Theme session E

Beyond ocean connectivity: embracing advances on early life stages and adult connectivity to assessment and management challenge

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The overall aim of the theme session (TS) was to create a forum that produced insights on connectivity across life history stages with an emphasis on how this information can be effectively applied to improve fisheries and ecosystem management. To achieve this goal, the TS called for cross disciplinary studies that investigate the movement of marine organisms with a specific focus on research that is being used to inform current assessment and management challenges. The 25 oral presentations were organized into six topical sections to provide the TS with a coherent structure, these included: i) conceptual and integrative talks (E:03, E:07), ii) biophysical and individual based modelling (E:02, E:11, E:13, E:18, E:21, E:22, E:23, E:25, E:29), iii) genetic techniques (E:05, E:08, E:24, E:26), iv) otoliths and other biological markers' techniques (E:04, E:14, E:15), v) spatial and temporal dynamics (E:01, E:09, E:12, E:19), and vi) tagging studies (E:10, E:27, E:28). Three posters were presented focusing on connectivity during early life stages (E:06, E:20, E:30). This diversity of perspectives was critical in achieving our aim to develop helpful generic insights for applied fisheries science. Indeed, the TS received a balanced combination of presentations with cutting-edge science in specific fields and presentations that provided integrative perspective across techniques. This report summarizes the research presented during the session.

Cross-disciplinary research was one of the focal points of the TS and several presentations (12 of 28) explicitly approached connectivity research questions using multiple approaches. These presentations synthesized information from: genetics and biophysical modelling (E:05, E:19, E:29), genetics and population dynamic modelling (E:08), multi-biological markers (E-24, E:30), biophysical modelling integrating adult/juvenile information (E:13, E:21, E:23), otoliths and biophysical modelling (E:14, E:15), and tagging with population dynamics (E:10). In the past, there has been a tendency for individual techniques to address questions at specific spatial and temporal scales. For in-stance, biophysical modelling has been conducted at shorter spatial and temporal scales (daily to seasonal), otoliths have been used to answer questions at regional spatial scales and intermediate temporal scales (years), and genetics used to investigate research questions at large oceanic and evolutionary scales. However, new research presented in the TS suggests that this is no longer the case and that current investigations on connectivity are operating across scales. This shift has been possible through the integration of research outcomes and techniques.

A focal point of the TS was also to highlight frontier research in specific techniques and several presentations presented advances from different fields. Two presentations provided examples of a classic challenge in biophysical modelling: effective implementation of early life stages behaviour (E:02, E:11). These talks provided evidence of the relevance of including variability of behavioural and life history traits into biophysical models in addition to mean values. Several communications also

presented new tools to model the physical ocean environment that aimed at improved modelling of mesoscale structures (E:18) and the spatial complexity of currents systems (E:25). In addition, new methodological concepts and approaches to improve metapopulation modelling of complex populations of coastal systems were presented (E:03).

A critical element of the TS was to attract communications that linked connectivity research with current challenges in the assessment and management of fishery resources and ecosystems. Novel research on these topics was also presented in Theme Session A ("Advancement of stock assessment methods for sustainable fisheries") at the ICES ASC 2015. The two key challenges highlighted in several presentations were: i) the mismatch be-tween the spatial scale of populations and management units, and ii) the incorporation of complex population structure into the assessment and management procedures. A conceptual talk (E:07) presented a general overview of the implications of and potential solutions for mismatches in scale of biological population structure and stock units, and some clear examples of mismatches (E:09, E:12) highlighted the need to account for spatial structure of populations in management. Several talks described methodological approaches to integrate the complexity of the spatial structure into the assessment and management procedures by including estimates of larval dispersal from biophysical models into assessment models (E:21), or analysing their potential influence explaining spatial and temporal variability of recruitment success observed (E:13, E:23).

Several presentations provided analytical approaches to explicitly include quantitatively information of the genetic structure on population dynamics models, while the species used to implement these techniques were sessile species or those living in coastal areas (E:08, E:19). Translating this methodology to larger stocks and species with higher mobility or living offshore will be a future research challenge. Other important topics included the implications of connectivity processes to management strategies. One communication presented research providing optimization strategies to cope with the spatial heterogeneity of natural resource systems (E:22), and another applied study presented evidence of the need for information on animal movement pat-terns to design mitigation strategies of the effect of anthropogenic structures that alter connectivity patterns (e.g. wind farms, E:27). Finally, one communication presented important insights on the connectivity on ecosystems services and properties illustrating the energy transport about key fatty acids across ecosystems (E:04).

General Discussions and Final conclusions.

There were lively discussions throughout the theme session with excellent audience participation during time provided for questions. Discussions during the coffee breaks were wide-ranging and enthusiastic. There was final half an hour wrap-up discussion introduced by the conveners with important insights from the audience. The final discussion period focused on the overarching question: What are the main challenges in getting beyond connectivity? Through our discussion we addressed the following topical questions: 1) How do we best integrate connectivity work in assessment and management? 2) Where does the stock concept go in future? 3) How do we deal with non-stationarity in connectivity?

Some of the key findings from this session include:

- Advances made in coastal systems studies, larval behaviour, and hydrodynamic-IBM models are starting to meet assessment challenges of large stocks.

- Applications of stock identification methods are improving our understanding of the structural complexity of marine populations.
- The implications of connectivity are being more broadly recognized as relevant to the assessment and management process.
- Cross-life history studies are a powerful tool that needs to be more recurrently used.
- There is still a lot of work to be done in integrating the spatial complexity of populations in assessment a management procedures.