



Theme session P

Recruitment dynamics in a changing environment: integrating spatial and temporal variability into stock assessment and management strategies

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Recruitment dynamics are a crucial component of population dynamics in fish and, therefore, management, yet our capabilities to functionally understand recruitment or predict it have remained poor despite decades of research efforts. This is mainly caused by the complexity of the recruitment process, which is subject to a range of environmental and ecological drivers with typically large variation in time and space. A thorough knowledge of recruitment dynamics is, however, essential to manage fish stocks successfully, communicate with stakeholders, and to predict responses to environmental change or anthropogenic impacts. Novel and robust approaches to understand recruitment dynamics, especially such that also include spatial dynamics, and integrating them into stock assessments and management strategies are therefore necessary.

The goal of this session was to showcase the current state of recruitment research by covering a broad range of topics from the underlying biology to stock assessment application. The focus was on studies that use empirical data to analyse or model spatial and temporal variability in recruitment, to link individual life-history, stock composition and environmental impacts at all life stages to help understand variation in recruitment, and to explore recruitment dynamics in stock assessment frameworks. There was a total of 19 oral presentations and 9 posters that were set within three major themes: 1) underlying biology of recruitment, 2) spatial modelling of recruitment-related processes, and 3) implementation of recruitment dynamics in stock assessment and management.

The contributions to the session showcased a variety of research questions, methodological approaches and ecosystems, yet most of them referred directly or indirectly to the long and challenging quest of trying to understand recruitment and the importance to do so. The first two talks integrated the different themes of the session. They linked novel insights on transgenerational plasticity in fish as well as the role of sub-populations and spatial dynamics for recruitment with stock assessment models and approaches for forecasting recruitment such as time-delay embedding model. The session continued with a range of talks that explored the underlying recruitment biology in various populations and ecosystems. The second major theme involved spatial dynamics relevant to recruitment, such as drift patterns and the distribution of eggs and larvae determining settlement and recruitment success or how heterogeneous spatial mortality affects recruitment. In the third and last segment, the focus shifted from a functional understanding of recruitment dynamics towards their relevance in stock assessment and management. The presenters discussed questions such as how spatial aspects and connectivity can be included in stock assessment models, integrating environmental effects on recruitment in stock assessment predictions or what the risks and benefits are of doing so. The session closed with talks that focused on the role of recruitment dynamics in management strategies of specific stocks or fish communities.

The main discussion points that were consistently brought up in the presentations and the panel discussion revolved around the main challenges in understanding recruitment dynamics,

how to handle their complexity, and ways to extract useful information for management. Some key insights and recommendations that were given:

- Progress has been made regarding the larval period and this knowledge is increasingly incorporated in models, but it often remains a black box that is difficult to communicate.
- Efforts in terms of recruitment variability should be focused on identifying the stocks that are most important and/or controversial from a stakeholder perspective, enabling scientists to communicate main mechanisms underlying population fluctuations to stakeholders.
- Approaches and relevance depend fundamentally on the temporal scope, i.e. whether recruitment should be predicted on an annual or long-term scale.
- Predicting inter-annual variability is mostly futile, research should therefore focus on long-term patterns.
- Species interactions and therefore ecosystem perspectives are important for long term perspective.
- Movement, behavioural responses and spatial questions in general are essential and will require a shift towards more adaptive, space-based management in the future.

Important questions that remained open included:

- Despite assessment models having advanced regarding their ability to model variability in recruitment and population dynamics, the examples and methods need to be shared more vastly. There are some examples, e.g. incorporation of environmental indices in stock assessment, but actual progress tends to be difficult to quantify.
- Management is moving away from traditional equilibrium thinking and stationary management targets, but how can variability caused by recruitment and other dynamics be even better incorporated in management strategies?
- A functional understanding of mechanisms and their predictability has proven difficult despite the increase in data availability and model advancements. Are attempts in this direction worth the scientific resources, or is it better to rely instead on robust management strategies that perform well without explicitly incorporating complex dynamics?

The session was successful in terms of participation and contributions but also highlighted many remaining challenges and a continued need for research efforts in this area. Topics to address are the fundamental questions that were brought up during the session. Notably, within the ICES context this includes the need to distinguish clearly between basic understanding of recruitment processes and knowledge that is beneficial for management, relating to the questions of how more information can be used in management and whether this results in actual gains of accuracy and certainty.