

***PICES/ICES collaborative research initiative: Toward regional to global measurements and comparisons of zooplankton production using existing data sets***

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*Workshop 10 participants at PICES-2019, Victoria, Canada.*

About 20 zooplankton ecologists met October 16, 2019, to discuss zooplankton production methodologies and measurements at a 1-day workshop during PICES-2019 in Victoria, Canada. The workshop focused on: i) the application and synthesis of zooplankton production rate measurements in the field; ii) modeling and laboratory validation studies; and iii) regional assessments of the performance/utility of empirical models for estimating zooplankton production rates using biomass time series. Much of the group discussion centered on how to take best advantage of online resources which can be used to derive broad-scale secondary production rate measurements using empirical models of zooplankton growth rates. The workshop was intended to focus on a number of issues relevant to PICES Working Group ([WG 37](#)) on *Zooplankton Production Methodologies, Applications and Measurements in PICES Regions* and ICES Working Group on *Zooplankton Ecology* ([WGZE](#)). Workshop presentations included direct estimates of growth, empirical models and indirect biochemical indices of zooplankton production.

Prof. Shin-ichi Uye (invited speaker, Japan) talked about how to go from individual-based to population and community-based production estimations and stressed the need for more direct measurements of species-specific growth rates before we can advance toward a community-level assessment of zooplankton production in the field. He also presented new information on the importance of tertiary production, using a chaetognath as an example. Next, Dr. Pei-Chi Ho (Chinese Taipei) showed how copepod-specific growth rates estimated from relatively short artificial cohort incubations were used to test the importance of the predator/prey stoichiometry on zooplankton production in the field. Apart from direct measurements, indirect approaches were also presented, such as models and enzymatic methods to facilitate the assessment of growth at the individual and community level. Prof. Hui Liu (USA) showed a new Individual-Based Model (IBM) that allows the *in silico* development of natural and artificial cohorts to estimate field production rates of the jellyfish, *Aurelia aurita*. Dr. Kazuaki Tadokoro (Japan) presented examples

of a physiological model of zooplankton growth rates applied to existing zooplankton biomass time series data. Dr. Karyn Suchy (Canada) compared crustacean production rates estimated from a variety of empirical models and applied to the west coast of Vancouver Island and the Strait of Georgia, BC, Canada. Also, Dr. Akash Sastri (Canada) and Ms. Megu Iwazono (Japan) showed the importance of biomass in determining copepod production rates from chitobiase and aminoacyl-tRNA synthetases (AARS) activity in the laboratory. Prof. John Dower (Canada) described a major decline in crustacean zooplankton production rates (estimated with the chitobiase method) and increases in gelatinous plankton biomass along the west coast Vancouver Island, since 2015. Finally, Dr. Lidia Yebra (Spain) looked at the [COPEPOD website](#) as a potential online tool which may be used to move towards a global estimation and mapping of zooplankton production rates using existing time series data. Additional contributions, as poster presentations, by Ms. Megu Iwazono (Japan), Mr. Fukutaro Karu (Japan), and Mr. Takeru Kanayama (Japan) highlighted their studies on zooplankton growth and feeding rates in the laboratory and field.

The afternoon discussion focused on three areas relevant to WG 37's terms of reference. Our first discussion item centered around collaborative activities for zooplankton production measurements and methodologies with ICES WGZE. Dr. Yebra emphasized the importance of networking and regional to global collaboration as major achievements of the collaboration between ICES WGZE and PICES WG 37, and that there was a general agreement on pursuing further collaborations between PICES and ICES members. Dr. Yebra also noted that we should be aware of a large community of zooplankton production scientists from the Mediterranean and southern hemisphere. A representative example of similar efforts by the global community is the International Group for Marine Ecological Time Series (IGMETS) initiative.

The second discussion topic approached a WG 37 term of reference related to using existing biomass time series and empirical zooplankton growth rate relationships to compile and compare secondary production time series. Several existing collaborations were identified and a general concern about how to choose the best model for times series comparisons was raised. Drawing on the experience of participants, the most important issue is not to choose a single common empirical growth rate model, but rather to select a model which accurately describes growth/production in a particular region. This could take the form of choosing region-specific species models or providing a range of production estimates based on several global models. The ultimate goal is to develop comparable time series of zooplankton production rates.

Finally, we discussed novel approaches for advancing zooplankton production measurements in the field.

Participants noted that existing empirical models were developed 15 to 30 years ago. Thus, it was agreed that efforts to compile new data not included in those models would be an excellent option for updating existing models prior to their application for zooplankton production time series.

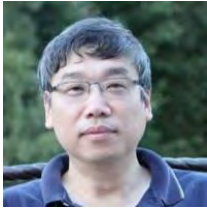
This workshop is the most recent in a series of international workshops organized to advance towards a global measurement and assessment of zooplankton production. Since the PICES-2012 workshop on "*Secondary production: Measurement methodology and its application on natural zooplankton community*" (Hiroshima, Japan, 2012) and the workshop on "*ICES/PICES cooperative research initiative: Towards a global measurement of zooplankton production*" at the ICES/PICES 6<sup>th</sup> International Zooplankton Production Symposium (Bergen, Norway, 2016), notable progress has been made by colleagues from PICES and ICES. Principal among these achievements is the establishment of PICES [WG 37](#) (2017–2020), and the publication of two review papers summarizing the recent advances in biochemical (Yebra *et al.*, 2017, *Advances in Marine Biology*, <https://doi.org/10.1016/bs.amb.2016.09.001>) and traditional (Kobari *et al.*, 2019, *Progress in Oceanography*, <https://doi.org/10.1016/j.pocean.2019.102137>) methodologies for zooplankton production estimation. To foster advances on these topics, additional workshops were organized by WG 37 during PICES Annual Meetings in 2017 ("*Advantages and limitations of traditional and biochemical methods of measuring zooplankton production*", Vladivostok, Russia), and in 2018 ("*Regional evaluation of secondary production observations and application of methodology in the North Pacific*", Yokohama, Japan), as well as a session at the 2018 Ocean Sciences Meeting ("*Zooplankton productivity as a function of trophodynamics in marine ecosystems*", Portland, USA). Also, two practical workshops (Manazuru, Japan, 2018 and Quadra Island, Canada, 2019) were recently organized and convened by WG 37 members to provide early career scientists with training on state-of-the-art methodologies for *in situ* zooplankton production measurement within an international context.

A main outcome of W10 was the expanding of international collaboration among plankton ecologists from the North Pacific and Atlantic. The prospective activities proposed for development during the workshop include a regional comparison of zooplankton production rates estimated from zooplankton biomass coastal time series in the Northeast Pacific, fostering the use of online databases, updating of current production empirical models with recent zooplankton growth rates, and promoting further international collaboration by pursuing new venues for discussion and knowledge exchange in form of workshops and summer schools.

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Dr. Yong Chen ([ychen@maine.edu](mailto:ychen@maine.edu)) is a Professor of Fisheries Science in the School of Marine Sciences at the University of Maine in Orono, Maine, U.S.A. Dr. Chen's research focuses primarily on fisheries stock assessment and management. Dr. Chen has authored and co-authored over 240 peer-reviewed papers in scientific journals, many technical and fish stock assessment reports, and has received over 8 million dollars in competitive research support for over 80 projects in marine capture fisheries stock assessment and management. Dr. Chen has an adjunct faculty appointment at the Shanghai Ocean University. He is currently a member of the United States New England Fisheries Management Council's Scientific and Statistical Committee. He is Editor-in-Chief of the Canadian Journal of Fisheries and Aquatic Sciences and the Aquaculture and Fisheries. His lab webpage is located at <https://www.umaine.edu/chenlab/>



Dr. Chih-hao (Zac) Hsieh ([chsieh@ntu.edu.tw](mailto:chsieh@ntu.edu.tw)) is a professor and the Deputy Director at the Institute of Oceanography, National Taiwan University. Zac received his Master degree from the Department of Zoology, National Taiwan University and Ph.D. degree from the Scripps Institution of Oceanography, University of California-San Diego. He is a theoretical ecologist as well as biological and fisheries oceanographer. His research targets range from microbes, plankton, to fish. His research integrates field observations, experiments, data analyses, and mathematical modeling. His research interests include forecasting dynamical systems, plankton food webs, and ecosystem-based approach to fisheries management.

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Dr. Lidia Yebra ([lidia.yebra@ieo.es](mailto:lidia.yebra@ieo.es)) is a Research Scientist at the Spanish Institute of Oceanography in Málaga, Spain. Her interests include zooplankton physiology and ecology, and she developed methodologies to estimate production rates using biochemical approaches, such as the activity of the enzymes aminoacyl-tRNA synthetases (AARS). She is a member of the ICES Working Group on Zooplankton Ecology and contributes to the ICES Zooplankton Status Report. In PICES, she is an ex officio member, representing ICES, of Working Group on Zooplankton Production Methodologies, Applications and Measurements in PICES Regions (WG 37).



Dr. Akash Sastri ([akash.sastri@dfo-mpo.gc.ca](mailto:akash.sastri@dfo-mpo.gc.ca)) is an oceanographer with Fisheries and Oceans Canada at the Institute of Ocean Sciences in Sidney, British Columbia, Canada, where he leads the La Perouse/West Coast of Vancouver Island Plankton Monitoring field program. He has a background in biological oceanography with a focus on the roles of marine plankton communities in changing environments. His Ph.D. (2007) thesis at the University of Victoria focused on the development and application of novel ways to measure zooplankton productivity routinely at sea. In PICES he is the Chair of the Biological Oceanography Committee, co-chairs the Working Group on Zooplankton Production Methodologies, Applications and Measurements in PICES Regions (WG 37) with Toru Kobari, and is a member of the Advisory Panel on North Pacific Coastal Ocean Observing Systems.



Dr. Toru Kobari ([kobari@fish.kagoshima-u.ac.jp](mailto:kobari@fish.kagoshima-u.ac.jp)) is Associate Professor on the Faculty of Fisheries at Kagoshima University supporting "Biological Oceanography" and "Fisheries Oceanography". He has a background in biological oceanography with a focus on the structural and functional roles of plankton communities on marine ecosystems. Toru completed his undergraduate studies in Faculty of Science at the Yamagata University, Yamagata, and a M.Sc. in Fisheries at the Hokkaido University, Hakodate. His Ph.D. (1999) thesis at Hokkaido University focused on the life cycles and interannual variability of *Neocalanus* copepods. His current research focuses on the trophodynamics and productivity of plankton food web in the Northwest Pacific. In PICES he co-chairs the Working Group on Zooplankton Production Methodologies, Applications and Measurements in PICES Regions (WG 37) with Akash Sastri.