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

Theme Session B

Beyond Geolocation: Inferring and explaining the behaviour of tagged fish

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Over the past decade, electronic data storage tags have become a valuable tool for fish biology and fisheries oceanography, and sophisticated hardware and analysis methods are now available to scientists in the field. A major achievement has been the ability to geolocate fish, i.e. track the movements of individual fish over time scales of months. At the ICES ASC 2009, the technology of electronic tags lay beneath a large number of presented studies, and two sessions were devoted specifically to tagging: Session J, which addressed integration of individual-based information into management, and this session B, which focused on the use of tagging data to illuminate the behavior of fish.

The session was well attended, with an audience counting between 50 and 75 individuals, and lively discussions continued at the poster session which followed immediately afterwards.

Progress in tag technology

The state of the art in tag technology continues to advance, both quantitatively with respect to size, memory and battery life, but also in terms of new sensors and multiple sensors on the same tag. J. Metcalfe and coauthors (B:04) presented progress on the observation of feeding and spawning events, using a magnetic sensor to measure opening and closing of the jaw and cloaca. The ability to observe behavior, rather than inferring it from proxy data, is pivotal. Metcalfe also discussed the use of accelerometers to measure small-scale activity and ultimately establish the energy budget of the tagged fish. S. Guðbjörnsson presented the contribution by J. Sturlaugsson and coauthors (B:05), which describes the measurement of the geomagnetic field in three dimensions. This information is useful both for characterizing behavior and for geolocation. The tag itself was presented in a poster (B:19) by H. Stockhausen and S. Guðbjörnsson. J. Behrens and coauthors (poster B:22) reported on a newly developed system for measuring cardiac output and blood flows, which will be used for analyzing cardiovascular tradeoffs in cod.

Progress in methods for analyzing data

Although sophisticated algorithms exist for analyzing tag data, there is a need for improved statistical methods. New tag technology continuously raises new challenges for data processing, and large unresolved problems remain in the merging of data sources, inference at the population level, and inference of behaviour. F. Royer and coauthors (B:11) discussed the standardization of heterogeneous data sets, including post-processing, needed to facility a combined analysis. T. Patterson and coauthors (B:07) demonstrated the use of hidden Markov models to estimate the behavioral state of tagged elephant seals, for which position can be measured using Argos. The model included the effect of

environmental conditions and had as one objective the mapping of habitat usage. M. Pedersen and coauthors (B:03) examined the problem of estimation position and behavioral state simultaneously, also using hidden Markov models. D. Baganz and coauthors (poster B:20) discussed the use of artifical neural networks for processing telemetry data while C. Lam and coauthors (poster B:24) advocated the use of wavelets to characterize the multiscale properties of the time series recorded with electronic tags.

Biological and ecological insights obtained with tagging

Data from electronic tags allows users to infer the behavior of the tagged fish and relate it to the environment. B. Galuardi and coauthors (B:14) examined the effect of sea surface temperature and chlorophyll on the behavior of Atlantic bluefin tune, in terms of vertical motion and path straightness, arguing that the quality of tagging data now allows statistical testing of hypotheses concerning behavior. E. Prince and coauthors (B:06) observed vertical behavior of Atlantic sailfish and blue marlin and explained spatial utilization differences between the eastern and western regions with different oxygen profiles. The hypoxia in the Eastern tropical Atlantic results in a habitat compression with implications for vulnerability to surface gears and stock assessment.

S. Neuenfeldt and coauthors (B:08) also considered response to hypoxia, albeit at a smaller scale. They examined the vertical behavior of cod in regions with hypoxic conditions in the deep, asking if observed behavior can be explained in terms of energy optimization of the forage/digestion cycle. T. Grabowski and coauthors (B:01, poster B:25) used data storage tags to examine the reproductive behavior of Atlantic cod. Inferring the number of spawning events and the time spent at spawning sites, they concluded that males and females showed behavioral differences consistent with a lekking mating system. They also demonstrated differences in spawning habitat selection, which can maintain population structure. J. Karlsen and coauthors (B:09) examined the behavior of cod at ship wrecks using an array of acoustic listening buoys and showed that presence at the wreck could vary with time of day or tidal phase. Behavioral mode varied among fish and individuals could also shift behavior. Stomach analysis indicated that the fish foraged on smooth bottom in proximity of the wreck.

D. March and coauthors (poster B:21) also studied behavior at the diel time scale using an array of acoustic listening buoys. They presented results on painted comber, showing highly active behavior during the day and resting behavior during the night. The fish did not perform diel horizontal migrations. G. DeCelles and coauthors (poster B:16) used the same technology to investigate seasonal movements of winter flounder in the Plymouth Bay estuary in the Gulf of Maine. Although different patterns were observed, temperature seems to be a major determinant in that the fish avoid the estuary both during low winter temperatures and high summer temperatures.

Tagging studies yield information at a wide range of scales. At the fine scale, A. Scheffer and coauthors (poster B:23) presented movements of king penguins during foraging, obtained with GPS and temperature-depth measurements. The data demonstrated that fine-scale foraging movements of king penguins could be related to both horizontal and vertical temperature profiles. The study suggested consequences of climate change on its foraging patterns. J. Brown and coauthors (B:02) presented results from tagging Patagonian toothfish, which displayed

diurnal vertical migrations, seasonal migrations between deep and shallow waters, and greater site fidelity than anticipated. The results contradicted existing assumptions about spawning migrations. D. Righton and coauthors (poster B:26) presented the Eeliad project, which uses data storage tags and other techniques to illuminate the life history of European eels, in particular their oceanic behavior.

In summary, the session documented that there is a rapid advance in the state of art of tagging technology, including analysis methods, and that tagging studies are answering increasingly complex questions regarding fish behavior and habitat utilization, for the benefit of both fish biology and fisheries oceanography.