Theme session O

Patterns, sources, and consequences of intraspecific variation in responses of marine fauna to environmental stressors

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Marine species face multiple stressors such as temperature, salinity, oxygen, and CO_2 at a variety of spatial and temporal scales, yet many species are widely distributed across broad environmental gradients. These taxa may respond to such stressors with physiological tolerance, acclimation, or adaptation, the latter of which increases intraspecific population structure. Examples of intraspecific variation are well known in marine fauna – especially fished stocks – because of the extensive monitoring of these populations by traditional means and, more recently, by genetic sampling. Identifying the mechanism(s) responsible for these shifts (e.g., relocation, demographic shifts, selection, tolerance, etc.) is crucial for providing appropriate advice to resource managers when predicting the effects of a changing environment on these ecologically and economically important taxa.

Research results presented in this half-day theme session were obtained from a variety of research approaches including observational, experimental, theoretical, and modelling methods for examining the biological effects of a variety of stressors including fishing, temperature, CO_2, anthropogenic contaminants, and sedimentation. The theme session touched on biological, ecological, and management issues but did not have contributions that used socio-economic examples as encouraged in the session announcement. An introductory overview was followed by nine oral presentations, four brief (3-min) poster summaries, and a discussion between the session conveners and the audience facilitated by the session proposer.

The presentations identified a number of biological and habitat variables of target species that are routinely collected by fisheries programs including geographic, depth, body length, and age distributions which make those taxa ready subjects for analyses and ecological inferences. Examples included shifts in distributions of spawning and nursery grounds, changes over years in the length and age of adult fish throughout the spawning season including changes in the ratios of smaller/younger to larger/older spawning fish in a population based on stock assessments, the masking and/or confounding of climate change effects with fish distribution and abundance patterns, the timing of onshore/offshore fish migrations, and the ability of fixed-season surveys to capture these dynamics. Some experimental studies were tied directly to management questions such as whether northwardly expansion of black sea bass and blue crab populations in shelf and inshore waters of the NW Atlantic will persist in temperature-salinity conditions typical of overwinter in more northerly estuaries. Advice gleaned from experimental studies reported in this theme session included the importance of using a large number of levels of any environmental factor if researchers intend to capture the full plasticity of a species' response to that factor. Still other reports focused on the potential for indirect/interactive biological effects on fish early life-stages when subjected to varied CO_2, thermal, and other stressors in the environment. The importance of meticulously controlling – and reporting – the husbandry methods of longer term experimental studies was emphasized. Two presentations examined the underlying genetic responses to climate gradients. One used a broad suite of species around a previously cryptic faunal population boundary, the other examined genomic clines of Atlantic salmon across a latitudinal/climatic gradient.

Two points emerged from these presentations and posters associated with the Theme Session. First, archiving data and metadata is becoming very important, whether looking at vital rates or phenotypic and genotypic responses. Second, experimental studies can examine management-related questions about fundamental fitness components (e.g., growth, development, and survival) but there are challenges in examining direct and interactive effects of multiple, simultaneously operating factors due to constraints on the scope of experimental designs (see below).

The Theme Session concluded with an extended discussion with topics prompted by a series of questions from the session conveners and proposer. Three main challenges were identified. The first challenge dealt with how researchers might best relate patterns of intraspecific population structure in nature revealed by transitions in gene expression to functional/performance consequences of population members. This challenge is not unique to fisheries science, indeed an explicit connection between population genetic patterns associated with habitats or single environmental factors to any fitness consequence is being discussed broadly in many biological disciplines. Among other strategies for a way forward, the participants identified the value of assessing progress on this front in other disciplines and whether those advances may be transferable to fisheries science. It was clear to attendees that collaboration among partners with complementary skill sets increases the likelihood of success in tackling this and other multiscale problems. Second, as experimentalists consider ever more complex scenarios in their study designs to capture the multifactorial environmental stressors present in nature, they must be judicious in the choice and number of factors, and in the number of factor levels. Ultimately, the experimental designs must be feasible. Some multifactor, response surface approaches for examining two or three concurrent environmental co-stressors were discussed by the group. Third, integration of information on environmental drivers and biological consequences revealed at one scale must be optimized for transfer to other scales. This requires communication and collaboration between field scientists, experimentalist, modellers, and resource assessment specialists. As emphasized in this theme discussion and the ICES plenary, and given the status quo of our science, a successful multiscale transfer of results is likely to require efforts on two fronts. First, the providers of such information must ensure that a need exists for this information or can be created (e.g., assembling a scientific and resource management package that highlights the utility of the biological information for better understanding population/ecosystem status and function, and vice versa). Second, work is needed to ensure open communication channels through what at times have been barriers to a more integrative progress. Venues such as the ICES ASC and ICES Working Groups provide examples of just the sort of mechanisms that might be used to further integrate studies across scales.

The session conveners were invited to contribute a perspective to Marine Ecology Progress Series, which outlines key emerging aspects of understanding phenotypic plasticity in marine organisms and its relevance to studying unfolding changes in population characteristics. The conveners are currently working on an outline of such a perspective, based on the insights generated from this session.