ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

Theme Session J

Integration of individual based information into fishery and environmental management applications

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Overview

The recent development of satellite, acoustic, archival and other forms of electronic tags has resulted in an increasing wealth of information about the spatio-temporal dynamics of the behaviour of marine fish, mammals and birds, much of which is potentially of great relevance to fisheries and environmental managers. However, as with other recent technological advances such as remote sensing and GIS, integrating new information into management tools can be difficult and depends on a coordinated effort between researchers in a number of different disciplines. To encourage such cooperative efforts, and to identify how best to break down barriers between different disciplines, this theme session aimed to review successful applications of individual based data to management situations. Appropriate contributions were sought to include: 1) modifying survey procedures in the light of new information about movements and behaviour; 2) formulating dynamic spatially explicit management models, for example by estimating the appropriate size of marine protected areas or by regulating international fisheries for highly migratory species; 3) linking individual behaviours to growth and other life-history characteristics; or 4) application of animal-collected data to oceanographic studies. Contributions were not limited to studies considering information from electronic tags but also included those utilizing novel applications of traditional mark-recovery tagging.

The session comprised 10 oral presentations and 3 posters. Of the oral presentations, 3 dealt with analysis of mark-recapture data using various types of conventional tag, including coded wire tags. One paper dealt with radio-tracking of alewife in freshwater habitats and 4 dealt with data from electronic data storage tagging studies. One paper was concerned data derived from satellite tags and one with VMS data for monitoring the movements of fishing vessels. The three posters all dealt with either satellite tag data or archival tag data or both.

Selected summaries

Several papers were of particular note. The first of these concerned incorporating mark-recapture data from conventional tagging studies with yellowtail flounder in the north-eastern USA into spatially explicit stock assessment models. The paper focused on the value of including spatial movement to increase the biological realism of assessment models because it avoids the assumption the stock is a closed population, and that emigration from an area is not simply interpreted as death. The paper described a forward projecting, multi-stock statistical catch-at age model that provides movement estimates between stocks. The results highlighted the importance of robust experimental design, the need

for accurate stock boundaries and a representative time series of tag release and recapture data that correspond with other types of data use in the model.

Another mark-recapture study on Atka mackerel (a prey of the endangered Steller sea lion) in the Aleutian Islands (Alaska) showed how such studies can be used to identify the potential value of trawl exclusion zones (10-20 nm) that have been established around sea lion rookeries to conserve prey abundance. In this context, mackerel abundance was estimated with respect sea lion energy requirements, and mackerel movement patterns were related to local fishing patterns. The resulting analysis provided very clear conclusions about which trawl exclusion zones were likely to be effective in conserving sufficient prey and which were not.

Two papers were presented describing different analyses of data storage tag data for cod in UK waters. The first described the spatial dynamics of cod in the Irish and Celtic seas and sought (successfully) to reconcile results from mark-recapture studies and data storage tag studies, showing that Celtic sea cod are much less dispersive than either Irish sea or Western English Channel conspecifics. The second presented data to show how vertical movement data from cod could be analysed to derive indices of availability, accessibility and catchability, and how these vary spatially, seasonally, and with migratory status. This information was then integrated with cpue data to show how seasonal changes in catchability can be attributed to the integration between cod migratory behaviour and the activities of fishing fleets.

A further paper described developments with a biologically based population movement simulation model for plaice that integrates information from data storage tagging studies and mark-recapture studies to provide a description of the movements and population structure of adult fish, while otolith microchemistry studies are used to augment the data by determining the contribution of larvae from various spawning grounds to different nursery areas, and the inputs form nursery grounds to different adult population subunits. Preliminary results were presented to show the consequences in terms of fishing mortality of different area and seasonal closures.

While many of the papers provided compelling evidence to show how better biological understanding could be used to improve fishery management and assessment, few of these studies have matured to the point that they are used to do so on a routine or regular basis. However, a study of southern blue fin tuna using pop-up archival tags provided a useful exception. In this, satellite sea surface temperature data are integrated with knowledge of the thermal and depth preferences southern blue fin tuna (derived from the tag data) to predict their spatial distribution of tuna using a near-real time habitat prediction model. Model outputs are provided on a fortnightly basis and used to set management lines that regulate spatial access to the eastern Australian longline tuna fishery in order to reduce non-quota capture of these fish. This capacity to provide seasonal forecasts offers both managers and fishers to plan for restrictions and modify their fishing activities.

The last paper of the session described a probabilistic approach for using the fishing vessel monitoring system (VMS) data to estimate the spatial and temporal distribution of fishing effort and landings. In this an analogy was drawn between the use of electronic tags to map the movement and distribution of fish, with the use of the VMS system to monitor the movement and distribution of fishing

vessels. The presentation described to use of hidden Markov models and information on fishing gear type to infer retrospectively where and when vessels were fishing. A key feature of the method was the ability to assign uncertainties to these inferences. While this approach does not provide a predictive model of fishing effort, when combined with landings data and estimates of fish distribution, it does allow landings (but not catch because discards are not currently accounted for) to be apportioned at high spatial resolution.

Conclusions

The concluding discussion session focused on the extent to which the results of tagging programs and the understanding of individual behaviour successfully feed through into fishery management or conservation plans. Overall, there was compelling evidence that better biological understanding will improve fishery management and assessment. Although few studies have yet matured to the point that they are used to do so on a routine or regular basis, those that had provided clear indications of how this can be achieved. One key aspect that was identified was the role of stakeholders and the value of keeping them informed about what is technically possible and how individual-based methods can be used to support or refute their (or others) assumptions about fish movements and biology.

One theme that was considered is that many tagging studies have shown that fish move substantial distances relative to the size of the managed area, yet few management models include such movement. The participants speculated this might be true because some management models are considered to be fairly coarse representations of reality due to inadequate estimates of growth, mortality and other parameters and that the work needed to develop a spatially explicit model to incorporate fish movement would not be justified given the other shortcomings. However, as better information is collected on the spatial distribution of fishing effort, say from VMS data, there may be pressure from the fishing industry to move toward fine scale management and this, rather than the availability of movement might be the motivation to develop spatially explicit models. Two examples of early spatially explicit management models, one for Georges Bank and one for the North Sea, were provided in the talks. The question was raised about the long term stability of migration patterns, because changing pattern, perhaps driven by environmental forcing, would require frequent tagging programs to estimate the migration rates.

Besides providing the data needed to determine movement rates in spatially explicit management models, a variety of other management uses of tagging data were considered. There has been an increasing trend to create closed fishing areas as a conservation measure, and tagging provides a way of determining how the area size, in conjunction with the scale of migration, to determine the effectiveness of the close area (a small area provides little protection to a highly migratory species). This was provided in the Atka mackerel example. Also tagging data can be used to define the temporal change in the habitat preference of a species, which, if predictable, could be used to develop special and temporal fishing closures to reduce bycatch of threatened species (southern bluefin tuna example).