Report of the Biological Oceanography Committee

The meeting of the Biological Oceanography Committee (BIO) took place from 18:00–19:30 h on October 19 and 14:00–19:00 h on October 22, 2014, in Yeosu, Korea. The Chairperson, Dr. Angelica Peña, called the meeting to order and welcomed members and observers (*BIO Endnote 1*). Dr. Peña introduced a new BIO member, Dr. Kaoru Hattori, representing Japan. It was noted that several members were not present at the meeting. In particular, there were no members from China and USA, and only one member from Russia and Canada. The lack of participation of BIO members to the meeting was discussed and it was agreed to bring this to the attention of Science Board. Because there were no members from English speaking countries (apart from Chairperson) at the meeting, there was no rapporteur on the first meeting. For the main meeting on October 22, a member of the U.S. delegation (Dr. William Sydeman) acted as rapporteur. The draft agenda was circulated and two items were added to the agenda: i) proposals for new expert groups, and ii) 2015 ICES ASC Theme Sessions for consideration of co-sponsorship. The agenda was adopted (*BIO Endnote 2*).

AGENDA ITEM 4
Annual review of BIO activities

a) PICES-2014 BIO-sponsored Paper/Topic Sessions

- ½-day BIO Contributed Paper Session, Convenors: Angelica Peña (Canada), Atsushi Tsuda (Japan);
- ½-day BIO Topic Session (S2) on "*Strengths and limitations of habitat modeling: Techniques, data sources, and predictive capabilities*", Convenors: Enyuan Fan (China), Elliott Hazen (USA), Sei-Ichi Saitoh (Japan), William Sydeman (USA), Yutaka Watanuki (Japan); Invited Speakers: Hiroto Murase (Japan), Martin Renner (USA);
- 1-day BIO/MEQ Topic Session (S3) on "*Tipping points: defining reference points for ecological indicators of multiple stressors in coastal and marine ecosystem*", Convenors: Rebecca G. Martone (USA), Ian Perry (Canada), Jameal Samhouri (USA), Motomitsu Takahashi (Japan), Maciej Tomczak (Poland), Chang Ik Zhang (Korea); Invited Speakers: Phillip Levin (USA), Tetsuo Yanagi (Japan);
- ½-day BIO/MONITOR/TCODE Topic Session (S4) on "*Use of long time series of plankton to inform decisions in management and policy concerning climate, ecosystems and fisheries*", Convenors: David Checkley (USA), Sanae Chiba (Japan); Invited Speakers: M. Lindegren (Denmark), A. McQuatters-Gollop (UK).

As shown in the following table, BIO had the highest number of orals, and posters (tied with MEQ) to evaluate during the meeting.

Committee	Total number of orals	Total number of posters
SB	13 (open to everyone)	3
BIO	**15**	**23**
FIS	7	8
MEQ	8	23
POC	10	13
MONITOR	1	1
TCODE	5	8

The "Procedures for Documenting PICES Topic Sessions and Workshops" from the Science Board Briefing Book were circulated to BIO members.

b) 2014 Inter-sessional symposia/session/workshop/meetings

Drs. Peña and Hiroaki Saito mentioned some highlights of the successful FUTURE Open Science Meeting. They also summarized the main points presented by the FUTURE Evaluation Team Meeting to Science Board. The Chair requested feedback from each member on how to select suitable members of the FUTURE SSC and what should be the priority topics during the next phase.

c) Travel and representation at the meetings of other organizations/programs

Reports from two meetings were presented: i) ICES/PICES Theme Session on "*Gelatinous zooplankton on a global perspective: interactions with fisheries and consequences for socio-economics*" at the 2014 ICES Annual Science Conference prepared by Dr. Richard Brodeur (*BIO Endnote 3*), and ii) ICES/PICES/ ECOKNOWS Symposium on "*Ecological basis of risk analysis for marine ecosystems*" prepared by Dr. Alexei Orlov (in *PICES Press*, Vol. 22, No. 2).

d) Publications

The final report of WG 26 on *Jellyfish Blooms around the North Pacific Rim* (Editors: R. Brodeur, S. Uye) is in preparation.

AGENDA ITEM 5
Reports of BIO active and proposed expert groups

a) Section on *Climate Change Effects on Marine Ecosystems* (S-CCME)

Dr. Jake Rice presented the report of S-CCME. He reviewed the objectives and recent work, including: 1) planning for PICES-2014 Topic Session (S7) on "*Recent assessments of climate change impacts on marine ecosystems*"; 2) workshop at the FUTURE Open Science Meeting (April 15–18, 2014, Kohala Coast, Hawaii, USA) to address readiness to use RCMs, coordinated with CLIVAR, model intercomparison, (W4) "*Ecosystem projection model inter-comparison and assessment of climate change impacts on global fish and fisheries*"; 3) dynamics of fish under climate change, develop cooperative science plan, (W3) "*Climate change and ecosystem-based management of living marine resources: Appraising and advancing key modelling tools*"; 4) work on Arctic ecosystems between US and Norway (Barents and Bering) under climate change, with focus on responsible development of the Arctic, *etc*.

Planned activities include: a) 3-day international workshop on "*Ecosystem projection model inter-comparison and assessment of climate change impacts on global fish and fisheries*" (August 10–12, 2015, Princeton, U.S.A.) to integrate and compare GCMs under different RCMs, model details, what works and what doesn't; b) Theme Session (S10) on "*Forecasting climate change impacts on fish populations and fisheries*" at the 3rd PICES/ICES/IOC Symposium on "*Effects of climate change on the world's oceans*" (March 21–27, 2015, Santos, Brazil), c) participation at the ESSAS Annual Science Meeting (June 15–17, 2015, Seattle, USA), on sea ice edge effects on marine ecosystems. There was some discussion about how the Arctic fit with PICES interest. There was agreement that focusing on sea ice is important but the geographic limits of PICES "region" are unclear. S-CCME requests a member of BIO to join S-CCME. BIO will address in the future (no immediate volunteers).

b) Section on *Carbon and Climate* (S-CC)

A summary of planned activities was given by S-CC Co-Chair, Dr. James Christian. He announced that Dr. Tsuneo Ono accepted the nomination to be new Co-Chair, replacing Dr. Toshiro Saino (deceased). The objectives for 2015/2016 are to: 1) convene 1-day Topic Session at PICES-2015 on "*Ocean Acidification Observation Network for the Arctic and sub-Arctic Pacific oceans*" (see *S-CC Endnote 3* in the Annual Report of S-CC), and 2) develop basin-wide acidification assessment and convene a workshop in 2016.

S-CC financial request: i) PICES affiliate member of SCOR WG 140 (Biogeochemical Exchange Processes at the Sea–Ice Interfaces; BEPSII) to attend a WG 140 meeting (March 20, 2015, Barga, Italy), ii) an early career scientist to attend an IOC/SCOR IOCCP training course on biogeochemical sensors (June 22–July 1, 2015, Kristineberg, Sweden), iii) proposed Topic Session at PICES-2015 (see above), and iv) 1-day meeting at PICES-2015.

c) Advisory Panel on *Marine Birds and Mammals* (AP-MBM)

A report was presented by AP-MBM Co-Chairman, Dr. Yutaka Watanuki. AP-MBM is due to be reviewed by BIO for another 3-year extension. Dr. Watanuki reviewed progress of last 3 years and plans for final PICES Scientific Report from its Spatial Ecology and Conservation Activity Plan. He also presented a rough plan for the next 3 years that focus on "Climate and Trophic Ecology of Marine Birds and Mammals". BIO is happy with progress and, as the parent committee of AP-MBM, supports the continuation of its activities, but wants to see the final report on Spatial Ecology (by the next ISB meeting), and also wants to provide AP-MBM time to develop its new activity plan. BIO suggested changes to the draft activity plan. In particular, some products need to be identified, such as a report or publications. An updated plan will be ready for BIO evaluation before the next ISB. A report summarizing the business meeting of AP-MBM , held October 17, 2014, was submitted to BIO.

d) Working Group 26 on *Jellyfish Blooms around the North Pacific Rim: Causes and Consequences*

Co-Chairs, Drs. Shin-ichi Uye and Richard Brodeur, were not able to attend the meeting, but submitted a report (*BIO Endnote 4*) describing past activities and progress on the preparation of the WG final report. They had some delays on the report but are working on completing it for next year.

e) Working Group 28 on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*

A summary of activities was presented by Co-Chair, Dr. Motomitsu Takahashi, including the outcome from the 1-day BIO/MEQ Topic Session S3 on "*Tipping points: defining reference points for ecological indicators of multiple stressors in coastal and marine ecosystem*" at PICES-2014, which had excellent presentations. The content of the final WG report was slightly modified; multiple stressors prevail, review of MSFD (Marine Strategy Framework Directive) indicators (11 general and many specific ones). A scientific paper by Boldt *et al*. on selecting ecosystem indicators for multiple stressors has been accepted for publication in *Oceanography* and will form the basis of a chapter of the final report which will be submitted by spring 2016.

f) Working Group 29 on *Regional Climate Modeling*

Co-Chair, Dr. Chan Joo Jang, presented a summary of activities for 2014/2015, which included a Theme Session (S2) on "*Regional climate modeling in the North Pacific*" at the 2014 FUTURE OSM (April 15–18, Hawaii, USA), 1-day POC/TCODE/FUTURE Topic Session (S10) on "*Regional climate modeling in the North Pacific*" at PICES-2014 and a Theme Session (S4) on "*Regional models for predictions of climate change impacts: methods, uncertainties and challenges*" at at the 3rd PICES/ICES/IOC Symposium on "*Effects of climate change on the world's oceans*" (March 21–27, 2015, Santos, Brazil). Dr. Jang also presented plans for the final WG report to be completed in 2016. There was some discussion on how to promote better communication and integration with other PICES expert groups.

Proposal for a new Working Group on "Biodiversity and Deep-water Biogenic Habitats"

Dr. Janelle Curtis, Chair of the Study Group on *Biodiversity Conservation* (SG-BC) presented a proposal to BIO to establish a new Working Group on "Biodiversity and Deepwater Biogenic Habitats". She noted that BIO has supported scientific activities related to biodiversity in the past decade, including a Census of Marine Life (CoML) symposium in 2003 in Washington, DC, USA, and a Topic Session (S4) on "*Census of Marine Life – Exploring ocean life: Past, present and future*" at PICES-2010. More recently, POC and BIO co-sponsored a Topic Session (S2) on "*Mechanisms of physical-biological coupling forcing biological hotspots*" at PICES-2011. If supported, the scientific outputs of the proposed expert group would be of interest to BIO

members and of broader relevance to the scientific activities that BIO undertakes, including: i) Technical guidance on development and application of predictive species and habitat modeling approaches, ii) Maps of known and predicted distribution and abundance of biogenic species habitat (and diversity) in North Pacific Ocean, iii) Potential biodiversity indicators of biogenic species/habitat for biodiversity assessment and monitoring, and iv) Identification of additional taxa that could serve as indicators of VMEs, and technical guidance on conducting assessments for these taxa.

BIO is supportive of the formation of this group since it feels this could be an important addition, but the proposal needs to include representation from more countries, identify specific activities, and collaboration with other expert groups. A final product needs to be articulated. BIO suggests the proposed expert group to focus on biogenic habitat and to include shallow habitat.

Proposal for a new Study Group on "Ecosystem Reference Points as a Common Currency across PICES Social-Ecological Systems"

Dr. Elliott Hazen presented a proposal for a 1-year study group that would be relevant to BIO, FIS, and POC. This study group would build upon the goals and outcomes of WG 28 and would address FUTURE Objective 1 to understand "what determines an ecosystem's intrinsic resilience and vulnerability to natural and anthropogenic forcing."

Although BIO supports the creation of this SG, it was not clear why BIO is being asked to sponsor it since it seems to belong closely to FIS. Also, since the SG would build upon WG 28, it may be better to postpone the study group until WG 28 finishes its work.

Summary of BIO decisions regarding expert groups' important matters

1. BIO will address at the next Annual Meeting the request from S-CCME that a member of BIO join S-CCME.
2. BIO has received a 3-year progress report of AP-MBM and supports the continuation of its activities, but wants to see the final report on Spatial Ecology (by the next ISB-2015), and a new activity plan before it approves a renewal.
3. BIO supports the proposal for a new Working Group on "Biodiversity and Deep-Water Biogenic Habitats".

AGENDA ITEM 6
FUTURE program

BIO members agreed with the FUTURE Team Evaluation Report and recommendations, in particular, with the need for better communication and coordination among expert groups. There was some discussion that the "FUTURE" acronym causes confusion, as this program is not just about projections, and individuals may be dissuaded from contributing to the program because of what the name implies. BIO members suggested it would be useful to clarify to PICES community that FUTURE is the second integrative science program of PICES but that: 1) not all science activities need to be aligned with FUTURE, and 2) FUTURE is not only about predictions/projections, but that understanding present conditions and carrying out process studies are also important. It was suggested that BIO science activities maybe have been negatively affected by lack of understanding of the program. How can BIO best contribute to FUTURE? BIO could oversee more integrative science such as more multi-disciplinary and multi-trophic level investigations. Also, although early career scientists give presentations at PICES Annual Meetings, they need to be promoted to participate in BIO Committee meetings and BIO-related working groups. However, members felt the main constraint of science activities and participation in PICES is likely due to lack of funding.

BIO approves the formation of a study group to explore production of the Ecosystem Status Report.

AGENDA ITEM 7
Relations with other international organizations/programs

a) Dr. Sinjae Yoo, representing SCOR, provided a summary of the SCOR Annual Meeting held in September in Bremen, Germany. BIO evaluated the SCOR working group proposals and recommended a proposal on "biogeography" but did not rank it high. (Science Board members have to evaluate new proposals between June and September.) Dr. Yoo mentioned that BIO was welcome to propose a PICES/SCOR working group, which BIO will keep in mind for the future.
b) Dr. Franz Mueter presented a summary of the activities of ESSAS. ESSAS has five active working groups: i) Modeling Ecosystem Responses, ii) Arctic-Subarctic Interactions, iii) Bioenergetics of Subarctic Fishes, iv) Human Dimensions, and v) Paleo-Ecology of Sub-Arctic Seas. The ESSAS Annual Science Meeting took place in Copenhagen, Denmark, in April 2014; ESSAS was represented by Dr. Mueter (Co-Convenor) of Topic Session S9 on "*Variability in advection and its biological consequences for Subarctic and Arctic ecosystems*" at PICES-2014. The next ESSAS Annual Science Meeting on "*Sea ice edge effects on marine ecosystems*" will be held June 15–17, 2015, in Seattle, USA. ESSAS asked BIO to consider supporting at least one sientist to attend the meeting.
c) Dr. Kenneth Drinkwater presented the new working plan of IMBER. He mentioned that IGBP is being replaced by the Future Earth program. IMBER has and will continue to collaborate with PICES and ICES.
d) Dr. Hidehiro Kato, representing PICES, attended the 66th scientific committee meeting of the International Whaling Commission (IWC) in Bled, Slovenia (May 12–24, 2014). He could not attend PICES-2014 but submitted a written document to AP-MBM and BIO (see *AP-MBM Endnote 4* in AP-MBM's Annual Meeting Report).
e) BIO briefly reviewed the information on 17 theme sessions that were approved by ICES for their 2015 ASC but did not identify any that BIO would like to sponsor.

AGENDA ITEM 8
PICES-2014 BIO Best Presentation and Poster award

Judges for selecting PICES-2014 BIO Best Presentation and Poster Awards were nominated: Kaoru Hattori and Hiroaki Saito (S2), Alexei Orlov (S3), Se-Jong Ju and Atsushi Tsuda (BIO). For the Poster presentation, each Committee member was to list two top candidates and provides the names to Dr. Peña before the end of the Closing Session so the rankings could be compiled by her. The Best Presentation Award to an early career scientist for a BIO-sponsored Topic Session was given to Jaeyong Bae (*Population structure and life history of Neomysis awatschensis (Crustacea:Mysidae) in Jeju Island, Korea*), and BIO Best Poster Award was given to Ah-Ra Ko (*Tracking seasonal dietary shift of Euphausia pacifica in the Yellow Sea using stomach contents and lipid biomarkers*).

AGENDA ITEM 9
Planning for PICES-2015

2015 PICES Annual Meeting theme, "*North Pacific ecosystem change and sustainability*", will take place in Qingdao, China. There was some confusion and difficulties among members on deciding what Topic Sessions should be sponsored by BIO. Because several BIO members did not attend the Annual Meeting, it was decided to sponsor sessions according to BIO Committee member ratings before the Annual Meeting. Thus, sessions that were added during the Annual Meeting were not considered.

BIO agreed to sponsor 3 Topic Sessions:
1. *The 2014/15 El Niño and anomalous warming of the North Pacific: What happened?* ($2k),
2. *Past, present, and future climate in the North Pacific Ocean: Updates of our understanding since IPCC* AR5 ($2k),
3. *Ocean Acidification Observation Network for the North Pacific and adjacent areas of the Arctic Ocean* ($1k).

AGENDA ITEM 10
Proposed inter-sessional meeting for 2015 and beyond

There was no input on this activity.

AGENDA ITEM 11
Documenting Sessions and Workshops

Dr. Peña reminded members of the request from Science Board to complete and send session summaries of topic sessions for PICES-2014 to the PICES Secretariat before the end of the Annual Meeting, and meeting reports of BIO expert groups within one month after the Annual Meeting.

AGENDA ITEM 12
Other business

BIO members discussed financial requests and set the following priority:
1. Travel support for an invited speaker to each of the BIO-sponsored Topic Sessions (See Agenda Item 9).
2. Support for an early career scientist to attend a training course (IOCCP) on biogeochemical sensors.
3. Support for one BIO representative to attend the 2015 ESSAS Annual Meeting.

BIO Endnote 1

BIO participation list

Members

Kaoru Hattori (Japan)
Se-Jong Ju (Korea)
Hyung-Ku Kang (Korea)
Alexei Orlov (Russia)
Angelica Peña (Canada, Chair)
Atsushi Tsuda (Japan, Vice-Chair)
Hiroaki Saito (Japan)
Nam-Il Won (Korea)

Observers

Christopher Anne (Japan)
Janelle Curtis (Canada)
Kenneth Drinkwater (IMBER, ESSAS, ICES)
Elliott Hazen (USA)
Franz Mueter (USA, ESSAS)
Patrick O'Hara (Canada)
Rolf Ream (USA, AP-MBM Co-Chair)
Martin Renner (USA)
Jake Rice (Canada)
Chris Rooper (USA)
William Sydeman (USA, rapporteur Oct. 22)
Motomtsu Takahashi (Japan)
Andrew Trites (Canada)
Yutaka Watanaki (Japan)
Sinjae Yoo (SCOR, past Science Board Chair)
Alexander Zavolokin (Russia)

BIO Endnote 2

BIO meeting agenda

1. Welcome, introductions, opening remarks
2. Membership changes: Dr. Michael Dagg stepped down as a member of BIO Committee representing USA. Dr. Kaoru Hattori is a new member of BIO Committee representing Japan.
3. Changes to, adoption of, agenda and appointment of rapporteur
4. Annual review of BIO activities
   a) 2014 PICES BIO Paper/Topic Sessions and Workshop
   b) 2014 Inter-sessional symposia/sessions/workshops/meetings
      – FUTURE Open Science Meeting (April 14–18, 2014, Kohala Coast, Hawaii, U.S.A.)
      – Inter-sessional Science Board Meeting (April 19–20, 2014, Kohala Coast, Hawaii, U.S.A.)
      – FUTURE Evaluation Team Meeting (April 19–20, 2014, Kohala Coast, Hawaii, U.S.A.)
      – Joint meeting of the Evaluation Team and Science Board (April 21, 2014, Kohala Coast, Hawaii, U.S.A.)
      – 2014 PICES Summer School on "*Ecological modeling for marine resources management and research*" (August 26–29, 2014, Gangneung, Korea)
   c) Travel and representation at the meetings of other organizations/programs
      – PICES convenor (Richard Brodeur) for the ICES/PICES session on "*Gelatinous zooplankton on a global perspective: interactions with fisheries and consequences for socio-economics*" at ICES Annual Science Conference, Sept. 15-19, 2014, Spain
      – PICES convenor (Alexei Orlov) for the ICES/PICES/ECOKNOWS Symposium on "*Ecological basis of risk analysis for marine ecosystems*" June 2–4, 2014, Finland, (see attached report).
   d) Publications
      – Final report of WG 26 on "Jellyfish Blooms around the North Pacific Rim" (Editors: R. Brodeur, S. Uye).
5. Progressive reports and future plans of BIO active groups
   a) S-CCME: Joint PICES/ICES Section on *Climate Change Effects on Marine Ecosystems* (S. Kim or A. Hollowed)
   b) S-CC: Section on *Carbon and Climate* (J. Christian)
   c) AP-MBM: Advisory Panel on *Marine Birds and Mammals* (Yutaka Watanuki or Rolf Ream)
   d) WG 26 on *Jellyfish Blooms around the North Pacific Rim: Causes and Consequences* (S. Uye or R. Brodeur)
   e) WG 28 on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors* (M. Takahashi or Ian Perry)
   f) WG 29 on *Regional Climate Modeling* (C.J. Jang or E. Curchister)

   Proposals for new expert groups
   – Working Group on "Biodiversity and Deep-water Biogenic Habitats" (Janelle Curtis, MEQ)
   – Study Group on "Ecosystem Reference Points as a Common Currency across PICES Social-Ecological Systems (Elliott Hazen)
6. Discussion of FUTURE program
   – Comments/views/opinions on evaluation of PICES FUTURE program by FUTURE Evaluation Team
   – Scientific priorities for next phase of FUTURE and key scientific questions that could be addressed within FUTURE
7. Relations with other international organizations/programs
   a) SCOR (Sinjae Yoo)
   b) ESSAS (Franz Mueter)
   c) IMBER (Ken Drinkwater)
   d) IWC (Hidehiro Kato?)
   e) PSG (Bill Sydeman?)
   f) ICES – 2015 ICES Sessions for consideration of co-sponsorship
8. PICES-2014 BIO Best Presentation and Poster award

a) Eligibility
   – Oral – 1st author and presenter should be early career scientist
   – Poster – no age limit
b) Sessions
   – BIO paper session, S2 and S3
c) Evaluation sheet (available from Secretariat, Rosalie)

9. Planning 2015 PICES Annual Meeting "*North Pacific ecosystem change and sustainability*" in Quingdao, China
   – BIO-related Topic Sessions (Conveners from BIO Committee and/or subsidiary bodies): 5 (ID# 1, 6, 9, 10 and 11) among total of 12 proposals
   – BIO-related workshops: 1 (ID# 3) among total of 5 proposals
10. Proposed inter-sessional meetings for 2015 and beyond
    a) 3rd PICES/ICES/IOC Symposium on "Effects of Climate Change on the World's Oceans" (Mar. 23–27, 2015, Santos City, Brazil)
    b) PICES/ICES/IOC 6th International Zooplankton Production Symposium (late April/early May 2016, Bergen, Norway). BIO recommended Atsushi Tsuda as convenor and Se Jong Ju and Desiree Tommasi as SSC members.
    c) PICES/ICES Symposium on "*Drivers of dynamics of small pelagic neritic fish resources*" (Early 2016, Western Pacific TBD). BIO recommended Bill Peterson as SSC member.
11. Documenting business meetings, topic sessions and workshops
    1. Business meeting summary (WG 26, WG 28, WG 29, AP-MBM, S-CC, S-CCME) – Chairs are asked to submit the summary reports to Secretariat within 1 month after the Annual Meeting.
    2. Topic Session summary – Conveners, to secretariat, before the end of the annual meeting: BIO Paper (A. Tsuda), S2 (Y. Watanuki), S3 (I. Perry), S4 (D. Checkley)
12. Other business
    PICES 25th Anniversary activities in USA in 2016 **—** Discuss possible activities of BIO
13. Adoption of BIO report and recommendations to Science Board

BIO Endnote 3

ICES/PICES Theme Session A on
"Gelatinous zooplankton on a global perspective: interactions with fisheries and consequences for socio-economics"

Conveners: Cornelia Jaspers, Denmark, ICES (coja@aqua.dtu.dk), Richard Brodeur, USA, PICES (rick.brodeur@noaa.gov), and José Luis Acuña, Spain, ICES (acuna@uniovi.es)

Theme session A on gelatinous zooplankton at the ICES Annual Science Conference 2014 in Spain attracted a large number of high quality research contributions from 18 different countries including Japan, Taiwan, Mexico, Russia, Israel, Australia, the US and many countries in Europe, and consisted of 29 oral and 16 poster presentations during the 1.5 day session. The high quality of presented research at this special theme session is underlined by the fact that two out of four outstanding presentation awards for the entire meeting were given to early career scientists from this session. The theme session was co-sponsored by ICES and was as such a follow up to the joint ICES/PICES session on jellyfish-fish interactions held at the annual PICES meeting in Hiroshima, Japan in 2012.

Gelatinous zooplankton (GZ) is a collective term for a taxonomically and functionally diverse group of organisms whose bodies contain a significantly higher water content than those of other classical zooplankton such as crustaceans. Members of the GZ – which include medusoid and siphonophore cnidarians, comb jellies and tunicates among others – exhibit rapid population dynamics leading to so-called blooms with the potential to interfere with ecosystem function, and impact fisheries, aquaculture and tourism. The main goal of this special theme session was to address the role and contribution of gelatinous zooplankton to the carbon cycling

and productivity of pelagic ecosystems, especially to higher trophic levels such as fish, and their impact on socio-economics (*e.g.*, jellyfish bloom formations due to bio-invasions, eutrophication, overfishing and impact on aquaculture and tourism).

The possibility that global change, overfishing, eutrophication, and other anthropogenic factors may be driving the oceans towards a "more gelatinous future" has stimulated research into the global distribution and long term trends of GZ biomass, a research focus exemplified by the global database of jellyfish records (JEDI) and the large regional coverage in this session. Contributions dealt with spatial and temporal variability of GZ biomass ranging from the North, Baltic, Mediterranean, Bering and Barents Seas to Australian and Japanese coastal waters, Gulf of Mexico and the northern California Current. Methodological approaches included not only classical sampling techniques but also promising technological advances with a presented *in situ* visualization tool allowing for micro-scale investigations of gelatinous zooplankton distribution patterns across frontal systems. This highlights that new approaches like camera systems should be incorporated into monitoring activities and field investigations to appropriately sample all spatial and temporal scales of the food web. A large set of presentations was devoted to address the distribution and impact of particularly problematic species like invasive or stinging groups (*i.e.*, scyphozoan and box jellyfish) and their direct impact on tourism, fisheries and aquaculture. Detailed studies on jellyfish fish interactions are sparse but apart from direct predation on fish recruits and interactions due to tissue damage and mass mortality in marine farmed fish, jellyfish can also be an important food source.

The direct predation impact of jellyfish on fish populations can be substantial, especially for regions where a large spatial and temporal overlap between fish recruits and jellyfish occurs. All these studies seem to respond to a growing concern of the potential threat jellyfish on aquaculture farms in Europe and Asia, where blooms lead to a mass mortality and high financial loss for the aquaculture industry. Further, as the geographic range of jellyfish is expected to expand due to climate change, these interactions between stinging jellyfish and aquaculture are expected to increase. Hence, detailed population dynamic investigations of bloom forming, stinging jellyfish species are needed to allow for establishment of a warning system for fishermen, like has been established for the NW Mediterranean Sea and in Japanese waters. A dramatic example of interference between gelatinous zooplankton bloom and fisheries was offered by the invited speaker Prof. Shin-ichi Uye from Hiroshima University, who reviewed the threat posed by jellyfish to fisheries in the Sea of Japan and adjacent coastal areas while demonstrating science-based mitigation practices which have saved the fishing industry several hundred million Euros annually.

Gelatinous zooplankton population dynamics are complex and require understanding of bottom-up and top-down pathways. Regarding bottom-up processes, several contributions addressed jellyfish reproduction potential in relation to hydrographical and environmental features including drift model for estimating the dispersal of recruits. The polyp stage and/or egg production rates are critical factors determining the future population size. In this context, examining the effects of the continued addition of artificial hard substrates necessary for polyp attachment is of paramount importance. Direct predation on fish eggs and larvae as well as competition for the same food lead to a complex interaction between jellyfish and fish; however, the detailed pathways whether it leads to either a fish dominated or a jellyfish dominated food web still remain hypothetical. Time series analyses from different regions of the worlds´ oceans showed that jellyfish overlap with fish in space and time and that jellyfish and forage fish share the same prey field (*e.g.*, Gulf of Mexico, Bering Sea, Barents Sea, Northern California Current). This leads to observed pattern of jellyfish-forage fish replacement cycles. Cross ecosystem comparison of the above mentioned systems show that jellyfish have a large footprint but a small reach component, leading to a low production available for higher trophic levels, while forage fish have a relatively small footprint and a large reach component, leading to higher transfer efficiencies up the food web. Hence, forage fish have a much larger reach/footprint ratio highlighting their importance as energy pathway compared to jellyfish. Modelling frameworks are now moving in the direction of incorporating different gelatinous zooplankton groups. For example, latest results of an Ecopath model were presented where three different functional gelatinous zooplankton groups were included, namely large carnivorous jellies, small gelatinous carnivorous and filter-feeders. Energy transfer metrics showed an order of

magnitude difference in the fraction of energy available for higher trophic levels compared to the footprint ratio between jellyfish and fish.

Regarding the socioeconomic perspective of gelatinous zooplankton blooms, our second invited speaker, Dr. Veronica Fuentes, from Spain, presented recent advances in understanding jellyfish population dynamics and socioeconomic consequences of jellyfish blooms. In the Mediterranean Sea, Fuentes and co-workers have established a tight coupling between society and scientific community including public outreach activities and a platform for jellyfish-sightings. A highly relevant tool in this context is the newly established jellyfish beaching information system. This system is based upon sighting information, monitoring activities, detailed knowledge about population dynamics of bloom forming species, and a new modelling framework which allows predicting species distributions to alarm authorities about beaches which are likely to suffer from jellyfish strandings.

Presentations showed that on a global scale the biomass of jellyfish has exceeded the biomass of small pelagic fish in several regions. Furthermore, it was shown that climatic changes can be linked to elevated jellyfish abundances with synchrony in jellyfish time-series evident across the world's oceans. While climate change signals were clear in many of the data sets presented, it is still highly debated which factors and mechanistic processes drive the observed variability in gelatinous zooplankton biomass between years and decades. Some studies highlighted the relationship between fish landings, their historic reduction due to overfishing and subsequent trends of increasing jellyfish populations. This indicates an indirect interaction between fishing impacts and jellyfish biomass, and potentially suggesting competition between jellyfish and the trophic level that the fisheries target (*i.e*., forage fishes). Though the causal relationships remain unclear, experimental results from this session confirm that direct competition effects between jellyfish and fish along with human impacts driving survival and reproduction of jellyfish (*e.g*., adding hard substrate and increased eutrophication levels) are important in understanding jellyfish population dynamics and the formation of blooms. Many risks (from reduced tourism to clogging of power plant coolant systems) associated with the threat of rising jellyfish and gelatinous zooplankton populations were identified during this session and these risks should be communicated to managers and policy makers directly. One presentation even highlighted the importance of public outreach and social media in communicating jellyfish science to a wider audience. If gelatinous zooplankton in general and jellyfish populations in particular are to be managed and their outbreaks prevented or mitigated, then the threat posed to fish, fisheries and other activities must be considered within an ecosystem approach to fisheries management. We have seen some attempts to do so in this session and hope that new results presented here will foster those approaches. In conclusion, jellyfish and gelatinous zooplankton threats to aquaculture, fisheries, tourism, and power generation are well known but the risks need to be better quantified. The trade-off between potential losses and the cost of mitigation should be considered and the acceptable risk levels evaluated. Ecosystem degradation and climatic changes alongside increased usage of the marine environment by man are likely to stimulate further outbreaks of gelatinous zooplankton populations and detrimental impacts by jellyfish may become more common. The development of an ecosystem approach to fisheries management provides a framework in which to address these issues.

Finally, the conveners from Theme Session A on gelatinous zooplankton have arranged for selected papers to be submitted to a special issue in *Journal of Plankton Research* devoted to this session theme and have commitments for over a dozen manuscripts to be submitted, including several from the PICES area.

BIO Endnote 4

Report of Working Group (WG 26) on *Jellyfish Blooms around the North Pacific Rim: Causes and Consequences*

The Working Group on *Jellyfish Blooms around the North Pacific Rim: Causes and Consequence* (WG 26) did not have an official meeting in 2013. There were plans to meet informally at PICES-2013 (Nanaimo, Canada) but due to U.S. government travel restrictions, Co-Chair, Dr. Richard Brodeur, was not able to chair the meeting. Several WG members who were in attendance did meet informally during PICES-2013 and proposed a session on jellyfish to be held at the FUTURE Open Science Meeting in Kohala, Hawaii, USA, but it was not accepted.

During the summer of 2014, Dr. Brodeur worked with two ICES colleagues (Cornelia Jaspers of Denmark and José Luis Acuña of Spain) to convene an ICES/PICES Theme Session A on "*Gelatinous zooplankton on global perspective: Interactions with fisheries and consequences for socio-economics*" at the 2014 ICES Annual Science Conference, September 15–19, 2014, held in A Coruña, Spain (see *Annex* for session description). WG Co-Chair, Dr. Shin-ichi Uye, was a keynote speaker for this session. This was a follow-up to the very successful PICES/ICES collaborative 1-day Topic Session (S7) on "*Jellyfish in marine ecosystems and their interactions with fish and fisheries*" held at PICES-2012, October 12–21, 2013, held in Hiroshima, Japan. The session, sponsored by the BIO and FIS committees, focused on the socio-economic impacts of blooms on humans, particularly related to fisheries.

Over the last twelve months, the WG members researched and wrote their sections for the report and numerous emails were exchanged among members. The WG made slight modifications to the outline of the report adding several new sections that were deemed useful to include. The major sections of the WG report are as follows: 1) Introduction and purpose, 2) Life history and population dynamics, 3) Sampling considerations, 4) Spatio-temporal variations of biomass and current bloom conditions in regional seas, 5) Physio-ecological properties, 6) Impacts on marine ecosystems and socio-economics, 7) Reducing jellyfish impacts, and 8) Conclusions and prioritized recommendations for future research.

Progress by the WG members has been made but unfortunately there are major sections of the report that have not been completed and no contributions have been received from three of the PICES member countries despite numerous requests from the Co-Chairs. This point has been raised with the PICES Secretariat and BIO and steps are being taken to remedy the situation. It is hoped that the report can be completed by the next PICES Annual Meeting.

Annex

Proposal for joint ICES/PICES Session on
"*Gelatinous zooplankton on a global perspective: interactions with fisheries and consequences for socio-economics*" at ICES 2014 ASC

Duration: 1 day
Sponsoring Organizations: ICES/PICES
Convenors: José Luis Acuña (Spain, ICES), Richard Brodeur (USA, PICES), Cornelia Jaspers (Denmark, ICES)
Invited speaker (funding to be confirmed): Shin-ichi Uye (Japan)

Gelatinous zooplankton, such as ctenophores, jellyfish and pelagic tunicates, contain groups belonging to the fastest growing metazoans on Earth, contributing more to secondary production than crustacean zooplankton during periods in certain regions. Irrespectively, gelatinous zooplankton remain understudied and disregarded in most food web investigations and are largely viewed as a dead end in the food chain. Lately, evidence has accumulated that gelatinous zooplankton populations have increased and likely have benefitted from global change. Further, anthropogenic stressors such as eutrophication, bio-invasions and overfishing have been correlated with increased jellyfish and ctenophore abundances with documented changes in food web structure, functioning and productivity of many marine ecosystems around the world. Especially in the Mediterranean

Sea, the Black Sea, the East Asian marginal seas, the Benguela Current, and fjord systems around northern Europe, bio-invasions and blooms of gelatinous zooplankton have gained public attention, with documented shifts in the food web structure, functioning and corresponding socio-economic consequences for fisheries and tourism. This theme session aims at addressing the role, position and importance of gelatinous zooplankton organisms for marine ecosystems and their impact on food web structure, functioning and overall productivity.

We encourage presentations on gelatinous zooplankton and their:

- spatial and temporal distribution patterns,
- contributions to carbon cycling in pelagic and benthic ecosystems including higher trophic levels,
- population dynamics or species interactions of native and invasive groups,
- socio-economic impacts *e.g*., on fisheries, aquaculture and tourism,
- potential as a fast growing, renewable resource.