

# Theme session F

## Linkages between spatial ecology and sustainable fisheries

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With human population growth and global climate change, marine ecosystem drivers and disturbances are predicted to change. Consequently, fish populations will not be in equilibrium and fisheries management will need to be proactive and adaptable to achieve socio-ecological sustainability. Ecosystem based management (EBM) provides a framework to manage ecological processes affecting marine fish productivity and vulnerability. However, there are key knowledge gaps in our understanding of fish spatial ecology, and how this can be incorporated into management, making it difficult to assess a stock's resilience to changing disturbance.

In fisheries ecology and management, the basic unit has often been considered to be the stock, often defined as the fraction of a population occupying a given region or area that is exploited, but with little explicit and meaningful consideration of the spatial processes affecting productivity and vulnerability. In the information age, a wealth of new data allows one to paint a much more nuanced picture where understanding the role of space use and movement become central. The purpose of our proposed session is to help integrate EBM and emerging understanding of movement and spatial ecology. This is done by bringing together fisheries scientists working in these fields to contribute presentations on emerging issues, methods and solutions to:

- spatially-explicit stock assessments and ecosystem-based modelling
- building tracking networks and data exchange
- integrating movement into resistance/resilience estimates and recognizing varying movement behavioral components within a stock
- spawning site selection and migrations
- larval dispersal and nursery habitat
- trophic dynamics and movement
- individual-based modelling of movement (DEBS, IBMS)
- full life cycle models
- effectively communicating the importance of movement ecology to managers and stakeholders

The session was very successful according to ICES standards: it received a total of 59 contributions, of which 20 were assigned to oral presentations, including 4 invited key-note speakers. A total of 27 posters were also included in the session.

Based on received contributions, the session was divided into three blocks:

### **1) The biological basis - ecology, connectivity and mechanisms**

A central motivation for this block was to identify drivers and mechanisms affecting spatial ecology at the individual and population scale, as these in turn affect our ability to assess abundance, biology, and fishing mortality needed for single species stock assessments. Several

contributions on Atlantic cod, including data analysis, modelling and tagging studies suggested that individual fish might not be tracing climate envelopes, as previously assumed. Rather, apparent geographical (northbound) shifts may be caused by changes in demography (and thereby life-histories) or decline/increase in spatially distinct sub-populations. The role of aggregate behaviour for both stock structure and management were also discussed in several contributions. Examples from the red drum and the Nassau grouper showed the importance and value of including spatially explicit knowledge in both management decisions and survey design.

## **2) Fisheries – fisherman behaviour, landings, vessels and emerging technologies**

As high-resolution data on fishing vessel movements, catch locations and landing size are becoming more easily accessible, new methodologies are exploring the potential value of this information for management purposes. This session showed recent developments through various combinations of mechanistic models and observational data, including novel insights into behavioural diversity. By coupling individual based models on fish behaviour to vessel movements, new insight on geographical distribution and local depletion emerged. Likewise, models of optimal fisher behaviour in relation to other fishers (based on AIS tracking) were also explored, and could potentially explain cases where CPUE remain high while stock is declining.

## **3) Integrating space into management regimes.**

Perhaps the most challenging part of this session was how to implement knowledge gained in the two previous blocks into management decisions. The last block of the session highlighted both current challenges and future solutions towards dealing with space. Examples from the Blue fin tuna management in the North Atlantic stressed the uncertainties of stock assessment when full spatial information (east and west) is lacking. Uncertainty in one area spills over to the other. However, for the Irish Sea, a new spatially explicit, fisher dependent system, emphasized the value of real time spatial information flow from fishers to management, which in turn can produce high resolution fishery regulations from week to week.

## **Discussion**

The implementation of space into management regimes was considered one of the session's prime challenges, and there was general consensus that spatial information is often underutilized in stock assessments. The example from the Nassau grouper was admirable, but unlikely to be applicable to most other stocks. Operationalizing stock spatial components was seen as a challenge and a need, but which may only be affordable for data-rich, highly valued resources. Tools to conserve resilience and age structure including spatial information was seen as an important avenue of research. Also, concern was raised regarding some climate change effects, including changes in phenology and the potential for stocks to be shifting in space and time faster than management could keep up. However, evidence for this was suggested to be limited, and in some places even incorrect, such as in the North Sea. Finally, it appeared that the lowest hanging fruit concerning the implementation of space in management was to include already existing spatial information from the fishing fleet regarding catch locations, size and species composition. To this respect, some rather mature examples for potential spatially dynamic management were well-perceived.

The conveners of this session encouraged authors within this theme session F to submit manuscripts to a special themed set of the ICES Journal of Marine Science.