) and trawl surveys routinely record cephalopod catches. However, it will be necessary to distinguish natural changes in the populations from those due to anthropogenic pressures (notably fishing).

Materials and methods: The work had three main components: (1) a review of biology, ecology and threats, (2) a new analysis of patterns and trends in life history, distribution and abundance, and (3) a synthesis including proposals for indicators and monitoring. Time series of fishery landings and research survey catches for loliginid squid, cuttlefish and octopus were analysed using generalised additive models to quantify spatiotemporal variation and to determine the extent to which this is environmentally driven. Datasets were acquired from Marine Scotland, Cefas, University of Caen, IFREMER and University of Aberdeen. Statoliths collected from *Loligo forbesii* in the 1990s were processed to determine age and compare growth rates under different environmental conditions.

Results and discussion: While a range of potential threats can be identified, overexploitation and damage to spawning areas by fishing are probably of the most immediate concern. In all the cephalopod series examined, substantial spatiotemporal variation was evident, including consistent seasonal patterns. There were strong environmental signals in both spatial and interannual variability. It is plausible that annual indices of abundance can be derived, which control for the seasonal cycle, spatial variability and the environmental signal in interannual variation, certainly for loliginid squid and cuttlefish. As with other mobile marine species, distribution is more difficult to quantity and is less likely to yield a viable indicator. Fishery exploitation indicators have been developed previously for English Channel cephalopod stocks (e.g. Royer et al. 2006). There is high variability in length-age relationships and although environmental signals can be seen and potentially controlled for, new results also confirm that reliable age-length keys are probably not attainable.

Data exist on cephalopod trophic interactions, contaminant burdens, life history, distribution, abundance, and fishery exploitation. However, only the latter three categories of information derive from ongoing monitoring programmes and thus represent the most feasible basis for establishing targets and indicators. However, in order to develop indicators, targets and monitoring programmes for cephalopods in UK waters under the MSFD, there are at least three potential steps need to be taken: (1) a mechanism to collate, quality check and analyse the monitoring data and evaluate the status of the monitored populations; (2) improved speciation of cephalopods in commercial landings; and (3) further studies to better disentangle the potentially confounding influences of environmental and anthropogenic signals in the data.

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