long-term changes in zooplankton biomass in the north west European shelf

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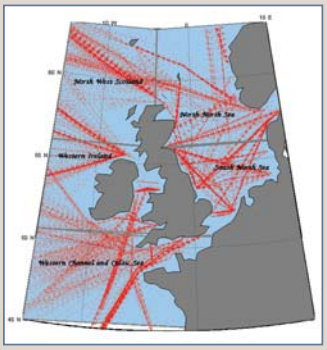
introduction

Climate change is impacting the marine ecosystem of the North-east Atlantic in observable ways. Data from the Continuous Plankton Recorder (CPR) survey over the last 40 years have shown that the total abundance of copepods in many parts of the North Atlantic has declined. The data also indicate distinct geographical shifts in community structure but because the CPR does not sample all zooplankton species with equal efficiency these observations may give a biased view of the overall changes that have occurred. We attempt to compensate for undersampling by using correction factors derived from previously published species-specific abundance ratios determined from comparisons of catches in WP2 and CPR samples [1,2] to evaluate the long-term changes in biomass size spectra over the last four decades in the surface waters of the European shelf. The North West European shelf was divided into five sub-areas and abundance data from the CPR survey between 1958 and 2003 corrected and transformed into biomass estimates for the 29 most abundant species of copepods and cladocerans found in this area. From this, we examine how biomass-size spectra may have changed in each region and the principal species shifts underlying such changes. Substantial shifts have occurred for all the regions studied and this will have potential impacts on trophic functions.

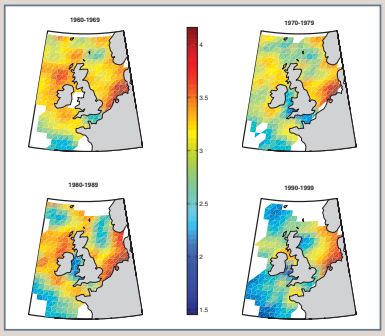
results



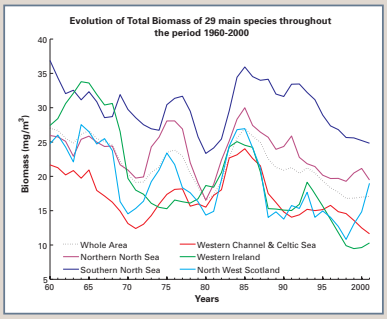
The CPR [3,4] provides excellent spatial and temporal coverage for much of the European Shelf. Our study included over 100000 samples during the period 1958-2003.

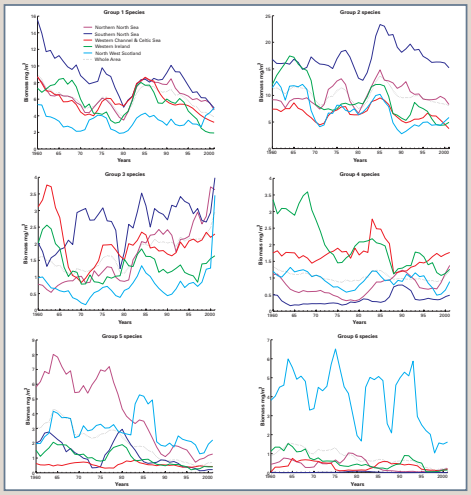
Species in increasing order of size	Dry Weight (mg)	Correction factor	Group
Oithona spp	0.0022	45.415	**Group 1**
Para-Pseudocalanus spp	0.0042	13.930	
Evadne spp	0.0055	18.16	
Corycaeus spp	0.062	26.8	
Acartia spp	0.0082	8.710	**Group 2**
Clausocalanus spp	0.0106	10.3	
Pseudocalanus elongatus	0.0109	11.550	
Metridia I-IV	0.0124	20	
Temora longicornis	0.0126	18.347	
Calanus I-IV	0.013	2.448	
Isias clavipe	0.0134	10.3*	
Centropages hamatus	0.0147	1.695	
Candacia I-IV	0.0237	10.3*	**Group 3**
Penilia spp	0.0263	10.3*	
Centropages typicus	0.036	1.695	
Podon spp	0.0375	5.050	
Calanoides carinatus	0.0533	10.3*	**Group 4**
Metridia lucens	0.0623	20	
Euchaeta hebes	0.0798	10.3*	
Candacia armata	0.1062	10.3*	
Calanus helgolandicus	0.1096	2.448	
Pleuromamma robusta	0.1877	10.3*	**Group 5**
Euchaeta acuta	0.2372	10.3*	
Euchirella rostrata	0.3045	10.3*	
Eucalanus crassus	0.3055	10.3*	
Calanus finmarchicus	0.3192	2.448	
Undeuchaeta plumosa	0.3281	10.3*	
Euchaeta norvegica	2.8411	10.3*	**Group 6**
Calanus hyperboreus	2.85	2.448	

** median value calculated from available WP2/CPR ratios due to lack of information for this particular species.*

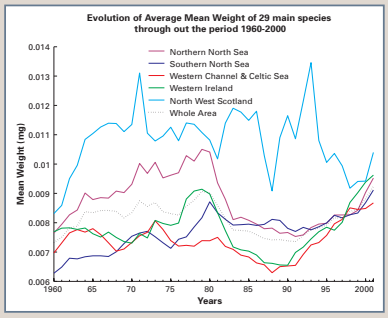


The use of under-sampling correction factors has a substantial impact: the area of highest biomass shifted from the Northern North Sea to the Southern North Sea and to a lesser extent to Western Ireland. This is due to the fact that species that are the less well sampled by the CPR (i.e. those with the highest WP2/CPR abundance ratios) often happen to be the smaller ones and these tend to be more abundant in the southern part of the North Sea.





Around 1980 a sudden decline of total biomass occurred followed by a recovery of biomass in smaller groups in the mid-late 1980s to early 1990s. These 2 events are visible for a majority of individual species as well and seem to affect smaller species more than larger ones as a result of the underlying structural shift in zooplankton communities, which have been widely reported and of a sufficiently large scale to be referred as a regime shift [5,6].



The general pattern in evolution of mean weight shows that a maximum was reached in the early 80s coinciding with the cold episodic event, followed by a sudden drop in the late 80s-early 90s coinciding with the warm episodic event, and a steady recovery from then on which indicates that the community of zooplankton is still undergoing structural changes. The pattern of change of average organism size differs according to areas and these are most likely a result of complex reorganization mechanisms within the zooplankton communities that are geographically dependent. Changes in mean size are a probable consequence of major changes in the community structure of zooplankton in the northeast Atlantic and attributed to increasing temperature and hydrogeographic changes [7]. The increase of mean size since the late 90s is driven mainly by some recovery in abundance of larger size classes and indicates that the community of zooplankton is still undergoing structural changes.

conclusion

Many fish larvae feed on zooplankton and thus, changes both in their food quantity and quality as well as seasonal timing (not mentioned here), will affect their survival and ultimately recruitment and could also induce structural changes within the fish community. If, as suggested by our results, the changes within the zooplankton community are still ongoing then it is essential to understand the causes of long-term zooplankton variations in biomass and community composition as well as zooplankton productivity processes in order to understand the dynamics of the fish stocks. There is growing evidence that climate affects fish ecology through cascading effects up the plankton food web and that such effects have been reinforcing the observed decline in fish stocks due to over-fishing [7]. Such results emphasize the need to take an ecosystem approach and include these effects in future fishery management.

In future work it will be important to derive seasonal biomass dynamics in order to detect how the changes in mean dry weight affect first feeding fish larvae. Also, copepod production will need to be estimated since nauplii and copepodites are greatly undersampled by the CPR.

Acknowledgements

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