

The PICES WG37 business meeting
20170923

*Tasks before the WG business meeting

*Assignment at the WG business meeting

1. Self-introduction
2. Background of the PICES working group on “Zooplankton Production Methodologies, Applications and Measurements in PICES regions” (described by T. Kobari)
3. Terms of references (described by T. Kobari)
4. Nomination for co-chairs of the PICES WG37
 - Akash Sastri (Canada) and Toru Kobari (Japan)
Because of the PICES rules, we need to nominate chair(s) at the first business meeting.
5. Future plans
 - ① Draft plans to promote terms of references (described by T. Kobari and A. Sastri)
 - Summarize assumptions, recent advances and limitations of both traditional and biochemical methodologies for measuring zooplankton production of natural populations and communities (ToR1).
 - Review paper for biochemical approaches was already published in Advances in Marine Biology (<http://dx.doi.org/10.1016/bs.amb.2016.09.001>).
 - Colleagues listed below might be potential authors of a review paper on the traditional methodologies (however, we need to ask). At the business meeting in Vladivostok, WG members report the other potential authors to have experiences on the traditional methodologies.
 - ◇ Natural cohort: ???
 - ◇ Artificial cohort: Hui Liu (USA)
 - ◇ Molting rate: Toru Kobari (Japan)
 - ◇ Egg production: Rob G. Campbell (USA)
 - ◇ Empirical models: Andrew Hirst (UK)
 - It would be the best if the manuscript draft is submitted to Advances in Marine Biology within 2018.
 - Produce recommendations and procedures for both traditional and biochemical zooplankton production rate measurement methodologies and make them available for worldwide users on a website (ToR2).
 - Recommendations and procedures for the biochemical methodologies were already included in the review paper as supplements. A. Sastri and T. Kobari will make some revision on the recommendations and procedures for the biochemical methodologies to post at the PICES website.
 - Such information for the traditional methodologies can be included by same way in the review paper. A. Sastri and T. Kobari will show the draft at the PICES 2018 annual meeting.
 - After some revisions of the drafts, co-chairs ask volunteers to 2 WG members to upload the information (as PDF files) at the PICES website.
 - Develop practical models for estimating zooplankton production to time-series (ToR3).
 - Some empirical models (e.g., Banse-Mosher or Ikeda-Motoda models) would be the best method(s) to estimate zooplankton growth (and production) with high temporal and spatial resolutions. L. Yebra (ex officio member, Spain) and T. Kobari (Japan)

will propose to collaborate with Lutz Postel for comparison of the difference in zooplankton production estimates among some models (just after PICES 2017 meeting). T. Kobari (Japan) will report the progress at the PICES 2018 annual meeting.

- L. Yebra (ex officio member, Spain), A. Sastri (Canada) and T. Kobari (Japan) will apply these practical models for estimating zooplankton production to some time-series, collaborating with T. Tadokoro (Japan), D. Steinberg (USA) and T. O'Brien (USA).
 - Build a platform of information exchange on zooplankton production measurements through an interactive website for regional and/or global mapping (ToR4).
 - This ToR is associated with ToR3. T. O'Brien (USA) and L. Yebra (Spain) report the progress for both ToR3 and ToR4 at the PICES 2018 annual meeting.
 - Build a network of scientists and laboratories measuring zooplankton production among PICES and ICES nations as well as developing countries (ToR5).
 - WG members seek scientists and laboratories measuring zooplankton production and report the information at the WG business meeting in 2017 (please refer another excel sheet).
 - Co-chairs ask volunteers to 2 WG members to make and upload a list of their information (e.g., name, institute, email, methodology used, some publications) at the PICES website.
 - Promote international collaborations among zooplankton production researchers through international organizations such as PICES, ICES and IMBER (ToR6).
 - WG members report some funding opportunities for international collaboration on zooplankton production estimates at the WG business meetings in 2017 and 2018. WG members also report some opportunities and ideas to compare zooplankton production estimates by sample exchanges with small funding or without funding.
 - This ToR6 will be simultaneously promoted with ToR2, ToR3 and ToR4.
 - Publish a final report summarizing results (ToR7).
 - A. Sastri (Canada) will show the previous reports for the past working groups as examples.
 - WG members discuss an outline (sections) of the report. All of the members try to be associated with each section or something similar.
 - Bibliography of zooplankton growth and production in the North Pacific will be included to the report. WG members assemble the literatures for zooplankton growth and production in each country and report them at the WG business meeting.
- ② 1 day workshop in the PICES 2018 annual meeting (Japan)
- Objective
 - Invited speaker and potential speakers
 - Morning
 - Invited speaker (S. Uye: 30 minutes for talk and 10 minutes for discussion)
 - 3 to 5 scientific reports for zooplankton production measurements (20 minutes for talk and 10 minutes for discussion)
 - Afternoon
 - 6 reports for zooplankton production measurements and related issues in own countries (WG members: 10 minutes for each and 10 minutes for discussion)
 - Discussion how to promote international collaborations

6. Others

- Group photo for the PICES press will be taken after the WG business meeting.

PICES Working Group Proposal (2016)

Title

Zooplankton Production Methodologies, Applications and Measurements in PICES regions

Abstract

Knowledge of marine zooplankton productivity is key to our understanding of how ecosystem-scale resource production (i.e. harvested fisheries) and biogeochemical processes will respond to broad-scale physical forcing such as climate change. Unfortunately, the very limited number and poor spatio-temporal resolution of zooplankton production rate measurements does not currently permit characterization of the variability of this rate relative to current and predicted physical, chemical and biological conditions. A fundamental barrier to improving our understanding of the processes driving variation in zooplankton production rates (population and community-level) is the lack of consensus on the most practical and relevant methods for measuring rates across a wide range of phyla and trophic levels. Development and application of practical approaches for estimating zooplankton productivity are urgently needed.

The proposed Working Group (WG) will focus on assessing the applicability of current methodologies (i.e., traditional and biochemical methodologies) for measuring rates of zooplankton production for natural mesozooplankton populations and communities (including non-crustaceans); and for applying the most practical methods to existing zooplankton time-series. Planned WG activities will be carried out over a period of three years.

1. Summarize assumptions, recent advances and limitations of both traditional and biochemical methodologies for measuring zooplankton production of natural populations and communities.
2. Produce recommendations and protocols for both traditional and biochemical measurements of zooplankton production rates and make these available globally to users on a website.
3. Develop practical models for estimating zooplankton production rates for time-series.
4. Build a platform of information exchange on zooplankton production rate measurements through an interactive website for regional and/or global mapping.
5. Build a network of scientists and laboratories measuring zooplankton production among PICES and ICES nations as well as developing countries.
6. Promote international collaborations among zooplankton production researchers through international organizations such as ICES, PICES and IMBER.
7. Publish a final report summarizing results.

Scientific Background

Zooplankton communities occupy a central position 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 increasing emphasis on quantitative assessments of marine ecosystem function has been focused on 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). Zooplankton production represents a quantitative proxy for the functional response of marine ecosystems since it corresponds to the zooplankton biomass accrued through consumption of lower food-web levels.

Zooplankton production has long been estimated using a variety of methods which either: 1) follow the development of zooplankton populations/communities over the course of several weeks or months (e.g., Hirche et al. 2001; Ohman and Hirche 2001); or 2) employ *ex situ* 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 these traditional methods in a chapter of the ICES Zooplankton Methodology Manual (Harris et al. 2000). However, shortly after its publication, a number of significant issues associated with incubation-based methods emerged. These issues have demanded revision of the application and interpretation of these approaches and their derived production estimates (Hirst and McKinnon 2001; Hirst et al. 2005; Kimmerer et al. 2007). Meanwhile, advances in biochemical tools for measuring zooplankton growth and production, which were not covered by Runge and Roff (2000), were also developed (Wagner et al. 2001; Sastri and Roff 2000; Oosterhuis et al. 2000; Yebra and Hernández-León, 2004) and have since been applied across a wide range of organisms and habitats (e.g., Yebra et al. 2004, 2009; Sastri et al. 2012).

Over the past half century, phytoplankton production rates have been measured using radio-isotope (Steeman-Nielsen 1952) and stable isotope-based approaches (Hama et al. 1983). In the early 1980's, similar measurement approaches were also developed for bacterial production rates (Fuhrman and Azam 1982). A major consequence of the long-term use of routinely applicable *in situ* methods for phytoplankton and bacterial productivities is that we can now generate their spatio-temporal patterns at relatively high resolution using satellite imagery. For instance, SCOR sponsored several working groups covering related topics such as the standardization for zooplankton sampling (WG3 and WG13), biomass measurement (WG23), and global comparisons of zooplankton time series (WG125). Despite support by SCOR and the availability of multiple measurement methods for zooplankton production, the routine and universal application of these methodologies is limited because they can only be used under specified conditions and are not necessarily comparable. Moreover, the existing production estimates include some uncertainty because zooplankton communities span a wide range of phyla and trophic levels.

In 2012 and 2016, PICES-sponsored workshops were convened to discuss the issues surrounding the application of current methods for estimating zooplankton production. The motivation for these workshops was the recognition that there is still limited knowledge of, or confidence in, the existing zooplankton production measurement methodologies relative to methods used for estimating primary and bacterial productivity. The two major conclusions emerged from the workshop:

- 1) We need to summarize assumptions, limitations and recent progress of existing methodologies which purport to measure zooplankton production.
- 2) We need methods which are routinely applicable to natural zooplankton populations and communities across a wide range of phyla and trophic levels.

In order to resolve these significant issues, an international WG on zooplankton production methodologies was proposed during both workshops.

Rationale

It is particularly timely to focus on zooplankton production because assumptions and limitations underlying the most commonly applied methods have now been reconsidered and other approaches have also been developed since the publication of the *ICES Zooplankton Methodology Manual* in 2000. A major consequence of these recent developments has been a general confusion about how these methods should be applied for natural zooplankton populations and communities, and how the various estimates can be compared. The latest IPCC report (IPCC 2013) has reaffirmed that global warming exerts widespread impacts on natural systems; a quantitative evaluation of secondary productivity is therefore both timely and critical for understanding how marine ecosystems adapt to continued global climate change. However, there is still little information on zooplankton production as a proxy for the integrated biological response of lower trophic levels in marine food webs. Indeed, the generation of global maps of primary productivity is now routine, but the ability to make similar spatial comparisons is lacking for zooplankton productivity.

At this stage, a comprehensive review of zooplankton production methodologies (in the context of recent advances) would allow us to:

- 1) Elaborate on recommendations for the standardized application of traditional and biochemical zooplankton production measurement methodologies for worldwide users
- 2) Develop and apply practical methods for estimating zooplankton production to existing time-series.

It is reasonable that the WG activities proposed here are sponsored by an international scientific organization such as PICES, since similar terms of reference are ongoing for the ICES Working Group on Zooplankton Ecology (WGZE). A PICES-BIO sponsored WG would not only promote information exchange and collaborations between PICES and ICES but also among previous (e.g., SCOR WG125) and ongoing projects (e.g., IGMETS and IMBER). Also, the WG would provide a basis for training in developing countries in North Pacific Ocean (e.g., Chinese Taipei and Mexico). For this purpose, the proposed WG has assembled scientific expertise from PICES nations and supporting members from ICES nations and from several developing nations in order to fully represent the worldwide community of zooplankton researchers as well as to foster a global exchange of scientific information and discussion.

Terms of Reference

This WG will:

1. Summarize assumptions, recent advances and limitations of both traditional and biochemical methodologies for measuring zooplankton production of natural populations and communities.
2. Produce recommendations and procedures for both traditional and biochemical zooplankton production rate measurement methodologies and make them available for worldwide users on a website.
3. Develop practical models for estimating zooplankton production to time-series.
4. Build a platform of information exchange on zooplankton production measurements through an interactive website for regional and/or global mapping.
5. Build a network of scientists and laboratories measuring zooplankton production among PICES and ICES nations as well as developing countries.
6. Promote international collaborations among zooplankton production researchers through international organizations such as PICES, ICES and IMBER.
7. Publish a final report summarizing results.

Working plan

Year 1 (2018)

1. WG meeting (just before or after PICES annual meeting: Japan)
 - ✓ Discuss schedules, plans and contributors for terms of reference and deliverables.
 - ✓ Discuss schedules and plans of symposium during the next PICES annual meeting in Canada.
2. PICES workshop (during PICES annual meeting: Japan)
 - ✓ Summarize practical disadvantages and limitations of both traditional and biochemical methodologies for measuring natural zooplankton production.
 - ✓ Develop the recommendations and standardized protocols for the traditional and biochemical methodologies.
 - ✓ Develop the methodologies or approaches for estimating zooplankton production which are applicable to zooplankton time-series
3. Contact information
 - ✓ Make a list of contact information on scientists and laboratories measuring zooplankton

production among PICES and ICES nations.

4. Review articles
 - ✓ Prepare manuscript drafts to review the assumptions, advantages and limitations of both traditional and biochemical methodologies for measuring production of natural zooplankton populations or communities.

Year 2 (2019)

1. WG meeting (just before or after PICES annual meeting: Canada)
 - ✓ Revise schedules and discuss plans for terms of reference and deliverables.
 - ✓ Apply practical models for estimating zooplankton production to some zooplankton time-series and compare the estimates and sensitivity of the model results.
 - ✓ Open recommendations and standardized protocols for both traditional and biochemical zooplankton production rate measurement methodologies on a website.
2. PICES symposium (during PICES annual meeting: Canada)
 - ✓ Overview plankton ecosystem status in PICES and ICES regions (Invited talks).
 - ✓ Introduce IGMETS project and the achievements (Invited talk).
 - ✓ Integrate latest information on zooplankton production methodologies, applications and measurements in PICES and the other regions.
3. Contact information
 - ✓ Open a list of contact information on scientists and laboratories measuring zooplankton production among PICES and ICES nations on a website.
4. Review articles
 - ✓ Submit, revise and publish the review articles on both traditional and biochemical methodologies for measuring zooplankton production.
5. PICES scientific report
 - ✓ Make a draft of PICES scientific report, including the following information on traditional and biochemical methodologies for measuring zooplankton production
 - Review of the assumptions, advantages and limitations applying natural zooplankton community.
 - Recommendations and standardized protocols.
 - Application of practical model to some zooplankton time-series and comparison of the production estimates.
 - Regional and global mapping of zooplankton production estimated with the practical models.

Year 3 (2020)

1. WG meeting (just before or after PICES annual meeting: Korea)
 - ✓ Discuss and revise PICES scientific report.
 - ✓ Make a regional and global map of zooplankton production estimated with the practical models to regional and global zooplankton time-series.
2. Session or symposium (during PICES annual meeting, Zooplankton Production Symposium)
 - ✓ Zooplankton production in marine systems (Invited talk).
 - ✓ Biochemical or physiological approach for estimating zooplankton production (Invited talk).
 - ✓ Introduction of latest zooplankton production measurements by both traditional and biochemical approaches.
3. PICES scientific report
 - ✓ Submit a final scientific report to PICES.

Deliverables

1. Reports or Peer-reviewed articles summarizing the assumptions, recent advances and limitations of both traditional and biochemical methods to estimate zooplankton production of natural populations and communities.
2. Guidelines on recommendations and procedures for both traditional and biochemical methods on a website of an international organization such as PICES and/or ICES.
3. Lists of contact information on scientists and laboratories measuring zooplankton production among PICES and ICES nations.
4. An interactive website for regional to global scale mapping of zooplankton production estimates incorporated to zooplankton time-series on a website.
5. A final report summarizing the results of the WG as a Scientific Report in PICES.

Capacity Building

1. Providing additional and interdisciplinary options for existing zooplankton time-series such as global mapping of secondary production, validation for ecological modellings and carrying capacity for fishery production.
2. Building a platform of information exchanges and collaborations for zooplankton production among ICES and PICES nations as well as developing countries.
3. Distributing latest methodologies and knowledge on ocean science to students and early-career scientists in developing countries through summer schools.
4. Convening international symposiums, sessions and workshops to discuss zooplankton methodologies, applications and measurements in ICES/PICES annual meetings and international conferences such as ASLO Meeting and Zooplankton Production Symposium

Relationship to other scientific efforts in international programs and organizations

1. Contributing to the update of the Zooplankton Methodology Manual (2000) produced by the ICES Working Group on Zooplankton Ecology (WGZE).
2. Contributing to the update of the Ecosystem Status Report produced by PICES.
3. Providing the additional options to the interactive website produced by IGMETS.
4. Promote zooplankton production measurements to science plans in international organizations such as PICES, ICES and IMBER.
5. Creation of a global network for zooplankton production researchers based on the products of SCOR WG125.

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