

Report of the Physical Oceanography and Climate Committee

An overture meeting of the Physical Oceanography and Climate Committee (POC) took place in Nanaimo, Canada, from 18:00–19:30 h on October 12, 2013. POC Chairman, Dr. Kyung-Il Chang, called the meeting to order, circulated the draft agenda, and introduced key issues that needed in-depth discussion and decisions at the formal POC meeting on October 16, 2013. Judges for 2013 POC Best Presentation and Poster awards were nominated: Drs. Kyung-Il Chang (S4), Shin-ichi Ito (S4), Emanuele Di Lorenzo (W2), and Yury Zuenko (POC). The formal POC meeting was held from 13:00–18:00 h on October 16, 2013.

Dr. Chang called the meeting to order and welcomed members and observers (*POC Endnote 1*). Two new POC members were introduced: Drs. Charles Hannah representing Canada, and Fangli Qiao representing China to replace Dr. Zhenya Song. Dr. Qiao did not attend the meeting for either day due to the unexpected passing of his colleague, Dr. Mingyuan Zhu, while attending the PICES Annual Meeting. Dr. Michael Foreman, Vice-Chairman of POC, agreed to act as a rapporteur. Three items were added to the agenda that were reviewed and decided at the overture POC meeting: i) discussions on producing of the next generation NPESR, ii) proposals for new, and extensions of, POC expert groups, and iii) other business on how to encourage more participation in the POC Paper session. The agenda was adopted (*POC Endnote 2*).

AGENDA ITEM 4

Completion of PICES-2012 decisions

The following items were listed on the agenda distributed prior to the meeting for POC members to review. They were not discussed at the meeting.

1. PICES-2013 POC Paper/Topic Sessions and Workshop

Title	Convenors	Invited speakers	Duration (day)	Date	Committees (Sponsors)
POC Paper Session	Kyung-Il Chang (Korea) Michael Foreman (Canada)		0.5	Oct. 18 (Fri.)	POC
S2: Are marine ecosystems of the North Pacific becoming more variable	Steven Bograd (USA) Elizabeth Logerwell (USA) William Sydeman (USA) Yutaka Watanuki (Japan)	Emanuele Di Lorenzo (USA) Michael Litzow (Australia)	0.5	Oct. 18 9(Fri.)	BIO/FIS/POC
S4: The changing carbon cycle of North Pacific continental shelves and marginal seas	Minhan Dai (China) Sophia Johannessen (Canada) Don-Jin Kang (Korea)	Miguel Goni (USA) Kon-kee Liu (Chinese-Taipei)	1	Oct. 16–17 (Wed.–Thur.)	POC
S6: Recent trends and future projections of North Pacific climate and ecosystem	Jack Barth (USA) James Christian (Canada) Enrique Curchitser (USA) Chan Joo Jang (Korea) Angelica Peña (Canada)	Jason Holt (UK) William Merryfield (Canada)	1.5	Oct. 15–16 (Tue.–Wed.)	BIO/POC/TCOCE/MONITOR/FUTURE
W2: Identifying mechanisms linking physical climate and ecosystem change: Observed indices, hypothesized processes, and “data dreams” for the future	Jack Barth (USA) Emanuele Di Lorenzo (USA) Marc Hufnagl (Germany) Jacquelynn King (Canada) Arthur Miller (USA) Shoshiro Minobe (Japan) Ryan Rykaczewski (USA) Kazuaki Tadokoro (Japan)	Jürgen Alheit (Germany) Bryan Black (USA) Carolina Parada (Chile) Hans-O. Pörtner (Germany)	1	Oct. 11 (Fri.)	POC/BIO/MONITOR/FUTURE (ICES)

2. 2013 inter-sessional symposia/sessions/workshops/meetings

- PICES Workshop on “*Radionuclides science and environmental quality of radiation in the North Pacific*” (Xiamen, China, March 14–15, 2013)
- Inter-sessional Science Board Meeting, May 20–21, 2013, St. Petersburg, Russia
- PICES/ICES FUTURE Workshop on “*Global assessment of the implications of climate change on the spatial distribution of fish and fisheries*” (St. Petersburg, Russia, May 22–24, 2013): Anne Hollowed (S-CCME Co-Chair, PICES), Suam Kim (S-CCME Co-Chair, PICES)
- PICES Summer School on “*Ocean observing systems and ecosystem monitoring*” (Newport, USA, August 19–23, 2013)
- 6th International SOLAS Summer School (Xiamen, China, August 23–September 2, 2013)
- WG 29 RCM-II Workshop (Busan, Korea, September 10–12, 2013)
- 4 ICES/PICES Joint Theme Sessions at the 2013 ICES ASC (Reykjavik, Iceland, September 23–27, 2013)
 - ✓ Session B: Responses of living marine resources to climate change and variability: Learning from the past and projecting the future (Convenor: Anne Hollowed, S-CCME Co-Chair)
 - ✓ Session M: Identifying mechanisms linking physical climate and ecosystem change: Observed indices, hypothesized processes, and “data dreams” for the future (Convenor: Emanuele Di Lorenzo, WG 27 Co-Chair)
- NOWPAP/PICES Joint Training Course on “*Remote sensing data analysis*” (Qingdao, China, October 21–25, 2013)

3. Travel and representation at the meetings of other organizations/programs

- PICES convenors, Shoshiro Minobe (POC, WG 27 Co-Chair), Hiroaki Saito (AP-COVE Chair), for CLIVAR/PICES joint session on “*Biophysical interaction*” in WCRP/CLIVAR Second International Symposium on “*Boundary Current Dynamics*” (Lijiang, China, July 8–9, 2013):
- PICES representative, Shoshiro Minobe (POC, WG 27 co-chair), to attend CLIVAR SSG meeting (Kiel, Germany, May 6–9, 2013), CLIVAR Pacific panel meeting (Lijiang, China, July 8–13, 2013):

4. Publications (GC 2012/S/5 decisions)

- Special issue of Progress in Oceanography on modeling dedicated to Dr. Bernard Megrey (Guest Editors: Drs. Enrique Curchitser, Shin-ichi Ito, Kenneth Rose, Michio Kishi, Myron Peck) to be published in 2015. Submission deadline: November 15, 2013.
- Special issue of ICES Journal of Marine Science based on selected papers from 2012 2nd International Symposium on “*Effects of climate change on the world’s oceans*” to be published in 2013.
- Report of the 2012 GLOBEC/PICES/ICES Workshop on “*Forecasting ecosystem indicators with process-based models*” (Editors: Drs. Emanuele Di Lorenzo, Arthur Miller, Shoshiro Minobe)

AGENDA ITEM 5

Reports of POC active groups

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

Dr. James Christian, Co-Chairman of S-CC, reported on the Section’s 2013 activities and 2014 plans.

1. S-CC was created in the fall of 2005 to continue the work of the disbanded Working Groups 13 (*Carbon Dioxide in the North Pacific*) and 17 (*Biogeochemical Data Integration and Synthesis*). At completion of its first 5 years, S-CC submitted a report and was reauthorized at the 2010 Annual Meeting to continue for another 5 years from 2011 to 2015. S-CC submitted its report at the 2013 Annual Meeting (*S-CC Endnote 4*) in accordance with PICES Rules of Procedure (Rule 13) that Sections shall be reviewed every 3 years. As a parent committee of S-CC, POC supports S-CC’s continuation of its activities until 2016.
2. PACIFICA data synthesis was completed and publication of its results is ongoing.
3. S-CC is re-focusing its objectives more on ocean acidification and de-oxygenation in support of FUTURE

objectives. It will produce syntheses and data products to achieve its new goal, accommodating the needs of the FUTURE APs and other expert groups, including a membership turnover if requested.

Joint PICES/ICES Section on *Climate Change Effects on Marine Ecosystems* (S-CCME)

Dr. Michael Foreman, member of S-CCME, presented summarized the Section's 2013/2014 activities and future plans. S-CCME convened a FUTURE workshop together with ICES on “*Global assessment of the implications of climate change on the spatial distribution of fish and fisheries*”, which was held in St. Petersburg, Russia from May 22–24, 2013. A report of the workshop is available on the PICES website at http://www.pices.int/publications/pices_press/volume21/v21-n2/pp_5-8_WS-SCCME.pdf. S-CCME co-sponsored 2013 ICES ASC Theme Sessions (Session B and Session M, and Workshops in PICES-2013 with ICES (W1 and W2).

PICES current and former members authoring IPCC chapters were also introduced: Chapter 10 – Detection and Attribution of Climate Change (Dr. Jim Overland), Chapter 28 – Polar Regions (Dr. Anne Hollowed), Chapter 30 – Oceans (Dr. Sukgeun Jung), and Chapter 5 (Dr. Jake Rice).

Planned theme/topic sessions and workshops in 2014 include Sessions for PICES FUTURE Open Science Meeting (April 15-18, Hawaii), two topic sessions for PICES-2014, and a theme session for 2014 ICES ASC.

Advisory Panel for a *CREAMS/PICES Program in East Asian Marginal Seas* (AP-CREAMS)

Dr. Yury Zuenko, a member of AP-CREAMS, gave a brief report of the Panel on its activities in 2013 and plans for 2014 and beyond. During its business meeting, national reports were given by Dr. Dongfeng Yu (China) on results of current observations in the Yangtze River estuary and adjacent seas and on a new project on mesoscale processes of the shelf-break in the northern South China Sea. Dr. Kyung-Ryul Kim reported on the 20th Anniversary of the first CREAMS expedition in 1993 held in Seoul in August 2013, and introduced a plan for a Korea–Russia joint expedition in the Japan/East Sea using the R/V *Lavrentyev* during October–November, 2013. This joint cruise has been and will continue to be conducted regularly, and it is possible for other scientists from PICES member countries to participate in the cruises. Dr. Kim encouraged interested scientists to contact him if they are interested in having work done on future cruises.

Dr. Jae-Hak Lee presented preliminary results from surveys in the East China Sea in October 2012 and a surface mooring east of Jeju-do Island which has been in operation since May 2012. He also introduced a new proposal on physical and ecological function of the East China Sea submitted to Ministry of Ocean and Fisheries of Korea, which would be the Korea EAST-II project if the proposal is approved. Dr. Zuenko presented results from long-term monitoring in Amur Bay: long-term trends in temperature, hypoxia, and zooplankton.

A PICES Summer School on “*End-to-end models for marine resources management and research*” is planned for August 26–29, 2014, at Seoul National University. The Summer School can accommodate about 30 postgraduate students and early-career scientists. One of the organizers (Dr. Chung Il Lee) contacted 5 scientists to serve as instructors, and a tentative day-by-day program was introduced. AP-CREAMS requested PICES to support all 5 instructors and 5 non-Korean students.

A progress report on the publication of a volume on the Yellow and East China Seas was also introduced, including a tentative list of contents. AP-CREAMS requested PICES endorsement of the publication and technical editing support.

At the AP-CREAMS meeting, the following recommendations were agreed on pertaining to the Supplementary Chapter of NPESR: Marine Ecosystems of the North Pacific Ocean 2003–2008:

- PICES should initiate the publication of the supplementary chapter without further delay as Science Board has already endorsed it.
- If there are further delays, AP-CREAMS will initiate efforts to publish the prepared manuscript outside

PICES, possibly as a book. However, this publication will not be a replacement of the missing chapter of the 2nd NPESR by any means. PICES should continue efforts for completing the 2nd NPESR and for the preparation of NPESR 3.

Working Group on *North Pacific Climate Variability and Change* (WG 27)

Dr. Emanuele Di Lorenzo, Co-Chair of WG 27 (<http://wg27.pices.int>), gave a brief presentation on 2013 activities and future plans for the WG. Science products of WG 27, including a list of members' publications and reports of the ECOFOR 2012 workshop (<http://wg27.pices.int/ecofor/>), have been updated. At its 2013 Annual Meeting, the WG prepared a draft of a final report which will be further expanded in 2013–2014. WG 27 members agreed to complete the following two synthesis papers: i) Reduced complexity models to hindcast and forecast North Pacific climate, ii) Coherent changes in North Pacific climate and ecosystems. WG 27 also plans to assemble an ocean currents database based on outputs of regional model hindcasts and AR5 models.

Dr. Shoshiro Minobe, WG 27 Co-Chair, convened a PICES/CLIVAR joint session on “*Biophysical interaction*” during the WCRP/CLIVAR International Symposium on “*Boundary current dynamics*” held in Lijiang, China, July 8–9, 2013. Nine talks were presented, which mainly addressed physical control of nutrients such as vertical mixing, upwelling, and advection in the western North Pacific and its marginal seas. At its conclusion, the necessity of constructing nutrient budgets on various long-term timescales including mean climatology and interannual-to-decadal timescales, and how those budgets respond to climate change, was discussed.

Dr. Minobe, representing PICES, attended the CLIVAR SSG meeting held in Kiel, Germany, May 6–9, 2013. He joined the tiger team of one of the focused and integrated research opportunities of the 2nd phase CLIVAR activities on “Biophysical interactions and dynamics of upwelling system” led by Dr. Ken Drinkwater.

WG 27 requested an extension of its lifespan for one more year, until 2015, to analyze CMIP 5 results, to contribute to the 3rd International Symposium on the “*Effects of climate change on the world's oceans*” (March 23–27, 2015, Santos, Brasil), and to devote more efforts on, and to develop recommendations for, new expert groups, completing some of its TORs. Considering its important contributions to FUTURE program, POC agreed to support the extension.

Dr. Di Lorenzo also planned to propose a new integrated study group together with the Section on *Human Dimensions of Marine Systems*-, focusing on the development of integrated model of coastal hypoxia and acidification. POC agreed to support the new expert group.

Working Group on *Regional Climate Modeling* (WG 29)

Dr. Enrique Curchitser, Co-Chair of WG 29, gave a brief summary of activities and plans of WG 29 followed by a review of its TORs and a brief description of downscaling and upscaling. He reported on the 2nd RCM workshop held in Busan, Korea from August 23–September 23, 2013. A total of 21 oral talks and 7 posters were presented during 3 scientific sessions: i) Processes in RCM (meso- and submesoscale motions), ii) Regional climate and ecosystem projections, and iii) Climate variability in the North Pacific. Based on discussions at the wrap-up session, the following issues in RCM were presented: i) How useful are idealized process models? ii) At what spatial resolution do results converge? iii) How important are sub-mesoscale processes for climate? iv) How much can be learned from one-way nesting? It was suggested that RCM-III could focus on physical–biological and ocean–atmosphere coupling.

Other activities of WG 29 included sponsoring topic sessions at PICES-2013 (S6: Recent trends and future projections of North Pacific climate and ecosystems) and FUTURE OSM (S2: Regional climate modeling in the North Pacific) in April 2014. WG 29 also plans to propose sessions including an RCM III workshop at the 3rd International Symposium on the “*Effects of climate change on the world's oceans*”.

WG 29 requested an extension of its lifespan for one more year, until 2015, to analyze CMIP 5 results and possibly to use them in regional models, to convene a workshop on RCM III (see above), and to propose a new

expert group to follow WG 29 activities without a gap in its crucial role in the FUTURE program. POC agreed to support the extension.

Summary of POC decisions regarding expert group important matters:

1. Approve the request for an extension of the lifespan for one year, for both WG 27 and WG 29.
2. Support a new expert group proposal for an integrated modeling approach prepared by WG 27.
3. Receive a 3-year progress report of S-CC, and approve its continued activity.

AGENDA ITEM 6

Relations with other international organizations/programs

1. Dr. Charles Hannah gave an update on the status of Argo on behalf of Dr. Howard Freeland. The one millionth Argo profile was delivered in November 2012, and the number of published research papers based on Argo data is 1409 since 1998. Float and sensor technology continue to improve, and the design of Argo is evolving towards more complete global coverage and regionally-enhanced resolution. National Argo programs, however, face tight resources, hence Argo must exploit continuing technology advances to become more efficient and cost-effective. Argo is progressing towards the future with two prioritized items: Implementing and sustaining the core global Argo mission, and the evolution of Argo with additional missions such as Deep Argo, Bio-Argo, and near-surface mission. Dr. Hannah demonstrated a new software, Global Marine Argo Atlas, which gives very easy access to data and simple software to produce various useful plots. The software also allows an easy and prompt update of Argo data. The software is available from the Argo Steering Team web site: http://www-argo.ucsd.edu/Marine_Atlas.html.
2. Dr. Shoshiro Minobe introduced new CLIVAR structure and research opportunities. He became a member of one of the research opportunities “Marine biophysical interactions and dynamics of upwelling system”, which is led by Dr. Ken Drinkwater. (See the WG 27 report above for additional activities of Dr. Shoshiro Minobe related to CLIVAR.)
3. Dr. Hee-Dong Jeong, NEAR-GOOS Coordinating Committee member, gave a brief summary of NEAR-GOOS activities. NEAR-GOOS is one of 13 GOOS regional alliances in the North East Asian Region. A Coordinating Committee meeting was held in Busan, Korea in October 2013 to review and discuss the work plan and to cooperate with other regional projects and international programs. Dr. Jeong also introduced the status of each country’s database management, and the development of cooperative regional observing systems in the Japan/East Sea, Russia (POI) and Japan (JMA) monitoring section (former PM-line), and on-going and future plans of ferry boat monitoring.
4. Dr. Lisa Miller provided a summary of SOLAS organizational issues including an emerging topic on the impacts of ship plumes on atmospheric chemistry, climate and nutrient supply to the ocean. She also introduced three joint SOLAS–IMBER working groups. The 6th SOLAS Summer School was held in Xiamen, China, in August 23–September 2, 2013, with an appreciation of PICES support. Thirty-six percent of the students came from PICES member countries. The SOLAS synthesis publication, “Ocean-atmosphere interactions of gases and particles” (edited by Liss, P.S. and Johnson, M.T.) is in press, and the SOLAS Open Science Conference will be held in Kiel, Germany from September 7–11, 2015. SOLAS is transitioning towards the Future Earth program, and accordingly preparing themes of major importance for SOLAS research over the next decades. An early white paper draft version of eight themes as a consultation document is available on their web site. A workshop was proposed for PICES-2014 to solicit community input to those themes. Future Earth is an alliance of ICSU, ISSC, UNESCO, UNEP, UNU, WMO (as an observer) and the Belmont Forum (a high level group of major research funders). The Belmont Forum is an alliance of funders and has been set up to be a more useable tool for research funding. Future Earth has a large social science component. Dr. Miller also introduced activities of SCOR Working Group on Biogeochemical Exchange Processes at the Sea-Ice Interfaces (SCOR WG 140), as affiliate member representing PICES.

5. POC reviewed theme session proposals for the 2014 ICES Annual Science Conference held in A Coruña Spain, and supported the proposal, “*Physical and biological consequences of exchanges between the Atlantic Subarctic and the Arctic*”, provided the Pacific be included in the title and abstract.

AGENDA ITEM 7

FUTURE issues

The Chairman introduced the structure and scientific programs for the FUTURE Open Science Meeting to be held in Hawaii in April 15–18, 2014, and reminded members of the abstract submission deadline.

At the overture meeting on October 12, the Chairman asked the chairs of POC’s expert groups to answer the following questions about FUTURE-related issues when they present their groups’ activities at the POC business meeting on October 16:

- (1) What are the expected deliverables and/or products related to FUTURE?
- (2) What are the gaps/obstacles in making progress with the expected contribution; and what will be the necessary actions to overcome these gaps?
- (3) What kind of coordination is needed with other expert groups; How well are we communicating with Committees/FUTURE APs on FUTURE matters? The following is the response of each group to those questions.

S-CC – (1) data products related to ocean acidification and de-oxygenation, analysis and synthesis of historical data, analysis of climate model projections and evaluation against observations, observations and projections of changes in open ocean [O₂] and [CO₃²⁻] to help separate local from large-scale influences;
(2) natural variability in observations and models, downscaling (dynamical, statistical ?), coastal data (extend dynamic range of interrelationship among salinity, pH, [CO₃²⁻], *etc.*), benthic influences; refocusing S-CC objectives;
(3) producing synthesis or data products according to the needs of the APs and other expert groups, membership turnover as requested by APs and other expert groups.

S-CCME – (1) scientific papers, reports, other synthesis products;
(3) WG 29 doesn’t know what S-CCME wants.

WG 27 – (1) scientific papers, final report, website repository, data archive of ocean circulation anomalies from regional models and IPCC outputs;
(2) entrain more climate modelers, develop critical datasets (ocean currents, physiological responses, *etc.*), share information, continue to connect to large-programs (*e.g.*, CLIVAR, ICES);
(3) communication through website, proposing a new expert group to enhance communication with S-HD.

WG 29 – (1) inventory of regional physical and coupled physical-biological modeling efforts in PICES region, regional analysis of CMIP5 model output, CMIP5 derived quantities (*e.g.*, MLD);
(2) limited available data (especially ecosystem variables), complexity of regional models and time-consuming modeling job, little expertise in modeling human activity; progress is being made slowly but surely;
(3) a natural connection to WG 27, coordination with TCODE required to seek for an efficient way to serve data and model product; Don’t know what products others need, and would be great to get representatives from other expert groups to attend the annual WG 29 meetings for closer communication on FUTURE.

The POC meeting on October 16 adjourned for about half an hour to attend the presentation made by Dr. Harold Batchelder, on behalf of AP-SOFE, on the draft proposal of the process to produce the next generation North Pacific Ecosystem Status Report (NPESR) submitted to Science Board by AP-SOFE and MONITOR. After the presentation, the POC meeting resumed starting from the discussion about the new NPESR process followed by the Chairman’s summary of the major changes described in the draft proposal. POC approved the proposal in principle, considering the demands of the PICES community to update the ecosystem status in the

North Pacific more frequently. POC members, however, wanted to know more details on the production of the new NPESR. The Chairman mentioned that he will circulate the proposal to all Committee members to receive further comments.

Some comments raised at the POC meeting on the new NPESR process: (1) It is not clearly dictated in the proposal whether or not hard-copy publication be made the same as the previous NPESR reports in the form of PICES special publication. (2) Inclusion of numerical model time series, especially where observations are unavailable, and Argo and satellite altimetry by setting up links to websites. (3) Concerns if there are enough dedicated PICES people with sufficient time to do it, especially those who have another paying job. (4) It was questioned whether the naming issue of the Japan/East Sea can be avoided in the new NPESR.

AGENDA ITEM 8

Election of new POC Chairman

Dr. Kyung-Il Chang will stand again as the Chairman and Dr. Michael Foreman will remain as Vice-Chairman

AGENDA ITEM 9

Planning for PICES-2014

1. Six Topic Sessions which POC or its expert groups co-sponsor were proposed for PICES-2014 as well as POC Paper Session (*POC Endnote 3*). Ranking of the proposed sessions was made and allotment of POC money for selected sessions was decided as follows: “Regional climate modeling in the North Pacific” (\$3,000), “Variability in advection and its biological consequences for Subarctic and Arctic ecosystems” (\$1,000), and “POC Paper Session” (\$1,000).
2. Two Workshops that POC or its expert groups co-sponsor were proposed (*POC Endnote 3*).
3. Half-day business meetings for S-CC, S-CCME, AP-CREAMS, WG 27, and WG 29 were requested.

ID	Title	Convenors	Duration (Day)	Committees (Sponsors)	Publication
	POC Paper Session		1	POC	
TS-2	Variability in advection and its biological consequences for Subarctic and Arctic ecosystems	Franz Mueter (USA) Ken Drinwater (Norway) Sei-Ichi Saitoh (Japan) Enrique Curchitser (USA)			
TS-6	Dynamics of pelagic fish in the North Pacific under climate change	Gerard DiNardo (USA) Suam Kim (Korea) Sei-Ichi Saitoh (Japan) Cisco Werner (USA)	1	S-CCME (ESSAS)	Yes
TS-12	Recent assessments of climate change impacts on marine ecosystems	Anne B. Hollowed (USA) Jake Rice (Canada) Sukgeun Jung (Korea) Hans-O. Pörtner (Germany)	0.5	S-CCME (ICES)	
TS-13	Climate change impacts on spatial distributions of marine fish and shellfish	Jonathan Hare (USA) Anne B. Hollowed (USA) Sukyung Kang (Korea)	1	S-CCME (ICES)	
TS-14	Use of long time series of plankton to inform decisions in management and policy concerning climate, ecosystems and fisheries	David Checkley (USA) Sanae Chiba (Japan)	0.5	AP-CREAMS	
TS-15	Regional climate modeling in the North Pacific	Chan Joo Jang (Korea) Enrique Curchitser (USA) Michael Foreman (Canada) Kyung-Il Chang (Korea) Shin-ichi Ito (Japan)	1	POC, WG 27, WG 29	Yes

		Angelica Peña (Canada) Hyodae Seo (USA)			
WS-1	SOLAS into the future: Designing the next phase of the Surface Ocean–Lower Atmosphere Study within the context of the Future Earth program	Lisa Miller (Canada) Minhan Dai (China) Yukihiro Nojiri (Japan)	0.5	S-CC (SOLAS)	
WS-2	Networking ocean observatories around the North Pacific Ocean	Ken Denman (Canada) Jack Barth (USA) Jae Hak Lee (Korea) Robert Weller (USA) Hidekatsu Yamazaki (Japan)	1.5	(Oceans Networks Canada, US CLIVAR)	Yes

AGENDA ITEM 10

Publication for 2014 and beyond

- AP-CREAMS submitted a proposal for publishing a book on “Oceanography of the Yellow and East China Seas” as the PICES special report. The book would be a review and textbook-style book of the area of about 300 pages long, and is expected to be published at the end of 2014. The Chairman introduced the a tentative list of contents of the book as was received from developed by AP-CREAMS (see *AP-CREAMS Endnote 3*). Mainly AP-CREAMS members will constitute the editorial board: Drs. Joji Ishizaka, T. Matsuno, T Jing Zhang, Jae-Hak Lee, JS. Kim, S., Dongfeng Xu, D., Yu Fei, Y., Sumei Liu, Vyacheslav Lobanov. AP-CREAMS requested PICES support of for technical editing and publication fee.
- S-CCME proposed a special volume in the ICES Journal of Marine Science for manuscripts given arising from presentations given in at the PICES/ICES Workshop on “*Global assessment of the implications of climate change on the spatial distribution of fish and fisheries*” held in St. Petersburg, Russia, from May 22–24, 2013 and from Theme Session B of 2013 ICES ASC.
- WG 27 proposed two synthesis papers (journals TBD): 1. Reduced complexity models to hindcast and forecast North Pacific climate (Cummins, Di Lorenzo, Davis, Yeh, Taguchi, Bograd), 2. Coherent changes in North Pacific climate and ecosystem (King, Ito, Minobe, Chiba, Davis, Ustinova, Zuenko, Di Lorenzo).

AGENDA ITEM 11

Items with financial implications

1. Topic sessions for PICES-2014 (see Agenda Item 9)
2. Proposed inter-sessional meetings and capacity building programs for 2014 and beyond:
 - 1st Pan-CLIVAR meeting, The Hague, The Netherlands, July 17–18, 2014: Travel support for Dr. Minobe to attend the meeting to represent PICES and implement PICES/CLIVAR collaboration. POC approved the request.
 - PICES Summer School on “*End-to-end models for marine resources management and research*”, Seoul, Korea, August 26–29, 2014 (GC decision 2012/S/3): The Chairman introduced an updated plan from the principal organizer of the Summer School, Dr. Chung-II Lee, at Gangneung-Wonju National University (*POC Endnote 4*). There were no specific comments on the updated program from POC members. AP-CREAMS requested travel support for 5 lecturers and 5 non-Korean students. POC approved the request.
 - BEPS-II (SCOR WG 140) meeting, Hobart, Australia, in March 2014: Travel support for Dr. Lisa Miller. POC approved the request.
 - 3rd PICES/ICES/IOC Symposium on “*Effects of climate change on the world’s oceans*”, Santos City, Brazil, March 23–27, 2015: Symposium convenor, Dr. Jacquelynne King, requested keywords or titles for topic sessions as soon as possible. PICES SSC members, Drs. Minobe, Qiao and Angelica Peña will decide the final topic sessions. WG 29 plans to propose a workshop which may be split into sub-sessions, possibly including RCM-III. Dr. Curchitser also plans to propose a topic session “*Modeling climate impacts across scales: from physics to ecosystems*” together with Drs. Jason Holt, Jerome

Fiechter, and Shin-ichi Ito. The session description was prepared and will be sent to Dr. Peña. Dr. Minobe plans to propose the following sessions: “*Impact of climate variability and change on nutrient distributions*” and “*Validation and utilization of Earth System models*”.

- PICES/ICES Early Career Scientist Conference proposal for 2017: The venue for the conference has not decided so far, although Korea and China have shown their intention to host the conference.

AGENDA ITEM 12

POC Best Presentation and Poster awards

Best presentation by an early career scientist for a POC-sponsored session was awarded to Colleen M. Petrick for her talk on “*How eastern Bering Sea climate variability affects the distribution of walleye pollock early life stages*” (W2) and best poster was awarded to Hiromichi Ueno for his presentation on “Decadal variation of temperature inversions along Line P” (POC Contributed Paper Session) See Session Summaries for more details (http://www.pices.int/publications/annual_reports/Ann_Rpt_13/2013-Session-Summaries.pdf).

AGENDA ITEM 13

Documenting sessions and workshops

The Chairman recalled the request from Science Board to complete and send documentation of topic session and workshop summaries convened by POC members for PICES-2013 to the Secretariat before the end of the Annual Meeting, and business meeting reports of POC and expert groups within one month after the Annual Meeting.

AGENDA ITEM 14

Other business

POC members discussed possible POC contributions to celebrate the 25th Anniversary of PICES in 2016. The following were suggested.

- If PICES considers a special journal issue, POC will contribute to it.
- A special POC session to highlight the accomplishments of POC, to summarize Working Groups that POC supported, and possibly to invite former POC Chairs.

A discussion on the declining number of papers submitted to the POC Paper Session and the declining participation of young physical oceanographers was made. The Chairman suggested that POC members should always contribute to the Paper Session, and that POC members also try to propose physics-dominated topic sessions. As part of this commitment, POC decided to allocate funds to POC Paper Session to invite a distinguished speaker presenting emerging issue(s) in physical oceanography.

AGENDA ITEM 15

Adoption of report and recommendations to Science Board

This POC report was circulated among, and approved by all POC members. All recommendations were brought by Dr. Kyung-Il Chang to the Science Board meeting on October 18–19, 2013.

POC Endnote 1

POC participation list

Members

Kyung-Il Chang (Korea, Chairman)
James Christian (Canada)
Enrique Curchitser (U.S.A.)
Michael Foreman (Canada, Vice-Chairman, rapporteur)
Shin-ichi Ito (Japan)
Hee-Dong Jeong (Korea)
Elena Ustinova (Russia)
Yury Zuenko (Russia)

Observers

Emanuele Di Lorenzo (WG 27)
Lisa Miller (SOLAS, SCOR WG 140)
Shoshiro Minobe (WG 27)
Vadim Navrotsky (POI, Russia)
Dmitry Stepanov (POI, Russia)
D.F. Xu (SIO/SOA, China)

POC Endnote 2

POC meeting agenda

1. Welcome, introductions, opening remarks
2. Membership changes
3. Changes to, adoption of agenda and appointment of rapporteur
4. Completion of PICES-2012 decisions
5. Reports of POC expert groups
 - i) Section on *Carbon and Climate* (Dr. James Christian)
 - ii) Joint PICES/ICES Section on *Climate Change Effects on Marine Ecosystems* (Dr. Michael Foreman)
 - ii) Advisory Panel for a *CREAMS/PICES Program in East Asian Marginal Seas* (Dr. Yury Zuenko)
 - iii) Working Group on *North Pacific Climate Variability and Change* (Drs. Emanuele Di Lorenzo and Shoshiro Minobe)
 - iv) Working Group on *Regional Climate Modeling* (Dr. Enrique Curchitser)
6. Relations with other international organizations/programs
 - i) Argo (Dr. Charles Hannah)
 - ii) WCRP/CLIVAR (Dr. Shoshiro Minobe)
 - iii) NEAR-GOOS (Dr. Hee-Dong Jeong)
 - iv) SOLAS and BEPS II (Dr. Lisa Miller)
 - v) Review of 2014 ICES ASC theme session proposals (Dr. Kyung-Il Chang)
7. FUTURE issues
 - i) FUTURE Open Science Meeting in 2014
 - ii) Contribution/Gaps/Communication issues from expert groups
 - iii) Draft proposal on producing next generation NPESR
9. Planning for PICES-2014
 - i) Ranking and allotment for proposed six Topic Sessions
 - ii) Two Workshops proposed by POC or its active groups
 - iii) Business meetings of active groups
10. Publication for 2014 and beyond
11. Items with financial implications
 - i) Topic Sessions for PICES-2014
 - ii) Proposed inter-sessional meetings and capacity building programs for 2014 and beyond
 - iii) Requests for PICES support for inter-sessional meetings and 2014 Summer School
12. POC Best Presentation and Poster awards
13. Documenting sessions and workshops
14. Other business
15. Adoption of POC report and recommendations to Science Board

POC Endnote 3**Proposals for POC-sponsored sessions and workshop at PICES-2014****POC Paper Session**

Duration: 1 day

Conveners: Kyung-Il Chang (Korea) and Michael Foreman (Canada)

Invited speakers: one

Papers are invited on all aspects of physical oceanography and climate in the North Pacific and its marginal seas.

POC Topic Sessions**TS-2 *Variability in advection and its biological consequences for Subarctic and Arctic ecosystems***

Proposed by S-CCME

Co-sponsor: ESSAS

Duration: 1 day

Conveners: Franz Mueter (USA), Ken Drinkwater (Norway), Sei-Ichi Saitoh (Japan), Enrique Curchitser (USA)

The advection of water masses and their associated nutrients and plankton is critical to biological processes within the subarctic gyres and on the productive shelf regions bordering the gyre. Cross-shelf and along-shelf advection regulate the supply of nutrients and plankton to these shelves, thereby affecting the productivity and species composition of the prey organisms that support higher trophic levels. Moreover, the advection of larvae to suitable nursery areas affects the spatial and temporal overlap between larvae and their prey and predators (match-mismatch dynamics). Advective processes have been linked to the recruitment success of walleye pollock off Japan and in the Gulf of Alaska, which benefit from increased retention within certain nearshore regions, and to recruitment patterns of flatfishes and crab in the eastern Bering Sea, which benefit from increased advection towards suitable nursery areas. Interannual variability in advection has long been understood as an important source of biological variability, while variability at shorter time scales (days to weeks) has only recently received more attention due to the increased availability of high-frequency observations and the development of high-resolution models. The main goal of this session is to explore how variability in the advection of nutrients, zooplankton prey, and early life stages at all scales affects the recruitment, abundance and distribution of subarctic fish and invertebrate species, including the potential to extend their range into Arctic waters. We invite papers that explore past variability and potential future trends based on field observations, analyses of long-term data series, and biophysical models. Contributions from both the Pacific and Atlantic Subarctic are welcome.

TS-6 *Dynamics of pelagic fish in the North Pacific under climate change [later changed to a workshop]*

Proposed by S-CCME

Co-sponsor: ISC

Duration: 1 day

Conveners: Gerard DiNardo (USA), Suam Kim (Korea), Sei-Ichi Saitoh (Japan), Cisco Werner (USA)

The goal of the workshop is to define a scientific framework to assess the dynamics of pelagic fish under climate/environmental variability. We will discuss the overlapping PICES and ISC science missions and outline a Science Plan for a multi-year collaborative effort. Climate variability affects pelagic fish distributions and migration, and ultimately pelagic fisheries, the level of impact depending on the persistence, direction, and magnitude of the variability. Survival and growth rates of pelagic fish are linked to oceanographic conditions, and changes to these conditions can have dramatic impacts on the composition of species assemblages within pelagic ecosystems, as well as the persistence and magnitude of individual pelagic

fish populations (PICES/ICES, 2013). Understanding the links between environment and pelagic fish behavior, growth, recruitment, and production are paramount to understanding the impacts of climate variability.

Pelagic fishes occupy surface waters of the North Pacific Ocean, from coastal shelf to open ocean ecosystems. Many of these species undertake large-scale feeding, spawning, and ontogenetic migrations linked to seasonal changes in water masses. For example, Pacific bluefin tuna use waters off Japan as a nursery habitat, undertaking an ontogenetic movement eastward to waters off North America where they remain as subadults for 2-3- years. Additionally, many pelagic species have environmental thresholds and preferences, which limit the spatial distribution of a species. The most important environmental factors include oxygen, salinity and temperature, and because these factors generally exhibit persistent spatiotemporal patterns, the general distribution of pelagic fishes is known. Knowledge of these relationships allows for the incorporation of climate change into stock assessments, which forms the basis for fisheries management.

PICES/ICES (2013) Report of the Workshop on Global Assessment of the Implications of Climate Change on the Spatial Distribution of Fish and Fisheries (WKSICCMESpatial), 22–24 May 2013. ICES CM 2013/SSGEF:11. 63 pp.

TS-12 *Recent assessments of climate change impacts on marine ecosystems*

Proposed by S-CCME

Co-sponsor: ICES

Duration: 0.5 day

Conveners: Anne B. Hollowed (USA), Jake Rice (Canada), Sukgeun Jung (Korea), Hans Pörtner (Germany)

The Intergovernmental Panel on Climate Change expects to release the full reports of Working Groups 1, 2 and 3 electronically in January, August, and September of 2014, respectively. Other organizations have recently completed assessment reports that focus on specific geographic regions or fishing sectors (e.g., the U.S. National Climate Assessment or FAO's report on *Priority adaptations to climate change for Pacific fisheries and Aquaculture: Reducing risks and capitalizing on opportunities*). Collectively these reports will mark a major milestone by updating our knowledge of the observed and projected implications of climate change on the earth. Of particular interest to PICES and ICES will be the findings of the reports with respect to impacts on marine ecosystems. This session encourages presentations that summarize the key findings of the IPCC. It also encourages talks that provide guidance and insight on future directions for climate change research within the ICES and PICES communities.

TS-13 *Climate change impacts on spatial distributions of marine fish and shellfish*

Proposed by S-CCME

Duration: 1 day

Conveners: Jon Hare (USA), Anne B. Hollowed (USA), Sukyung Kang (Korea)

Changes in fish and shellfish distributions are an important indicator of climate change and are being incorporated into national climate change assessment. Fishing, however, also affects fish and shellfish distributions and fishing effort is changing in many ecosystems. Changes in distributions will also affect fisheries, shifting the resource toward or away from fishing ports. We invite papers that examine the combined effect of climate change and fishing on fish and shellfish distributions and the impact of these changes on fisheries. Specifically, we encourage papers that 1) develop and use analytical approaches for separating the effect of fishing and climate, 2) evaluate life history and fishery traits that are associated with shifting distributions, and 3) examine the effect of shifting distributions on fisheries, fishing communities, resource economics, and international allocation.

TS-14 *Use of long time series of plankton to inform decisions in management and policy concerning climate, ecosystems and fisheries*

Proposed by AP-CREAMS

Duration: 0.5 day

Conveners: David Checkley (USA), Sanae Chiba (Japan)

Plankton plays key roles in the pelagic ocean. Planktonic plants, invertebrates and the early developmental stages of vertebrates are important for trophic and population dynamics of many taxa, many of which are exploited and some are protected; the flux of energy and material, including carbon; and as indicators of ecosystem status. Phytoplankton has been both sampled in situ and observed remotely, from satellites. Zooplankton has been collected by nets. Increasingly, optics, acoustics, and 'omics' are used and developing. Sampling programs worldwide now span decades, often with ancillary data. From these, time series of plankton abundance have been created, with varying levels of taxonomic and geographic resolution. Often, such programs have been in support of fisheries management. Increasingly, however, they are also relevant to management and policy decisions affecting ecosystems and climate. In turn, such programs require justification for their continuation. Examples of such programs include the California Cooperative Oceanic Fisheries Investigations (CalCOFI), the Global Alliance of Continuous Plankton Recorder Surveys (GACS), and many other plankton sampling programs worldwide (many zooplankton programs are listed at <http://www.st.nmfs.noaa.gov/copepod/>). The objective of this session is to learn how time series of plankton have been, are being, and might be used to inform decisions in management and policy concerning climate, ecosystems, and fisheries. We invite presentations on both time-tested uses of plankton time series and on novel, untested uses.

TS-15 *Regional climate modeling in the North Pacific*

Proposed by POC/WG27/WG29

Duration: 1 day

Conveners: Chan Joo Jang (Korea), Enrique Curchitser (USA), Michael Foreman (Canada), Kyung-II Chang (Korea), Sin-ich Ito (Japan), Angelica Peña (Canada), Hyodae Seo (USA)

Regional climate models are a key scientific tool for understanding climate change on a regional scale which is essential for consideration of many socio-economic impacts of climate change and its adaptation. Despite their limitations including systematic errors in forcing fields given by global climate models and uncertainties in downscaling methods, it is recognized that regional models are necessary for understanding and projecting regional climate changes because of improved model resolution.

This session calls for papers addressing the recent efforts for regional climate modeling such as developing novel approaches for dynamic downscaling, comparison between regional and global climate model results, detection and evaluation of regional climate changes in the North Pacific Ocean simulated by regional and global climate models, assessment of their uncertainty, and coupling of regional climate models with biogeochemical models. This session aims to assemble and share existing expertise in recent efforts to regional climate models by providing a platform to discuss their limitations and reliability.

POC Workshop

WS-1 SOLAS into the future: Designing the next phase of the Surface Ocean-Lower Atmosphere Study within the context of the Future Earth program

Proposed by S-CC

Co-sponsor: SOLAS

Duration: 0.5-day

Conveners: Lisa Miller (Canada), Minhan Dai (Canada), Yukihiro Nojiri (Japan)

For more than a decade, the Surface Ocean-Lower Atmosphere Study (SOLAS) has fostered cutting-edge research in air-sea interactions, facilitating communication, coordinating and directing research, and advocating for new projects. The SOLAS program has facilitated major advances, changing fundamental understanding in a number of subjects, including the significance of ocean acidification, the roles of DMS and marine organic matter in atmospheric chemistry, and the importance of sea-ice biogeochemistry in controlling air-sea exchange. At the same time, the significance of earth system science to society has become increasingly apparent, and FutureEarth is replacing the International Geosphere-Biosphere Programme as a major SOLAS sponsor. Within this context, SOLAS is plotting a new course for the next 10 years. This discussion session is one of a number at various conferences that is soliciting community input into the future of SOLAS. In particular, we are asking the question: In a world where Earth system science is coming under increasing political and public scrutiny, what is and should be the contribution of SOLAS science to society? Ideas and conclusions from this and other, similar workshops will be incorporated into the new SOLAS science plan.

POC Endnote 4

**PICES Summer School on
*“End-to-End models for marine resources management and research”***

1. Background

An ocean ecological model and its application are representation of an ecological system which is ranging in scale from an individual population to an ecological community, or even an entire system. The real systems are quite complicated because they involves biotic and abiotic components all interacting over a large area and a long time span. Understanding and predicting the changes in marine ecosystem requires high quality observation and experiment data. The models are formed by combining known ecological relations (e.g. the relation of sunlight and water availability to photosynthetic rate, or the relation between predator and prey populations) with data gathered from field and laboratory experiments. Ecological models are useful tools to describe ecological conditions and have long been developed to understand ecosystem behavior mechanism and to predict changes in community composition and ecosystem functioning. In particular, there has been a rapid rise in the development of end-to end model dealing with the effects of climate change and human activity on the marine ecosystem through the food web. End-to-end models combine physicochemical oceanographic descriptors and organisms ranging from microbes to higher-trophic-level organisms. The demand for End-to End approaches including bottom-up and top-down control in food webs arises from the need for quantitative tools for ecosystem-based management. End-to-end models that can deal with bottom-up and top-down controls that operate simultaneously and vary in time and space and that are capable of handling the multiple impacts expected under climate change.

This summer school intends to help graduate students and early-career scientists as well as new comers by providing basic knowledge for advanced applications. The 4-day summer school will cover an introduction to marine ecosystems (e.g. concept of the ecosystem) and parameter optimization of marine ecosystem model and

its application. The courses will be composed of lectures, seminars, and hands-on training in parameter optimization and end-to-end model application.

The official language of the school is English.

2. Purpose

End-to-End Models have applications in a wide variety of disciplines, such as natural resource management, wildlife conservation and agriculture. These models are formed by combining known complicated ecological relations with field observation data, and are being used in order to make an understanding about the process in systems and predictions about the dynamics of the real ecosystem. The purpose of this Summer School is to review and present methods of modeling in ecological relations, and to show how these models (methods) can be applied to understand and predict change in ecosystem.

3. Dates and venue

Date: 26–29 (Tuesday ~ Friday) August, 2014

Venue: Seoul National University (Republic of Korea)

Lecture & Workshop: Bd. 25-1/1st floor International Conference Room

Hands-on Exercise: Bd. 25-1/2nd floor Room 210 (SEES Computer Room)

4. Number of students

Maximum 30

5. Steering Committee

Dr. Chris Harvey: National Marine Fisheries Service, NOAA
chris.harvey@noaa.gov

Dr. Chung Il Lee: Gangneung-Wonju National University (principal organizer)
leeci@gwnu.ac.kr

Dr. Emanuele Di Lorenzo: Georgia Institute of Technology
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Dr. Isaac Kaplan: National Marine Fisheries Service, NOAA
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Dr. Tae-Hee Na: Seoul National University
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Dr. Yang-Ki Cho: Seoul National University
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6. Lecturers

Dr. Chris Harvey: National Marine Fisheries Service, NOAA
chris.harvey@noaa.gov

Dr. Chung Il Lee: Gangneung-Wonju National University
leeci@gwnu.ac.kr

Dr. Emanuele Di Lorenzo: Georgia Institute of Technology
chris.harvey@noaa.gov

Dr. Isaac Kaplan: National Marine Fisheries Service, NOAA
isaac.kaplan@noaa.gov

Dr. Kenneth A. Rose: Louisiana State University
karose@lsu.edu

Dr. Rubao Ji: Woods Hole Oceanography Institution
rji@whoi.edu

7. Registration

The summer school can accommodate a maximum of approximately thirty participants. If there are more than thirty applicants, students will be selected by the organizing committee and lecturers. Participants will be notified of their selection by the end of June, 2014. Participants must complete a Student Summer School Application Form, and send it with supporting documents to gwnu2008@gmail.com before May 31, 2014. The official language of the summer school is English.

8. Lecture Notes and Publication

Please download these electronic versions of lecture notes (<http://seoul.snu.ac.kr/pices2014/lecture/>, not prepared yet!) with lecturers' names ahead for yourself to prepare summer school courses. Color printing would be limited during the summer school period, so please prepare your own printed version if you think it is of help to you. Local conveners will provide you with a printed lecture note at the registration desk. Dr. Chung Il Lee will update the above site as soon as she receives additional materials from lecturers, so check the above site until you leave your country. If you have any problem with downloading these files, please contact Dr. Chung Il Lee (gwnu2008@gmail.com).

9. Lecture Plan - Draft

Day 1 - Tuesday (August 26): Introduction to End-to-End Modeling

Topics: continuous and discrete differential eq. with example of NPZD (continuous), IBM (discrete, difference equation), time-stepping schemes (Euler Forward/Backward the stability, Runge-Kutta and numerical integration for non-linear equations, why do we build models (e.g. hypothesis testing, understanding, diagnosing, forecasting, what is an end-to-end model)

Lectures:

1. **Why do we build models?**
2. **Introduction to End-to-End models** [e.g. definition = can handle climate as input (types of climate input). At least two species at each trophic (how to determine which species include). Fishing pressure is included (not a constant mortality) (how to model fishing pressure)].
3. **Continuous and discrete equations & dynamics** [NPZD equations, discretization and numerical schemes, example for IBM].
4. **Modeling Lab** [MATLAB Tutorial with a point model NPZD, sensitivity to quadratic mortality, closing with simple IBM].

Day 2 - Wednesday (August 27): Food-Web Models

Topics: theory, structure and application of several End-to-End models, including Ecopath, Ecopath with Ecosim (EwE), and IBMs

Lectures:

1. **Representing growth mortality and reproduction** [how to account for these dynamics in models that include fish]
2. **Introduction of Food-web Model**
3. **Parameter for Food-web Model**
4. **Simulations with Food-web Model** (e.g. Ecospace)
5. **Modeling Lab** [EwE tutorial, use model to test scenario for future climate by running a small sensitivity analyses. Ecopath is a balanced time independent model, Ecosim has time]

Day 3 - Thursday (August 28): Time dependent dynamic simulation (e.g. Ecosim)

*Topics: Adding time dependent forcing in the ecosystem model (e.g. climate forcing and fishing pressure).
How to model fishing pressure?*

Lectures:

1. **Including the effects of *climate* in ecosystem models**
2. **Including the effects of *fishing* in ecosystem models**
3. **Using time dependent information for fisheries management**
4. **Modeling Lab** [Tutorial to use a simple Ecosim and add fishing/climate]

Day 4 - Friday (August 29): Space dependent dynamic simulation (e.g. IBM)

Topics: Overview of models that include space e.g. Atlantis, Multi-species IBM. Lagrangian particle dynamics, using physical models to implement particle tracking algorithm, adding behavior to particle to develop IBMs.

Lectures:

1. **Overview of space dependent ecosystem models** (Ecosim, Ecospace, Atlantis, IBMs) (possible move to day 2), **Ecospace Model**
2. **Intro to IBM Models: Implicit and explicit approaches** (why and how to include space, implicit/averaging/closure problem and explicit/fully resolving)
3. **IBM Models: particle tracking and physical circulation** (overview of the physical model)
4. **IBM Models: Adding behavior** (e.g. theory of movement, implementing behaviors in particle tracking algorithms)
5. **Modeling Lab** (example of MATLAB Lagrangian/IBM: the case of a gradient/front structure in 2D with temperature as the cue for behavior, with some eddies at the front)