ICES Theme Session M

Ecological Consequences of Reduced Body Size of Organisms for a Future Ocean

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The overall aim of the theme session was to integrate physiological and ecological knowledge across different taxa or trophic levels to produce new insights into a future ocean. Specifically, the theme session aimed to present and discuss current knowledge of the causes and consequences of smaller body sizes for marine ecosystems, from the local to regional and basin scales. The 17 oral presentations given at the ASC covered organisms ranging from bacteria (M:17, M:18), phytoplankton (M:19, M:20, M: 21, M:22), zooplankton (M:013, M:14), benthos (M:15, M:16), and fish (M:01, M:02, M:03, M:04, M:05, M:07, M:08). Four posters were presented encompassing bacteria (M:12), benthos (M:11), and fish (M:09, M:10). Most contributions addressed changes in body size at community level (12) while the remaining (7) focused on changes at population or species level. Having this multi-level perspective was critical to achieving our aim of developing generic insights relevant to predicting the consequences of warming oceans. This report summarises the generic insights that were developed during the session.

It is clear that theory is guiding many investigations into the impacts of warming temperatures on body size of individuals. The general trend towards smaller body sizes at warmer temperatures underlies Bergmann’s Rule, Jame’s Rule and the Temperature-Size Rule (TSR). Presentations which explicitly tested these rules included bacteria (M:17), phytoplankton (M:20), zooplankton (M:14), benthos (M:15) and fish (M:08). The increasingly detailed physiological understanding of why warming results in smaller body size partly motivated experimental studies using small organisms that are amenable to experimental treatments (bacteria - M:17) and manipulation in the field (phytoplankton - M:20).

The analytical approaches taken to investigating drivers of change in body size at the population and community levels included the analysis of spatial gradients in temperature and body size (M:01, M:07), the analysis of temporal trends in temperature and body size (M:13, M:14, M: 15, M:18, M:19), and size spectra analysis (M:03, M:05, M14). In the case of the latter, warming is hypothesised to increase the steepness of the community size spectrum by increasing the prevalence of small organisms, primarily within the phytoplankton assemblage and reduce the mean and maximum size of phytoplankton by approximately one order of magnitude.

One issue mentioned in several presentations and during questioning was the potential for confounding factors to cause changes in body size that could be incorrectly attributed to warming. The most common is the potential for fisheries-induced evolution to result in smaller body sizes of fish (M:04, M:08, M:09, M:16). It was noted (M:08) that detecting a synchronous temperature impact that was affecting ectotherms simultaneously having different life histories is one way of disentangling temperature impacts from fishing mortality trends. Similarly, predation impacts size structure (M:04). Upwelling is an example of environmental factor having a strong effect on both temperature and body size (M:13). It could therefore be a driver of change in body size of small organisms (M:19) rather than climate change. Aquaculture impacts on phytoplankton size structure were noted (M:21, M:22).

Over the two days of presentations, there were several themes that emerged as having support across multiple levels. The TSR has good support for bacteria (M:12,M:17), zooplankton (M:13, M:14), benthos (M:15) and fish (M:08). This emerging coherence across different levels is gratifying and lends itself to further analysis (see final paragraph). There were several presentations that examined implications of smaller body sizes for energy allocation (M:18) and maturation (M:15).

A key aspect of the success of the theme session was the relatively narrow focus. Many ICES Theme Sessions are really umbrellas for highly disparate contributions. This was not the case for Theme Session M. Although it was unclear how many contributions would be submitted we were gratified by the number of presentations that were submitted to the session. ICES might in future consider what the appropriate balance should be between broadly defined Theme Sessions and narrowly defined ones. We received many positive comments regarding the session and think that it partly stems from the coherent thread running through many of the presentations.

The discussion was lively throughout the theme session with excellent audience participation during questioning. There were two 15-minute blocks of time (one resulting from cancellation of M:06) and a 30-minute block of time mid-way through the theme session. Discussions during these breaks were wide ranging and enthusiastic. Several novel points were developed including the possibility that as fishing mortality is reduced the impacts of environment on body size might become more detectable.

Several of aspects of the Theme Session proposal were not fully realised in the nature of the contributions. There was one poster contribution describing ecosystem model predictions of the impacts of smaller body sizes on ecosystem functioning (M:10) but clearly this aspect could be explored further. There were no presentations using simulations to project implications of smaller body sizes for ecosystem functioning and population dynamics (the “Future Ocean” that was explicitly part of the session title). This deficiency suggests that the area of enquiry explored by Theme Session M is at an early stage of development and concentrating on developing empirical support through analysis of existing databases or targeted experiments. This is the necessary pre-cursor to developing well-grounded sets of expectations about how future oceans will adapt to warmer temperatures.

The co-convenors concluded that it would be appropriate to develop plans for future research into the topic. During the Theme Session it emerged that the possibility that regional seas are shifting towards reduced body size is not included in the IPCC 5th Assessment Report. Discussion at the theme session flagged up that this emerging body of knowledge about a possibly “universal” response to warming should be included in future assessment reports. This is consistent with the broad aim of improving representation of the scientific knowledge and evidence base related to marine ecosystems in future assessment reports that was highlighted during the discussion on Wednesday afternoon during the ICES/PICES Strategic Initiative on Climate Change (SICCME) Open Session. As a consequence, the co-convenors of the Theme Session are intending to invite a small group of presenters to contribute to a review paper.