Distribution and abundance of cephalopods in UK waters: long-term trends and environmental relationships

Graham J. Pierce[a,b], L.C. Hastie[a], Vasilis Valavanis[c], Colin D. MacLeod[d], Jonathon Plotner[a], Beatriz A. Roel[e], Jim Ellis[e], Finlay Burns[f], M. Begoña Santos[g], Camilo Saavedra[g] and Simon Greenstreet[f]

a. Oceanlab, University of Aberdeen, Main Street, Newburgh, Aberdeenshire, AB41 6AA, UK. E-mail: g.j.pierce@abdn.ac.uk
b. CESAM and Departamento de Biologia, Universidade de Aveiro, 3810-193 Aveiro, Portugal
c. Hellenic Center for Marine Research, P.O. BOX 2214, 71003 Iraklion, Crete, Greece
d. GIS in Ecology, Glasgow, UK
e. Cefas, Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK
f. Marine Scotland Science, Marine Laboratory, PO Box 101 | Victoria Road | Aberdeen AB11 9DB, UK
g. Instituto Español de Oceanografia, Centro Oceanografico de Vigo, Subida a Radio Faro 50, 36390 Vigo, Spain

As part of a project which aimed to evaluate the feasibility of developing indicators of marine ecosystem status based on cephalopods, we analysed spatiotemporal variation in abundance,, and environmental relationships, using trawl survey catch data for cephalopods in UK waters (1980-2013) from Cefas and Marine Scotland Science databases. These data presented some challenges, notably the use of several different trawl gears, variable tow durations, and varying levels of taxonomic resolution. Accounting for gear type and tow duration, data were analysed separately for each cephalopod family and season to account for different phases of the life cycles being present at different times of year. The families investigated were Loliginidae, Octopodidae, Ommastrephidade, Sepiidae and Sepiolidae.

A GAM framework was used to summarise spatiotemporal variation in abundance at family level and the relationships of spatial and long-term temporal variation with environmental variables, including depth, substrate (available for inshore waters) and several oceanographic variables (e.g., SST, chl signals), also considering fishing pressure. Long-term trends for each family varied between areas and seasons, although this may reflect the presence of several species within families. In Scotland, where *Loligo vulgaris* is rare and *L. forbesii* is normally distinguished from *Alloteuthis spp*., survey data suggested a peak in abundance of this species around 1990 and a generally increasing trend since the mid-1990s. Spatial patterns in distribution in all families were related to both physiographic and oceanographic features. As expected substrate type had most effect on those families in which eggs are attached to objects on the seabed.