DRAFT Theme Session B – Large-scale changes in the migration of small pelagic fish and the factors modulating such changes

Convenors: Jürgen Alheit (Germany), Dave Reid (UK), Yoshiro Watanabe (Japan).

Introduction

The aim of this session was to bring together studies across the world on observed changes in migration patterns of small pelagic fish. The theme session brought together studies on species often highlighted as showing migration changes such as the major Pacific sardine species, *Sardinops caeruleus, S. melanostictus and S. sagax*, but also extending to *Sardinella* species off the coast of Africa, anchovies and myctophids off the S. American coast, mackerel, sprat and herring in the north east Atlantic and Baltic and even Pacific hake in the California current system.

Overview

A series of papers were presented on the changes in migration behaviour of the Pacific sardine. These fish are found throughout the Pacific. Yoshiro Watanabe and Yoshioki Oozeki, presented two papers on changes in distribution of sardine linked to both population fluctuations (B::04) and to changes in the hydrography of the area (B:09). Population ranges expanded as would be expected in high abundance periods, and the fish also responded to oceanographic changes in particular in relation to spawning area use. From the other side of the Pacific Nancy Lo reported similar changes in distribution with abundance for the Californian sardine (B:03). The distribution range contracted markedly during the collapse of the 1960s and then expanded when the stock recovered. There were again good links to ocean climate, with migration linked to warm waters off California, but strangely this does not appear to be the case in waters further up the coast. Rubén Rodríguez-Sánchez presented a similar link to warm water frontal systems (B:02) for Pacific sardine around the southern tip of the Baja California peninsula. This paper illustrated how changes in the California Current could lead to periodically isolated sardine populations in the Gulf of California. In the Humboldt current system sardine is often seen as having linkages to populations of anchovy. Francois Gerlotto presented a paper (B:12) on the possibility of behavioural interactions between the two species leading to observed changes, however, the study concluded that major scale climatic changes were the most likely causes of changes in both species. Similar links with ocean climate were also shown for a quite different species, Pacific hake in the NE Pacific in a paper presented by Ken Cooke. Again, there were strong links to the variability in the global indices e.g. ENSO, but also that this could be modified by quite small scale local variability in hydrographic conditions, and also fish abundance.

Sardine and related species are also found in the Atlantic and show some similar responses to changes in their environment. In a paper presented by Janet Coetzee (B:11), evidence for large scale changes in distribution from the western facing to the southern facing coasts were described. The authors considered the role of environmental changes, fishing pressure and demographic changes in explaining these changes, highlighting that it is often not possible to ascribe change to one factor alone. A them that emerged in a number of other papers. Further north up the west African coast Alla Galactionova, demonstrated substantial changes in the migration and distribution of chub mackerel *(Scomber japonicus*) and round sardinella (*Sardinella aurita*) (B:05). These changes could be linked to major oceanographic changes, but also to the abundance of the two species. Remment ter Hofstede presented a poster on this species in the same area (B:15) and linked the migration changes not only to environmental conditions but also to spawning activity and to changes in fish condition.

In European waters the presentations examined a different range of species, including herring, sprat and mackerel. In a paper presented by Dave Reid (B:14) the long term changes in migration timing of mackerel were described. In this case it was difficult to link the substantial changes in migration during the 1970s and 1980s to changes in hydrography, particularly as the period of change was followed by a relatively stable timing, but in the context of substantial oceanographic changes. However, possible links to the NAO were described. In the case of the Norwegian spring spawning herring Geir Huse demonstrated substantial changes in the migrations in the last 50 years, and particularly in overwintering areas (B:10). However, there was little or no evidence that this was linked to oceanography, as the different areas showed radically different temperature and salinity characteristics. The authors concluded that the changes were the result of large incoming year classes, failing to link up with adult migrations and establishing new overwintering areas. In the Baltic, Valeriy Feldman (B:06) showed that the basin scale distribution and migration of sprat had strong links to climate, sea temperature and ocean water inflows. However at the meso-scale, age structure and the vertical hydrographic structure were also important. This meso-scale and vertical structure context was also illustrated in a paper on Myctophid fish in Peruvian waters presented by Francois Gerlotto (B:13), but authored by Rodolfo Cornejo et al. This showed the link between vertical distributions and also movements on and off shore in response to oxygen depleted layers in particular.

Two overview papers were also presented. Jürgen Alheit presented a comparison between the migrations of many of the species dealt with in this session, in particular sardines, herring and anchovy (B:08). The presentation included the famous example of the Bohuslän herring in the Skagerak, with migration changes charted from the 1100s and linked to warm water periods. The presentation also contrasted the changes in the Pacific sardine presented in other papers, and compared patterns in many of these, including the often described synchrony between Japanese and Californian sardine, which has been much less evident in recent years. The second paper, presented by Pierre Petitgas (B:07), presented a development of the hypothesis that migrations were largely controlled by older fish in the population which “led” the younger fish. Some aspects of these ideas had previously been articulated by Corten and McQuinn among others. The example presented in B:10 on the NSS herring illustrated an aspect of the same idea, where the influx of large numbers of young herring broke this linkage.

Conclusion

The session was wrapped up by a wide ranging discussion led by the conveners. The general conclusion was that there were many documented examples of small pelagics showing substantial changes in both distribution and migration. In many cases these had been linked to global scale climate features such as the NAO, PDO or ENSO events. However, climate/oceanography links could be demonstrated at increasingly local levels; from variation in currents e.g. Humboldt, Kuroshio, California and Benguela systems; through location of fronts, e.g. in Baja California, to local vertical structure e.g. off Peru or in the Baltic. Other factors that affected migrations included stock abundance e.g. in Japanese, Californian or S. African sardine, condition factors and spawning e.g. sardinella off W. Africa, and demographic structure e.g. S. African sardine and NSS herring. The possibility of human impacts e.g. fishing was a further factor. The conclusion has to be that while major scale oceanographic features (NAO etc. ocean currents etc.) can be important in setting the context, in many cases very local features and the behaviour and physiology of the fish themselves are also critical factors. Many of the species considered are wide ranging and can tolerate quite substantial ranges of temperature, so it may be reasonable to conclude that responses to changes in this parameter may not be the only or even the most important factor to consider.

The session concluded with an invitation to the workshop to be held in Nantes, France on "Testing the Entrainment Hypothesis" [WKTEST], co-chaired by Pierre Petitgas, France, and Iain McQuinn, Canada (4th – 7th June 2007). The workshop is planned to document diagnostic case studies in pelagic, demersal and benthic fish that evidence / falsify the entrainment hypothesis, and based on this to define the understanding of the mechanisms by which life cycles patterns are maintained or change, and report on the consequences of the understanding for spatial fisheries management and recovery plans. Many of the authors who presented in this session agreed to take part in the workshop and to help further develop the research into these migrations.

The conveners thanked the many, and active participants in the session, for their contributions to the presentations and to the discussion. The session was well attended, despite being on Saturday morning and the discussions lively, wide ranging and providing important incentive for taking this work forward at WKTEST.