Proposal for a SCOR Working Group

Zooplankton Production Measurement Methodologies and Their Application

Abstract

Climate change will affect material and energy flux pathways in marine ecosystems. Zooplankton communities and their rates of production represent key aspects of the structure and function of marine ecosystems. Unfortunately, our understanding of the processes driving variation in zooplankton production is limited and this is due in part to difficulties identifying which methods are the most practical and relevant for measuring the production rates of natural zooplankton populations and/or communities across a wide range of phyla and trophic levels. A quantitative evaluation of existing, new and emerging methodologies is urgently required.

The proposed Working Group will focus its attention on assessing the applicability of existing methods (i.e. traditional methodologies) as well as the development of novel methodologies (i.e. biochemical-based approaches) for measuring zooplankton production rates. Work will be conducted over a period of four years, culminating in a final report that will:

1. Summarize the assumptions, recent advances and limitations of the traditional methodologies and novel biochemical-based approaches used to estimate production of zooplankton populations or communities
2. Present experimental protocols for biochemical-based approaches to estimate zooplankton production, and post these to a web site as well as publish them in a peer-reviewed journal
3. Validate and calibrate zooplankton production rate estimates measured by biochemical-based approaches and traditional methodologies through a cooperative and collaborative research program
4. Propose zooplankton production research activities to be encouraged in ocean science plans of PICES (North Pacific Marine Science Organization) and ICES (International Council for the Exploration of the Sea) membership nations

Rationale

Secondary production represents the rate of elaboration of biomass (via growth and reproduction) for direct and indirect consumers of primary production in marine food-webs. Zooplankton in particular occupy a central position in marine food webs, but we lack accurate estimates of their production. Reliable estimates are needed to fully understand the functional response of marine ecosystems to global climate change. Traditionally, zooplankton production has been measured as one of the quantitative evaluations of ecosystem function, integrating the production estimate for each zooplankton population or group. Despite the use of several methods for estimating zooplankton production over the last century, the routine and universal application of each of these methods is limited because they can only be used under specified conditions and are not necessarily comparable. Also, the estimates include some uncertainty because zooplankton communities span a wide range of phyla and trophic levels.

It is particularly timely to focus on zooplankton production methodologies because assumptions underlying the most commonly applied traditional methods have been re-evaluated and new approaches have been proposed since the publication of the ICES Zooplankton Methodology Manual in 2000. At this stage, a comprehensive comparison of these methods (in the context of recent advances) may allow us to: 1) evaluate advantages and limitations of these methodologies for their application to zooplankton populations or communities; 2) compare the production rates estimated by each method; and 3) to propose one or more as a “routine” method for natural zooplankton populations and communities.

A Working Group formed in SCOR and endorsed by the PICES and ICES would be the best way of focusing a global scientific effort on the topic of zooplankton production. Since this topic is fundamental to oceanographic science, it is appropriate that the activity is carried out by an international scientific organization such as SCOR. Moreover, an endorsement by both PICES and ICES would enhance the exchange of information and discussion between members of these organizations as well as between advanced and developing countries. We want to assemble scientific expertise from PICES and ICES nations and several developing nations in order to fully represent the world-wide zooplankton community.

Scientific Background

Zooplankton communities play a dominant role in the flow of matter and energy passing from primary producers to animals at higher trophic levels in marine ecosystems (e.g. Lalli and Parsons 1993). Over the past two decades, the need for quantitative evaluation of marine ecosystem function has been emphasized as a necessary component of improving our understanding of how marine ecosystems respond to global climate change (e.g. Walther et al. 2002; Edwards and Richardson 2004; Boyce et al. 2010). While SCOR has sponsored four working groups that focused on standardization for zooplankton sampling (WG3 and WG13) and preservation (WG23) of biomass estimation and global comparisons of zooplankton time-series (WG125), there is still little knowledge on the underlying rate processes. Over the past half century, phytoplankton production rates have been estimated using radio-isotopes (as originally proposed by Steeman-Neilsen 1952) and more recently using stable isotope-based approaches (Hama et al. 1983). In the early 1980's similar approaches were also developed for the measurement of bacterial production rates (Fuhrman and Azam 1982). A major consequence of the long-term use of routinely applicable *in situ* methods for primary productivity is that we can now generate spatio-temporally resolved maps of primary production rates coupled with satellite imagery. On the other hand, zooplankton production has been traditionally estimated with methods (i.e. traditional methods) that either: 1) follow the development of zooplankton populations or communities over the course of several weeks or months; or 2) employ fixed-period incubations (e.g. Burkill and Kendall 1982, Kimmerer and McKinnon 1987; Berggreen et al. 1988; Peterson et al. 1991). Incubation-based techniques with simultaneous sampling of natural communities are the most widely used methods in the field. In 2000, Runge and Roff (2000) reviewed the field application of the traditional methods as well as the development of biochemical and radiochemical methods in a chapter in the ICES Zooplankton Methodology Manual (Harris et al. 2000). However, shortly after this publication, some studies (Hirst and McKinnon 2001; Hirst et al. 2005; Kimmerer et al. 2007) documented limitations of the incubation-based methods which necessitated revisions to application and interpretation of these approaches and their derived productivity estimates. Meanwhile, new approaches for measuring zooplankton production using biochemical materials and enzyme activity (i.e. biochemical-based approaches), which were not covered by Runge and Roff (2000), were also developed and explored (Wagner et al. 2001; Sastri and Roff 2000; Oosterhuis et al. 2000; Yebra and Hernández-León, 2004).

In October 2012, a PICES workshop was convened in Japan to discuss the issues surrounding the most commonly used methodologies for the assessment of zooplankton production. The motivation for this workshop was the recognition that there is still little knowledge of or confidence in the existing zooplankton production methodologies (relative to those used for estimating primary and bacterial productivity). Two major conclusions emerged from the activities at the workshop: 1) we need studies that compare traditional with biochemical-based approaches; and 2) there is no method that can be routinely applied to natural zooplankton populations and communities across a wide range of phyla and trophic levels. In order to resolve these significant issues, an international Working Group on zooplankton production methodologies was proposed during the workshop.

Statement of Work

The proposed Working Group would:

1. Summarize the assumptions, recent advances and limitations of the traditional and biochemical approaches used to estimate production of zooplankton populations or communities across a wide range of phyla and trophic levels
2. Present experimental protocols for biochemical-based approaches to estimate zooplankton production on a website and in a peer-reviewed journal
3. Validate and calibrate zooplankton production estimates by biochemical-based approaches and

traditional methodologies through a cooperative research program

4. Propose and encourage zooplankton production research activities in science plans of PICES and ICES membership nations

Term

2014 to 2017 (4 years)

Meetings

To discuss the roadmap of this Working Group and to make a plan for a cooperative research program, the first meeting will be convened during March 2014 just before or after the meeting of the ICES Working Group on Zooplankton Ecology (WGZE). A second meeting will be held in association with the cooperative research program (see Statement of Work), during summer of 2015 or 2016 in Kagoshima, Japan. To discuss the Working Group's report and prospective activities, a final meeting will be held just after the 2017 ASLO Summer Meeting.

Sessions held at international conferences

The Working Group proposes a session during the 2015 Zooplankton Production Symposium to share and discuss the assumptions, recent advances and limitations in zooplankton production methodologies and their applications to natural zooplankton populations and communities. Through this symposium, the working group will summarize the information. A session will be proposed for the 2017 ASLO Summer Meeting, to report the review on zooplankton production methodologies (both traditional and biochemical-based approaches) and measurements for natural populations and communities and the results from the above-mentioned cooperative research program by the working group.

Capacity Building

The Working Group will contribute to promote a cooperative research program measuring zooplankton production among ICES and PICES nations including developing countries. Also, the working group members will encourage a summer school on the methodologies for young scientists.

Working Group Membership

Working Group membership is proposed to consist of 14 specialists in zooplankton production ecology who have experience with the use of traditional methodologies and/or biochemical-based approaches. We also recognize that the Working Group members should be represented from both ICES and PICES countries in order to properly cover the global scale of this subject area. Full members would steer this working group and associate members would help with the tasks of full members.

Members

Full Members

1. Toru Kobari (Japan, T/B: Co-Chair)
2. Lidia Yebra* (Spain, B: Co-Chair)
3. Akash Sastri (Canada, B)
4. William T. Peterson (USA, T)
5. Andrew Hirst (UK, T)
6. Wim J. Kimmerer (USA, T)
7. David McKinnon (Australia, T/B)
8. Sigrún Jónasdóttir* (Denmark, T/B)
9. Felipe Gusmao (Brazil, T/B)
10. Jenny Ann Huggett* (South Africa, T/B)

Associate Members

1. Ruben Escribano (Chile, T)
2. Hyung-Ku Kang (Korea, T)
3. Tomonari Kotani (Japan, T)
4. Marina Sabatini* (Argentina, T)

*: female scientists

T: contribution to traditional methodologies

B: contribution to biochemical-based approaches

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