DRAFT Theme Session Q – Use of data storage tags to reveal aspects of fish behaviour important for fisheries management

Conveners: David Somerton (USA) and Julian Metcalfe (UK)

Introduction

Electronic data storage tags (DSTs) are powerful tools for discovering new information about the geographical movements, behaviour and environmental experience of wild fish ranging freely in their environment. Since their first large-scale deployment on marine fish in the early 1990s the use of DSTs has expanded greatly as the tags have become smaller and less expensive. Data from these tags have revealed detailed aspects of diurnal, tidal, and seasonal movement patterns that influence our ability to assess and manage commercial species.

The purpose of this Theme session was to draw together scientists from across the ICES region to see how tag and tagging technology, data analysis and new biological understanding has developed in recent years, and to consider how this might be applied to fisheries science. The session comprised fifteen oral communications and four posters from scientists from across Europe and from the USA. The Session was divided into two parts, the first dealt with aspects of geolocation and migration, while the second dealt with aspects of fish behaviour.

Presentations

Highlights during the morning session included a paper (Q:02) on habitat occupation of cod in the eastern Baltic in which a novel geolocation method based on depth, temperature and salinity measurements was used to reconstruct the movement paths of cod released in 2003 and 2005. Subsequently, for each movement path, the suitability of the environment for spawning (based on water oxygen levels) was compared to the conditions cod would have experienced had they moved at random. The results show that most cod restrict their horizontal movements to the areas in which egg survival is likely to be maximised. This remarkable behaviour during the spawning season demonstrates a strong link between individuals and their environment, and suggests that cod are capable of selecting habitat in order to optimise their reproductive success.

Several papers dealt with the development of improved methods for determining geolocation of fish from DST data. The first of these (Q:05) demonstrated the applicability of the particle filter method for geolocation of fish tagged with data storage tags. Particular emphasis was put on the calculation of the uncertainty. The method is general, but in this example was demonstrated on Baltic cod.

Another paper (Q:17) presented an algorithm (PSAT Tracker) that performs the task correcting light-based geolocation estimates of electronic tag positional data by matching with satellite sea surface temperature (SST) imagery series. Given certain assumptions about swimming speed, the algorithm selects multiple, matching candidate points for each day of SST data and then costs the most efficient path without recourse to a serial solution. Validation assessments of PSAT Tracker, based on simulation exercises and analysis of double tagging experiments, were presented. Features of the Tracker software and its integration within the EASy-GIS package were illustrated in the context of tagging studies of striped marlin (*Tetrapturus audax*) in the North Pacific.

One of the papers on migration (Q:06) described a DST tagging study of cod off the eastern Skagerrak coast depicting a migratory route to the North Sea during the spawning season, and back again to the Skagerrak later in spring. These findings have bearings on population separation and divergence in marine fish species, as they suggest a strong behavioural component in the distribution pattern of cod in the eastern North Sea region, which is in

compliance with a sub-population structure already discernible from other sources of information.

One of the papers presented in the afternoon session on behaviour described the vertical distribution of adult cod in Icelandic waters and availability to fisheries as revealed by tagging experiments using both conventional tags and DSTs. The vertical distribution of the fishery was deduced from depth information from recapture data. This was compared with time spent at depth by the fish shown by DST data. The results show considerable time spent by the fish at deeper levels than is indicated by the distribution of the fishery. This difference in availability varies between areas of release. Results indicate that there is a tendency for temporal stability in the behaviour of selection of depth and ambient temperature in feeding migrations and the more time cod spends in deeper waters, the lower the probability of capture. Occurrences of deep types of feeding migrations vary between spawning components. Feeding migrations of adult cod from the continental shelf to deeper waters (below 200 m.) should therefore influence fishing mortalities.

As an example of the way DST technology can provide detailed information on a scale relevant to fisheries management, paper Q:04 described results from a large EU funded project on cod (EU-CODYSSEY) which aims to improve understanding of the behaviour and distribution of cod in the NE Atlantic in support of stock assessments and Recovery Plans. The project, which concludes early in 2007, involves nine European research institutions in eight different countries. Over the last four years, members of the research team have tagged over 2500 cod with DSTs in four different regions (North Sea, Barents Sea, Baltic Sea and Icelandic plateau). To date, over 450 tags have been returned, yielding tens of thousands of days of data. The results challenge previously held assumptions regarding migratory behaviour, feeding behaviour and the tolerance of cod for extreme environmental conditions. The project has been able to derive rates of migration, stock mixing and availability to fisheries. The results will be of value to fish biologists and fisheries managers at national and international level.

The session concluded with a paper (Q:16) describing the development and application newly developed ‘RAFOS fish tag’ (FRAFOS) that reverses the tracking process of conventional acoustic tags by receiving acoustic signals from moored sound sources, allowing triangulation of geographic position during deployment on fish. The authors reported on progress in developing this archival tag for geolocating juvenile and adult demersal shelf fishes. The tag and navigation system are similar in concept to those of isopycnal RAFOS floats, in which arrival times of low frequency tones broadcast from anchored sources are archived and later retrieved for retrospective positioning. The principal differences between the RAFOS fish tag and RAFOS floats is that the tag is small enough to be attached to or implanted in fish about 50 cm or larger, and the tags must be recovered from the tagged fish to download data. Prototype RAFOS fish tags are being deployed on adult yellowtail flounder, *Limanda ferruginea*, on Georges Bank to study movement in the vicinity of an offshore area that is closed to fishing. Deployment of sound sources will be on or along the edge of the continental shelf where detection ranges appear to be on the order of 100 to 120 km for sources generating a sound pressure of 180 dB re 1 μP. The tags are expected to have a data storage life of several months to two years.

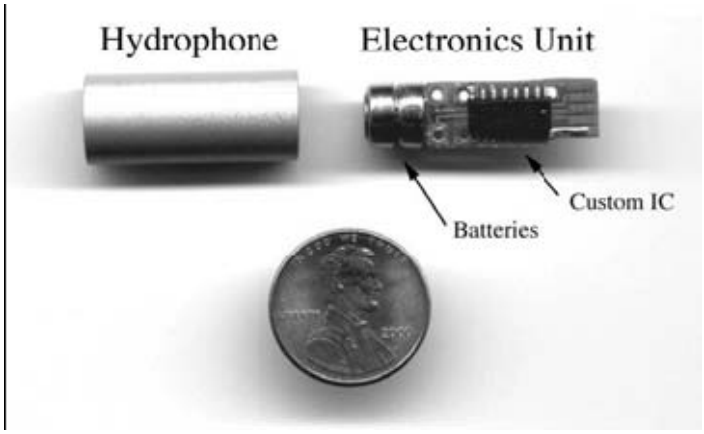

Fig. 2 The RAFOS fish tag.

Conclusion

As world fisheries continue to be heavily exploited, with drastic reductions in catches, or even closures of entire fisheries (e.g. Newfoundland cod in the 1990s) being necessary to conserve stocks, there is an increasing need for rational management that takes more account of fundamental biology. This applies not only to traditionally and newly developing fisheries, but also for functionally important species and for those of conservation interest. For most of these species we know little of their migratory behaviour, or of the environmental factors that affect it.

Fortunately, management agencies are becoming increasingly aware of the need to understand fish behaviour and migration, not just because they are interesting, but also because they are fundamental to many basic elements that underpin fisheries management. The challenge now is to ensure that the knew knowledge being obtained from DST studies is built into future assessment and management methodologies and that the outputs are taken through into management advance.