Theme Session P
New methodology for tracking fish, mammal, and seabird behaviour and migrations

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To be more consistent with the ecosystem approach to management, fishery stock assessment models are increasingly becoming spatially explicit in terms of growth, reproduction and fishing mortality. An important element of such modelling efforts is the correct specification of the biomass flow between spatial compartments due to fish migration. Migration rates have traditionally been estimated using mark and recapture studies, but the accuracy of such information was largely dependent upon the spatial distribution of commercial fishing effort. Recently, however, a variety of electronic tagging methods have allowed the determination of the migration routes of individual fish in a way that is less dependent on the tag recovery pattern. Among the recent innovations to obtain geographic positions are acoustic tags and PIT tags using large scale receiver arrays, pressure-based archival tags using tidal drift or tidal matching models and light-based archival tags. New methods for linking geo-positions into migration trajectories that better incorporate positioning errors include Kalman filters, particle filters and calibrated smoothing algorithms. Collectively these methods are providing individual-based migration information that will not only allow better parameterization of fishery management models but also provide the data needed to better understand the influence of environmental factors on the timing and extent of fish migration.

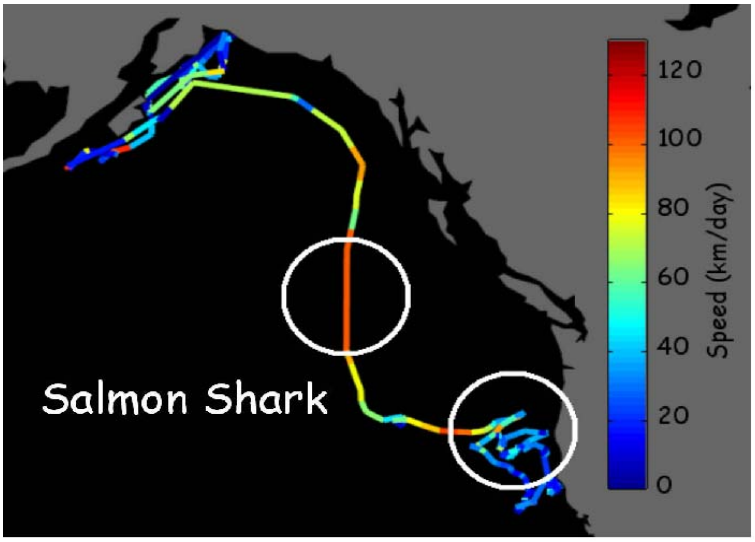
Of the 15 oral presentations, seven focused on the analytical complexities associated with estimating movement trajectories from the various types of data collected by electronic tags. Currently the most common analytical techniques are Kalman filters, Particle filters and Hidden Markov Models. P:09 considered improving the basic Particle filter by including an attractor function to insure that a fish track ultimately converged on the known tag recovery location. P:01 considered a new method utilizing a maximum likelihood approach to estimate the geo-locations and weighted cubic-spline smoothing of the geo-locations to estimate the movement trajectory. This approach was shown to be very similar to the more complex Kalman filter. P:05 considered improving the Hidden Markov Model approach by including bottom temperature information in addition to tidal information. For North Sea cod, this addition was shown to improve the precision of the geo-locations in some, but not all, situations. P:12 Also considered Hidden Markov Modeling, but applied the model to a finite element grid rather than the traditional rectangular grid, which greatly increased its spatial resolution allowing greater precision in discriminating alternate probable tracks in areas with complex geography. P:02 considered another form of geo-location smoothing included in a software package called GAMPATH. Throughout all of these talks a recurring theme was the need to isolate the positional noise from the real fish movement track and that each type of tagging technology provided data with unique error characteristics that must be considered relative to the magnitude of the travel distance to develop reasonable tracklines. The next group of talks considered emerging tagging technologies.

Another theme of the presentations focused on emerging tagging technologies. P:10 considered the Ocean Tracking Network which is a rapidly developing network of oceanographic moorings with acoustic receivers that will allow tracking of acoustically tagged species in coastal areas. P:11 considered a new marine mammal tag - the Life History Tag - that can detect the death of a seal, based on the loss of body temperature, then detach itself, float to the surface and transmit the event to a satellite.

The remaining talks focused on the migrations of specific animals with particular emphasis on the environmental correlates to the movement. P:04 considered Atlantic cod in the North Sea;

P:07 considered Gannets; P:03 considered grey seals; P:15 considered white sharks; P:14 considered salmon sharks in the north pacific; P:06 considered southern bluefin tuna near Australia and P:16 considered northern bluefin tuna near Nova Scotia.

In subsequent discussion it was recognized that for many marine taxa the basic issues of geo-location and tracking have been developed even though the actual number of observation may still be quite low. Studies are now needed to link animal movements to the environmental variables that initiate or cue the migration behaviour. In addition, studies are needed to determine the best way of linking animal movement information to the solution of management issues, which to be successful will require a strong interaction between tagging scientists and fisheries modelers.



Figure

Salmon shark trajectory showing, in white circles, a rapid, direct, transit phase and a slow, convoluted, feeding phase. ICES CM 2008/P:14 Migration of a high trophic level predator, the salmon shark, between distant ecoregions. Kevin C. Weng, David G. Foley, James E. Ganong, Christopher Perle, George L. Shillinger, and Barbara A. Block