Report of Working Group 37 on *Zooplankton Production Methodologies, Applications and Measurements in PICES Regions*

The second meeting of the Working Group on Zooplankton Production Methodologies, Applications and Measurements in PICES Regions (WG 37) was held on October 25, 2018 from 14:00 to 17:00 h in Yokohama, Japan, under the chairmanship of Dr. Toru Kobari (Japan) and Dr. Akash Sastri (Canada). 16 participants including the national representatives and observers attended the meeting (***WG 37 Endnote 1***). Several members who could not attend the meeting reported progress on their inter-sessional activities (see ***WG 37 Endnote 2***) and/or provided comments through the E-mail communication.

AGENDA ITEM 1
Description on terms of references

Dr. Kobari described the terms of references for the Working Group (see WG 37 webpage).

AGENDA ITEM 2
Activities in 2018

Drs. Kobari and Sastri reported the following WG activities achieved in 2018.

- Drs. Kobari, Sastri and Yebra Lidia convened a session on "*Zooplankton Productivity as a Function of Trophodynamics in Marine Ecosystems*" at the Ocean Science Meeting 2018 on 15 February 15 in Portland, Oregon, USA. More than 30 people attended, and 6 talks and 9 posters were presented (see ***WG 37 Endnote 3***).
- Drs. Kobari, Shinji Shimode and Koichi Ara convened a Practical Workshop Phase 1 from October 22 to 24, 2018 (just before the PICES 2018 Annual Meeting) in Manazuru Marine Center for Environmental Research and Education, Yokohama National University. Nineteen participants, including conveners and support staff, attended. Onboard sampling, laboratory work and lectures on egg production and empirical models were provided (see PICES Press, Vol. 27, No. 1).
- The Co-Chairs convened a Workshop in the PICES 2018 Annual Meeting on 25 October 2018 in Yokohama. Twenty-eight people attended, and 8 talks and 4 posters were presented (see W6 in 2018 Session and Workshop Summaries).

AGENDA ITEM 3
Future plans

Plans to promote terms of reference

After Dr. Kobari described the tentative plans regarding the WG terms of references, the participants provided comments and suggestions.

1. Review papers on traditional and biochemical methodologies (ToR1).
   - Review paper by L. Yebra, T. Kobari, A.R. Sastri *et al*. on biochemical approaches published in *Advances in Marine Biology*, 2017, 76: 157–240, http://dx.doi.org/10.1016/bs.amb.2016.09.001.
   - Review paper on traditional methodologies written by T. Kobari, A. Sastri and L. Yebra following comments and suggestions kindly provided by Dr. Charles Miller. Additional comments and suggestions will be provided by Drs. R. Hopcroft and H. Liu. This review paper will be submitted to Special Issue

on Climate, Zooplankton and Salmon (Dr. Bill Peterson Commemorative Issue) of *Progress in Oceanography* by the end of November 2018.

2. Guidelines and recommendations (procedures/protocols) of traditional and biochemical methodologies (ToR2).
   - Recommendations and procedures for the biochemical methodologies were included in the review paper by Yebra *et al*. (2017; see above) as supplements. The Co-Chairs asked Dr. Yebra (*ex officio* WG member, representing ICES) to make the draft based on the review paper. These documents will be posted on the PICES website and/or final report.
   - Similar guidelines for the traditional methodologies are now being developed by the WG members and colleagues. The Co-Chairs asked WG members and colleagues for guidelines on the following: molting rate by Dr. Hopcroft (USA member) and T. Kobari (Co-Chair), artificial cohort by H. Liu (USA member), egg production by Dr Shinji Shimode (materials for Practical Workshop Phase 1), empirical models by Dr. Koichi Ara (materials for Practical Workshop Phase 1) and physiological models by T. Kobari. Dr. Kobari will circulate some examples of these guidelines after PICES-2018. These guidelines will be posted on the PICES website and/or final report.

3. Develop practical models for estimating zooplankton production to time-series (ToR3).
   - The Ikeda-Motoda method would be only one to be applicable to zooplankton time-series due to the wide coverage of various taxonomic groups, locations and situations, minimum requirements of variables for only temperature and animal body weight, and high temporal and spatial resolutions.
   - Dr. Kobari applied the Ikeda-Motoda model to some zooplankton data-sets (Kobari *et al*., 2018, *Fisheries Oceanography*, 27: 336–350, https://doi.org/10.1111/fog.12256). Drs. Kazuaki Tadokoro and Sastri demonstrated the applications of the Ikeda-Motoda model to zooplankton data-sets in the Inland Sea of Japan and on the Canadian coast at workshop W6 during PICES-2018 (see also Agenda Item 7).
   - WG members encouraged the use of such applications, using zooplankton time-series or data-sets in the PICES region. Drs. Kobari and Tadokoro will help in the estimation.
   - On the other hand, as suggested by Dr. C.H. Hsieh, the regional model for zooplankton growth or production applicable to the PICES region should be developed by sharing data-sets of the direct measurements on zooplankton growth/production and environmental variables. The Co-Chairs asked Drs. Liu, Hopcroft, and Hsieh to work on the development of the regional model using their data sets. Dr. Kobari will also contribute.

4. Build a platform of information exchange on zooplankton production measurements through an interactive website for regional and/or global mapping (ToR4).
   - The Co-Chairs asked Dr. Yebra to apply the Ikeda-Motoda and/or Banse-Mosher models to the COPEPOD data base in collaboration with its organizer, Dr. T. O'Brien (USA member). Unfortunately, it was reported that it was too difficult to get permission from each data owner.
   - As alternative approaches, the Co-Chairs seek zooplankton data-sets or time-series in the PICES region, and permissions from the data owners. Available zooplankton data-sets or time-series and their data owners are as follows. Other data sets are welcome.
     - Station P and line P in the subarctic North Pacific (I. Perry, A. Sastri, Canada)
     - BATS in the subtropical North Atlantic (D. Steinberg, T. Kobari, USA)
     - Newport line in the western US coast (J. Fisher, USA)
     - Tsushima Strait in the Japan Sea (T. Kobari, Japan)
     - Kuroshio in the East China Sea (T. Kobari, Japan)
     - A-line in the western North Pacific (T. Tadokoro, Japan)
     - Inland Sea of Japan (K. Tadokoro, Japan)
     - Strait of Georgia (I. Perry, A. Sastri, Canada)

- Using these estimates, regional comparisons of zooplankton production estimates will be included in the final report.
- WG 37 will seek comparisons between the group's mesozooplankton productions with the models at each time-series to the results of mesozooplankton biomass or abundance from ETSOs.

5. Build a network of scientists and laboratories measuring zooplankton production among PICES and ICES nations as well as developing countries (ToR5).
   - The Co-Chairs asked the WG members to seek scientists and laboratories measuring zooplankton production. In particular, information from Chinese and Russian representatives is especially welcome as there is nobody available at the moment. (Dr. Hong Xia Ming will contact Chinese WG member Dr. Qing Yang on this issue)
   - The Co-chairs are making a list of the information on the scientists and laboratories (*e.g.*, name, institute, email, methodology used, publications) which will be posted on the PICES website.
   - The Co-chairs will ask Dr. Yebra to join this list from ICES Working Group on Zooplankton Ecology.

6. Promote international collaborations among zooplankton production researchers through international organizations such as PICES, ICES and IMBER (ToR6).
   - The Co-Chairs asked the WG members to seek the information on potential funding opportunities for international collaboration on zooplankton production estimates. Some examples of Japanese funding were introduced at the meeting.
   - The Co-Chairs proposed "Practical Workshop Phase 2" to be held just before PICES-2019 (***WG 37 Endnote 4***). Biochemical approaches are the target methodologies in this workshop.
   - *In situ* or laboratory experiments for comparing the traditional methodologies will be conducted by Drs. Kobari and Sastri and preliminary results were already demonstrated at PICES-2017. These results will be published in the final report.
   - The Co-Chairs will seek a collaborative session or workshop with *ex officio* member, Dr. Yebra in the 2021 Zooplankton Production Symposium.

7. Publish a final report summarizing results (ToR7).
   - Dr. Kobari proposed a tentative plan of contents and responsible authors for the final report, referring the previous reports for the past working groups as follows.

     In Memoriam (Toru Kobari and Akash Sastri)
     Executive Summary (Toru Kobari, Akash Sastri and Lidia Yebra)
     1) Introduction (Toru Kobari)
        Background and Rationale
        Working Group Timeline
     2) Principle, advantages/disadvantages and recommendations
        2-1) Traditional methodologies (from review paper) (Toru Kobari)
           Natural Cohort
           Artificial Cohort
           Molting Rate
           Egg Production
           Empirical Models
        2-2) Biochemical approaches (from review paper) (Lidia Yebra)
           Nucleic Acid Indices
           Enzymatic Methods
           Chitobiase Activity
           Protein Synthetases Activity

3) Procedures
   3-1) Traditional methodologies
      Artificial Cohort (Russ Hopcroft and Hui Liu)
      Molting Rate (Russ Hopcroft and Toru Kobari)
      Egg Production (Shinji Shimode)
      Empirical models (Koichi Ara)
      Physiological models (Toru Kobari)
   3-2) Biochemical approaches (from review paper)
      Nucleic Acid Indices (Toru Kobari)
      Chitobiase Activity (Akash Sastri)
      Protein Synthetases Activity (Lidia Yebra)
3) Zooplankton Production Measurements in Regional Seas (review on the previous studies)
      Gulf of Alaska (Russ Hopcroft and Hui Liu)
      Bering Sea (Akash Sastri)
      Okhotsuk Sea (Russian members?)
      Western North Pacific (Toru Kobari)
      Japanese Coast (Toru Kobari)
      Korean Coast (Se-Jong Ju and Jung-Hoon Kang)
      East China Sea (Chinese members?)
4) Application of Empirical Models to Zooplankton Data Sets in PICES region
      Station Papa (Akash Sastri)
      West Coast of Vancouver Island and Strait of Georgia (Akash Sastri)
      Inland Sea of Japan (Kazuaki Tadokoro)
      Western North Pacific (Toru Kobari)
      Oregon coast (Jennifer Fisher and Samantha Zeman)
      Bering Sea (Dave Kimmel? and/or Russ Hopcroft?)
5) Comparisons among Methodologies
      Protein Synthetase Activity vs. Natural Cohort (Toru Kobari)
      Chitobiase Activity vs. Natural Cohort (Akash Sastri)
6) Concluding Remarks (Toru Kobari, Akash Sastri and Lidia Yebra)
      Recommendations
      Future Prospects
7) Acknowledgements (Toru Kobari)
8) References
9) Supplemented Information (Toru Kobari)
      Appendix 1 WG37 Terms of References
      Appendix 2 WG37 Membership
      Appendix 3 Business Meeting Reports from Past PICES Annual Meetings
      Appendix 4 Session/Workshop Summaries of International Conference Related to WG37
      Appendix 5 Bibliography
      Appendix 6 Information on Laboratories Working on Zooplankton Production

- WG members discussed the outline, sections and responsible authors of the report at the WG business meeting 2018. This tentative plan will be circulated in November 2018 and confirmed within 2018 (all responsible authors will start to write from 2019).
- Bibliography of zooplankton growth and production in the North Pacific will be included in the report. WG members will assemble the literature for zooplankton growth and production studies for each country and report them at the WG business meeting 2018. Currently, there is limited or no information on papers in the Chinese and Russian waters.

Workshop for PICES-2019

Drs. Sastri and Kobari proposed 1-day workshop for PICES-2019 (***WG 37 Endnote 4***). This workshop is intended to provide a venue for further projects collaborating with the ICES Working Group on Zooplankton Ecology. The proposed workshop supports the terms of reference and final report of WG 37.

Practical Workshop Phase 2

See ***WG 37 Endnote 5***.

AGENDA ITEM 4
Others

Bibliography for zooplankton production methodology and measurements in the PICES region

The published papers on Korean and Japanese waters are listed to the report bibliography. The Co-Chairs asked WG members to collect more literature, in particular, papers from the Chinese and Russian regions.

Report of Workshop at PICES-2018

Dr. Kobari showed the participants the summary report of W6 on "*Regional evaluation of secondary production observations and application of methodology in the North Pacific*" that will be submitted it to the PICES Secretariat after the Annual Meeting.

WG 37 members and participants at workshop W6.

WG members and guests enjoy dinner at a Japanese soba restaurant after a successful Workshop (W6) at PICES-2018.

Report of Practical Workshop Phase 1 in Manazuru

Dr. Kobari showed the participants a report of the Practical Workshop Phase 1 that will be submitted to PICES Press after the Annual Meeting.

WG 37 Endnote 1

WG 37 participation list

Members

Se-Jong Ju (Korea)
Jung-Hoon Kang (Korea)
Russ Hopcroft (USA)
Hui Liu (USA)
Toru Kobari (Co-Chair, Japan)
Akash Sastri (Co-Chair, Canada)
Kazuaki Tadokoro (Japan)

Members unable to attend

China: Qing Yang
Russia: Vladimir Napazakov
USA: Todd O'Brien

Observers

Jennifer Fisher (USA)
Chih-hao Hsieh (China)
Megu Iwazono (Japan)
Takeru Kanayama (Japan)
Lian Kwong (Canada)
Hong Xia Ming (China)
Emma Moritoshi (Japan)
Chailinn Park (Korea)
Atsushi Tsuda (Japan)
Naoki Yoshie (Japan)
Samantha Zeman (USA)

WG 37 Endnote 2

WG 37 meeting agenda

1. Terms of reference

2. Activities in 2018
- Session in the Ocean Science Meeting
  - Practical Workshop Phase 1
  - Workshop in the PICES 2018 Annual Meeting

3. Future plans
  - Plans to promote terms of reference
  - Workshop in the PICES Annual Meeting 2019
  - Practical Workshop Phase 2

4. Others
  - Bibliography for zooplankton production methodology and measurements in the PICES region
  - Report of Workshop in PICES 2018 Annual Meeting
  - Report of Practical Workshop Phase 1

WG 37 Endnote 3

Session in the Open Science Meeting

Zooplankton Productivity as a Function of Trophodynamics in Marine Ecosystems
Oregon Convention Center, Oregon, USA
February 15, 2018

Presentations

6 Talks (4 abstracts withdrawn)

1. T. Kobari: Session introduction, Zooplankton Productivity as a Function of Trophodynamics in Marine Ecosystems
2. G.A. Paffenhofer: Do doliolids eat eggs and juveniles of copepods?
3. C. Barth-Jensen *et al*.: Temperature-dependent egg-hatching and production of the egg-carrying copepods *Microsetella norvegica* and *Oithona similis* in a high latitude fjord
4. T. Ohnishi *et al*.: Identification method for starved female *Calanus sinicus* (Calanoida: Copepoda) based on differential gene expression profile
5. T.A. Venello *et al*.: Estimating crustacean zooplankton production rates and energy transfer in the NE Pacific
6. J. Duffy-Anderson *et al*. (presented by David Kimmel): Copepod dynamics across warm and cold periods in the eastern Bering Sea: Implications for walleye pollock (*Gadus chalcogrammus*) and the Oscillating Control Hypothesis

9 Posters (1 abstract withdrawn)

1. B.T. Jaspe *et al*.: Abundance, distribution and species composition of cyclopoid copepods in the upwelling region off northern Zamboanga Peninsula, Philippines
2. T. Kobari *et al*.: Community structure, standing stock and productivity of mesozooplankton in the southern Kyushu, Japan
3. T. Honma *et al*.: Spatial and temporal variations in community structure, standing stock and productivity of mesozooplankton in the downstream of the Tsushima Strait
4. C. Mckinstry and R.W. Campbell: Seasonal variation of zooplankton abundance and community structure in Prince William Sound, Alaska, 2009–2016
5. A. Poje *et al*.: Growth of calanoid copepods on an Arctic shelf
6. K. Suchy *et al*.: Temporal variations in depth-specific crustacean community structure and productivity estimates in a temperate fjord
7. L. Brotz and D. Pauly: The scale of jellyfish fisheries
8. R. Abualhaija *et al*.: Variability of zooplankton production across temporal and spatial scales in the Eastern Mediterranean ultra-oligotrophic pelagic region
9. R. Wahle *et al*.: The ‘Great Disconnect’: New lows in Gulf of Maine lobster recruitment during a boom in egg production linked to changes in the pelagic food web

WG 37 Endnote 4

Proposal for an inter-sessional Practical Workshop Phase 2

Following on the success of the practical workshop on "Production methodologies and measurements for in situ zooplankton', which was co-hosted by PICES Working Group 37 and Yokohama National University, we propose a second practical workshop that focuses on biochemical methods. PICES Working Group 37, Ocean Networks Canada and the Hakai Institute will jointly host this second workshop.

The goal of the second workshop is to provide a "hands-on" practicum on the two most widely used biochemical methods for measuring zooplankton production rates. The first method is Aminoacyl-tRNA-synthetases activity. The second method is Chitobiase activity. In addition, lectures would be given by Hakai and UBC scientists detailing other phytoplankton and zooplankton collection methods.

We suggest that a 3-day workshop is run at the Hakai Institute's Quadra Island field station preceding the PICES 2019 Annual meeting that is taking place in Victoria, Canada. Tentative dates are October 14 to 16, 2019. Quadra Island is located about 4 hours north of Victoria by car and ferry. Once at the Hakai Institute's Quadra Island field station, participants will have access to boats for sample collection, laboratory space for learning and practicing and biochemical methods, and meeting space for dedicated lectures and discussions. In addition, accommodation and food provided by the Hakai Institute means that attendees can stay on site and focus on outcome of the workshop.

We estimate that there will be 10 international participants at this workshop (3 to 4 lecturers and 6 early career attendees). We estimate the following in kind support from ONC and the Hakai Institute:

- Transport from Victoria to Quadra Island (funded by ONC) ~$750.
- Accommodation, field and lab support, and food on Quadra Island (funded by Hakai Institute at $200 per person per day) ~$6000.

There are several anticipated deliverables of this workshop:

- About 10 Canadian and international scientists will be exposed to Hakai Institute's Quadra Island field station where new zooplankton production techniques will be taught and learned.
- This workshop is a partial fulfillment of one of Working Group 37's terms of reference.

This would enhance collaborative opportunities, particularly between ONC and Hakai.

WG 37 Endnote 5

Proposal for a Workshop on
"*PICES/ICES collaborative research initiative: Toward regional to global measurements and comparisons of zooplankton production using existing data sets*" at PICES-2019

Duration: 1 day

Convenors: Toru Kobari (Japan), Akash Sastri (Canada), Lidia Yebra (ICES/Spain)

Suggested Invited Speakers: TBD

Material and energy transfer in the lower food web are integrated through zooplankton communities. The standing stock and productivity of this group represent a proxy for the functional response of marine ecosystems to regional and global climate change. A variety of methods and information on zooplankton production rates have been assembled over the past half century, however, we are still struggling in our evaluation of zooplankton productivity and its driving forces. This workshop will discuss prospective tasks and collaborative research activities in an effort improve and standardize zooplankton field (and laboratory) methods from both PICES and ICES nations. We encourage presentations and discussion on novel applications of traditional and biochemical methodologies and/or new approached for evaluating zooplankton productivity in the field.