First CREAMS/PICES Workshop on East Asian Seas Time-series

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Workshop description

The first workshop on East Asian Seas Time-series (EAST), co-sponsored by the Ministry of Maritime Affairs and Fisheries (MOMAF) of the Republic of Korea, the School of Earth and Environmental Sciences of the Seoul National University, and PICES, was held April 21-22, 2005, at Seoul National University. More than 50 marine scientists from 7 countries attended the workshop (see photo below), which provided a forum for exchange of scientific information and expertise, and to explore how earlier experiences of time-series studies might assist in the development of future East Asian Seas Time-series. PICES recently produced a North Pacific Ecosystem Status Report (PICES Special Publication 1, 2004) which described conditions in many North Pacific ecosystems. Production of future updated status reports requires that there be an ongoing ocean/climate/ecosystem observing system to document change, and analytical capacity to interpret any changes observed. This workshop brought together experts from other Pacific time-series sites with Asian scientists looking to develop future observation programs in East Asian seas. Emphasis for the first workshop was on reviewing prior research and monitoring programs in the Japan/East Sea (JES), and on developing a framework for a future JES program. This was envisioned as the beginning of a workshop series that will eventually generate implementation plans for other East Asian seas (*e.g.*, Okhotsk Sea, Bohai/Yellow Sea, East China Sea and South China Sea).

Participants of the first CREAMS/PICES workshop on East Asian Time series (August 21-22, 2005, Seoul, Korea).

The workshop opened with a welcome address by Kyung-Ryul Kim (Korea), one of the workshop convenors [other convenors were Harold (Hal) Batchelder (U.S.A.), Vyacheslav Lobanov (Russia) and Yasunori Sakurai (Japan)]. Then followed a keynote talk by Steven Emerson (U.S.A.) and 7 invited talks on time-series observations at other locations in the North Pacific, and a poster session with more than 40 posters displayed. Information on selected Pacific Ocean time-series discussed at the workshop is shown in Table 1.

Steven Emerson gave a plenary lecture on biological and physical processes that can be informed by time-series observations of gases, focusing on diurnal oxygen cycles (to characterize diurnal changes one needs to average data over many days because of several diverse processes that impact dissolved oxygen; *e.g.*, approximately 150 days of remotely measured dissolved oxygen data from a mooring were used to observe diurnal changes in Puget Sound, Washington, U.S.A.), annual cycles of oxygen, nitrogen and noble gases, and decadal changes in upper thermocline gas concentrations as an indication of ocean ventilation. Several new technologies (moorings, floats, gliders) were described that will be used to provide more global coverage of net annual oxygen production, gross photosynthesis and decadal-scale changes.

David Checkley (U.S.A.) summarized 55 years of observations of the California Current by CalCOFI (California Cooperative Fisheries Investigations), including the rationale for the sampling (to understand causes of sardine population fluctuations), methods of sampling, new technologies (CUFES—Continuous Underway Fish Egg Sampler; DNA-specific probes), and accomplishments of the program. The primary achievements were to describe temporal variability in the California Current, to hypothesize and examine processes that might be responsible for observed phenomena (*e.g.*, warming leading to deeper or stronger stratification, reduced nutrient supply and reduced production), and to provide information useful for management of long-standing fisheries (sardines) and new fisheries (market squid).

Table 1. Selected Pacific Ocean time-series discussed at the EAST workshop.

Location	Sampling Period	Presenter
Scripps Pier SST CalCOFI (multiple stations)	1916- (ca. 90 years) 1949- (56 years)	David Checkley
Northeast Pacific (multiple stations) GAK1 (59.845˚N, 149.467˚W) Seward Line Newport Line	1997–2004 (ca. 7 years) 1970- (ca. 35 years) 1997- (7+ years) 1969-73; 1983; 1996-(not continuous, but spanning multiple regimes)	Harold Batchelder
Station PAPA (50˚N, 145˚W) and Line P	1956- (ca. 50 years)	Frank Whitney
HOT (22.75˚N 158˚W) Station November (30˚N 140˚W)	1988- (ca. 18 years) 121 cruises between July 1966 & May 1974 (8 years)	Michael Landry
Line A (transect south of Hokkaido)	1988- (18 years)	Atsushi Tsuda
Station KNOT (44˚N, 155˚E)	1998-2001 (3 intensive years; less intensive recently)	Toshiro Saino
Station SEATS (18˚N, 115.6˚E)	1999- (ca. 6 years)	Kon Kee Liu

Hal Batchelder reviewed a much shorter (7-8 years) period of observations by the U.S. Global Ocean Ecosystems Dynamics (GLOBEC) Program in the Northern California Current and coastal Gulf of Alaska. An important component of U.S. GLOBEC studies in the Northeast Pacific is the nested analysis of spatial and temporal scales—spanning from a few meters to basin-scale in space, and a few minutes to centennial in time. The broad spatial and temporal scales to be considered in understanding the linkages between climate, ocean conditions and ecosystem and population responses, require a diversity of approaches, including process-oriented studies, broad-scale observations, retrospective analysis, and modeling. Examples of spatial-temporal approaches were shown. The influence of remote large-scale forcing on local processes was illustrated using a 2002 hypoxia event off central Oregon that resulted from anomalously strong southward transport of high-nutrient, cold and fresh ("minty") subsurface water from the Eastern Subarctic Gyre.

Frank Whitney (Canada) described insights from the physical, chemical and biological measurements made along Line-P since sampling began in 1956 at Ocean Station PAPA in the Eastern Subarctic Gyre of the North Pacific. Principal milestones were the improved understanding of mixed layer dynamics, interannual variability and, more recently, warming trends, and recognition of both spatial and temporal variation in conditions. Time series observations along Line-P have been complemented by focused, process-oriented research programs such as the SUPER program evaluation of the grazing control hypothesis in the 1980s, and JGOFS and SERIES studies on iron and light control of phytoplankton production in the last 15 years.

Michael Landry (U.S.A.) summarized the core ocean physics, biogeochemical and organismal biology measurements made at the Hawaiian Ocean Time Series (HOT) station in the northern subtropical Pacific since 1988. Regular time-series sampling at HOT has revealed significant temporal variability at scales spanning months to decades. Time series of mesozooplankton has shown both significant seasonal variability in biomass (factor of 2 from summer to winter), and a long-term increasing trend since the late 1990s, with the latter due to the non-migrant, surface-resident plankton. This illustrates the importance of finer-grained analysis of the trophic compartments of the plankton. HPLC-derived pigments indicate substantial increases in *Prochlorococcus* and cyanobacteria in 1996. The presentation emphasized that there is significant temporal variability at multiple scales, and that understanding the mechanisms underlying the community changes requires observations of most, if not all, of the trophic levels.

Toshiro Saino (Japan) described the JGOFS North Pacific Process Study that was carried out at Station KNOT (44ºN, 155ºE) in the Western Subarctic Gyre. The most intensive study period was 1998-2001, when 27 cruises were conducted. The goal of this intensively sampled period was to characterize the seasonal and spatial variability of biological productivity and biogeochemical cycles, to develop a carbon budget, and to compare the results with other JGOFS stations (HOT, BATS, PAPA). Phytoplankton biomass (as chlorophyll-*a*) exhibited a diatom peak in spring, but remained low during the rest of the year; picophytoplankton abundance peaked in late June-August, after the diatom peak.

Atsushi Tsuda (Japan) reviewed the history of sampling along the Akkeshi transect (A-Line) south of Hokkaido, and described the seasonal and interannual variability in the Oyashio region. Since 1990, physics, currents, nutrients, net plankton, various optical measurements, size-fractioned chlorophyll, and other biogeochemical parameters have been measured 7 times per year. Significant seasonal variations in temperature, surface nutrients, chlorophyll and zooplankton biomass are now documented. Many stations that were occupied in June-July, after the termination of the spring bloom, have residual nitrate and silicate, suggesting limitation by something other than macronutrients—

perhaps iron. Iron is highest in winter, lower in spring, and very low in May. On longer time scales, observations of the Oyashio region extending back to the late 1960s indicate an approximately 20% decline of subsurface dissolved oxygen concentration, superimposed with decadal scale fluctuations of a nearly similar magnitude (Fig. 1).

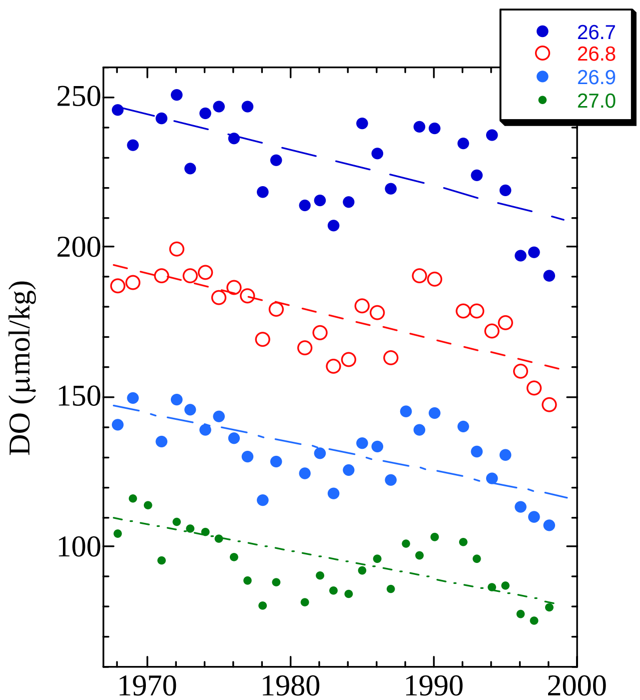

Fig. 1 Long term (from 1968 to 1998) declining trend of subsurface oxygen concentration (at isopycnals 26.7-27.0) in the Oyashio region of the western North Pacific (from Ono et al. *2002.* Can. J. Fish. Aquat. Sci. *55: 1878-1893).*

The final presentation on the first day was by Kon-Kee Liu (China-Taipei) on the South-East Asia Time-series Study (SEATS) station in the South China Sea. SEATS goals are to understand how monsoonal forcing and ENSO control biogeochemical cycling in this region; to monitor how episodic events, like typhoons and eddies, impact upper ocean biology; and to link present biogeochemical processes with paleo-records to examine climate change impacts on ocean biogeochemistry. Ship-based sampling has been conducted bi-monthly or quarterly at the SEATS station (18ºN 115.6ºE) since September 1999. SeaWiFS and ship-board observations indicate significant seasonal variation in phytoplankton biomass, with highest values in mid-winter and lowest in summer. This cycle is correlated with monsoonal winds, with highest values occurring at the peak of the NE monsoon, and summertime low values during the relatively weak SW monsoon. SeaWiFS data from >6 years indicate significant interannual variation that appears more related to ENSO effects and the Indian Ocean Dipole Moment, than to local wind anomalies.

Two activities were carried out during the second day of the workshop: (1) a series of 9 presentations on previous and potential future research and monitoring of the Japan/East Sea (Fig. 2), and (2) a group discussion about the process for developing a mission statement, an implementation plan, and listing of specific goals and hypotheses for future JES studies.

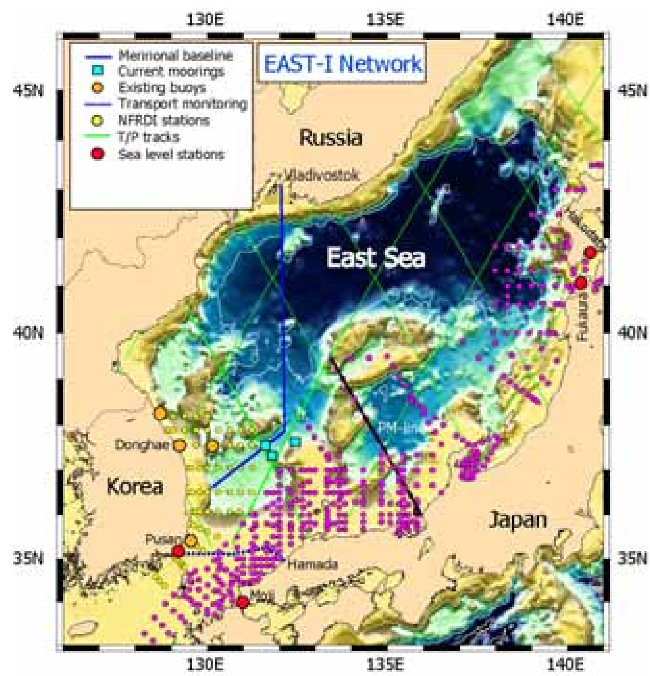

Fig. 2 Potential components of an EAST Japan/East Sea observation network (from presentation by K.-I. Chang at the workshop).

Toshitaka Gamo (Japan) made the case for the JES being a small "model" ocean. The JES has several deep basins, a subarctic gyre, a subtropical gyre, deep-water formation isolated from global deep water formation, and high primary production and export flux. All of these make the JES a good model system for the larger oceans. Sanae Chiba (Japan) described several Japanese time series datasets of the JES. These include the PM Line across the Tsushima Current region (1972-present; black line in Fig. 2), spawning and nursery ground surveys for fisheries, and the Hirota plankton collections from 1966-1990. There is a N-S gradient in nutrient availability and in timing of the spring bloom (earlier in the south). The copepod community in the northern JES has large calanids, similar to the Oyashio region, while the southern JES has smaller, subtropical copepods, more typical of the Kuroshio region. Regime shifts and decadal variation were observed in community structure and biomass, with different responses in southern and northern parts of the JES. Mechanisms responsible for these responses were discussed. Biological observations, especially along the PM line, need to be continued, and perhaps expanded, and more monitoring is needed in the northern JES.

Vyacheslav Lobanov (Russia) presented results from recent (1995-2005) Russian studies of deep convection, ventilation, mesoscale eddies and coastal upwelling. Extremely cold winter conditions of 2000-01 resulted in the production of new bottom water in the JES. No similar bottom water renewal event had been observed for perhaps 50 years. Yury Zuenko (Russia) reviewed past ocean research of the TINRO-Center in the JES. Effort has varied through time, driven primarily by fisheries demands. High sampling efforts off Korea and Russia in the 1950s and 1980s were motivated by the need to understand the dynamics influencing active mackerel and sardine fisheries, respectively. When these fisheries collapsed, so did the need for ocean observations. Fisheries surveys and ichthyoplankton monitoring in recent years have focused on Russian near-shore shelf regions of the JES.

Kyung-Il Chang (Korea) described a future Korean CREAMS/PICES program called CHEESE for Circulation, Hydrography, and Ecosystem Response in the East Sea, which has as goals (1) understanding the multi-scale (seasonal to interdecadal) variability of hydrography and circulation, (2) identifying processes controlling carbon cycling, (3) understanding climate impacts on physical and chemical conditions of the JES, and (4) establishing permanent observation stations and a data exchange network. Core observations would be repeat ship surveys, ocean moorings, volunteer observing ships, satellite-tracked floats, and satellite observations (Fig. 2). Suggestions on modifications to the program were welcomed.

Tongsup Lee (Korea) described initial plans for CarboEAST, which is a program to examine carbon cycling of the JES, with emphasis on meso-scale processes, feedbacks and climate sensitivity. Sinjae Yoo (Korea) argued that the JES ecosystem provides a model for basin scale ecosystem changes since the JES has two gyres, a subpolar front, deep thermohaline circulation, warm core rings, ice formation and melting, and strong seasonal cycles in forcing. Importantly, the JES has strong, unambiguous signals of long-term ecosystem change (PICES Special Publ. 1, 2004) and shows high variability in ecosystem properties in space (northern gyre, southern gyre, and coastal regions). However, much remains unknown about the JES ecosystem, particularly the spatio-temporal variability of photosynthesis, bacterial production and microbial loop dynamics, and size composition of lower-trophic levels. Long-standing issues in pelagic ocean ecology, such as changes in production throughout (due to physical forcing), changes in food web structure, and timing (match-mismatch) of seasonal cycles, are amenable to investigation in the JES.

Chul Park (Korea) reviewed the plankton, hydrographic and nutrient chemistry surveys that have been conducted bi-monthly since 1961 around the entire Korean peninsula (yellow dots in Fig. 2). He assessed the strengths and weaknesses of the current sampling program, and proposed changes to improve the efficiency and effectiveness of the surveys. The strength of continuing the existing plan is that there is a long continuous record, and reluctance to change time-series midstream. However, insufficient manpower and funds to process the data create difficulties in making the products of the surveys available. Dr. Park proposed a modified program which would reduce the bi-monthly survey to a quarterly survey (in February, May, August and November), supplemented by higher frequency (bi-weekly) sampling of a few (2-3) key stations. Several scientific objectives were proposed to achieve better knowledge of (1) zooplankton community ecology, (2) physiological and behavioral dynamics of ecologically important zooplankton species, (3) trophic studies of energy/biomass transfer from zooplankton to fish, and (4) climate change influence on zooplankton community ecology.

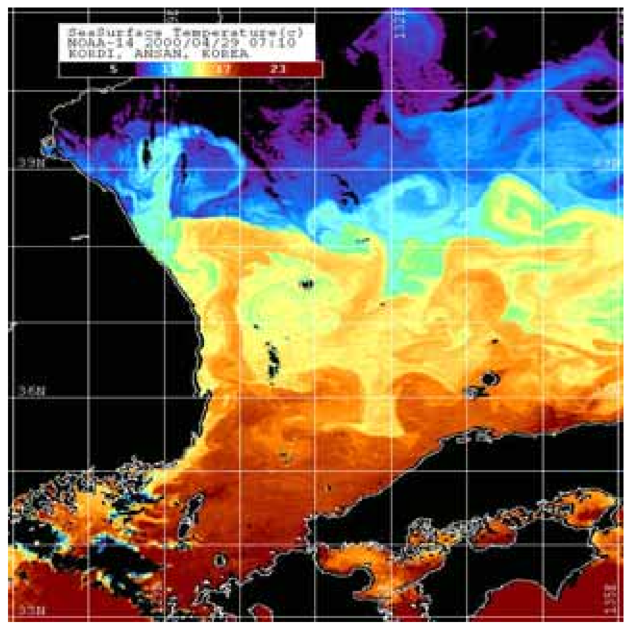

Fig. 3 Sea surface temperature in the southern half of the JES on 29 April 2000. Note the strong gradients in temperature across the subpolar front (blues [<10˚C] to the north, yellows [>15˚C] to the south), and the high mesoscale variation in temperature both at the subpolar front and within the northern and southern gyres (from presentation by S. Kim at the workshop).

Suam Kim (Korea) described fisheries oceanography and fish community structure in the JES, focusing on commercially important pelagic and demersal fisheries. He noted that the JES is dynamic, with two different current systems colliding in the middle to form a meandering subpolar front, and that eddies and recirculation of currents due to fronts and topographic steering creates significant biological heterogeneity and gradients in productivity (Fig. 3). Walleye pollock are important fisheries in the northern JES, and as studies off Alaska have shown, transport, retention and survival of pollock larvae are important in establishing large year classes. Catch of pollock in the JES has varied markedly through time, with peaks in the 1930s and 1970-1985 (with a maximum in 1981-82). Catches are low throughout most of the 1950s, 1960s, and since the late 1980s. Studies are needed to examine the biophysical coupling that determines larval pollock survival in the JES. Distribution of adult fish (and squid) is controlled by hydrodynamics and water mass characteristics, but additional studies are needed to explore these relations. Ecosystem structure in the JES changed after the 1976-77 regime shift: biomass of phytoplankton, squids, and some fish (small sharks, Pacific saury, sandfish) declined, while many other fish (walleye pollock, Pacific sardine, other small pelagics) increased. Mechanisms responsible for these changes are unclear, and should be investigated by integrated modeling of lower and higher trophic levels.

At the conclusion of the series of presentations, a general discussion of EAST studies in the JES ensued. This discussion was led by H. Batchelder and K.-K. Liu. It is important that EAST has specific goals, objectives and scientific hypotheses. We debated whether there needed to be clear "societal benefits" of the EAST program *vs.* "improved scientific understanding". A consensus on this point was not reached, even though it was argued that long-term funding of open-ended time series programs is difficult to maintain unless there are clear societal goals (improving ocean health, more sustainable fisheries, *etc*.).

Discussion focused on basic science, mission statement, and defining general goals for an EAST JES program; details for a specific implementation of the program was deferred to a later time. In addition to general comments, there was discussion of specific hypotheses that might be part of an EAST program in the JES. Below, in an unprioritized order, are the key points raised during the discussion; these are listed as recommendations, but some are more ideas than recommendations. As a next step, it was strongly advised that an Advisory Panel should be formed under PICES to initiate and oversee the program and to develop the workshop summary into a science plan for EAST (see full report online on the PICES website).

Recommendations

- The development/design of the EAST JES program should follow the format used previously by SEATS.
- A TEN year plan should be prepared that can consider climate change and variability issues, and that uses the JES as a "miniature model ocean". The JES may be a logistically manageable sized system in which key process can be understood that will have application to the much larger North Pacific Ocean. Its isolation and small size make it feasible to monitor the entire system (using the technologies described above) at low cost (compared to instrumenting the entire Pacific).
- A JES study could provide an example of what the impacts of climate change might be on a regional sense. Related to this, it was mentioned that the EAST JES program must be a multinational collaborative effort between Russia, Japan and Korea, since the JES is a shared ocean, and perhaps when the EAST implementation plan is developed, the IGBP IMBER program, which includes both biogeochemistry and ecosystem structure and function elements, should be approached for "endorsement" or "sponsorship".
- A product of the EAST JES program should be scientific knowledge, and also improved ideas about how to coordinate and integrate a multinational Ocean Observing System. EAST leaders, after development of an implementation plan, should explore formal connections with the Global Ocean Observing System (GOOS), and in particular its component for the North East Asia Region (NEAR-GOOS).
- New scientific knowledge from the program should have eventual application to management and public policy, specifically, to document the effect of anthropogenic activities on the oceanography of the East Asian marginal seas. A question was raised about whether we understand the natural variability well enough to discriminate/differentiate between natural and anthropogenic causes of change.
- The issue of two-way connections was mentioned. Anthropogenic activities, such as pollution, climate change, fishing, mariculture, *etc*., can certainly have impacts on ocean systems, but it is just as important to recognize the human dimension issues, *e.g.*, that natural and human impacts can have feedback on human populations and activities.
- Although the emphasis of the workshop was specifically on the JES, it was noted that CREAMS is an East Asian marginal seas program, which might eventually include many other regional seas (Yellow, ECS, Bohai, South China Sea, Okhotsk), and that the plan developed for the JES may be a model for other regions to follow in the future. The EAST JES study and other time-series studies in the East Asian marginal seas, such as SEATS, may form a regional network as a part of GOOS. Inter-calibration and other joint activities may be implemented in the future.

Specific hypotheses/goals

- Climate (atmospheric pressure patterns, winds, freshwater balance, *etc*.) variability controls physical forcing (ocean circulation, stratification, surface and boundary fluxes) in the JES, and its interaction with adjacent basins;
- Climate impacts the JES ecosystems and linkages across trophic levels;

- Biogeochemical processes are controlled by climate variability/change and physical processes at shorter time scales (seasonal and eddy scales);
- Explore projected IPCC global and regional forcing (What are the most important time-scales of physical forcing in the JES?);
- Resolve multiple temporal scales; at least down to event scale (a few days?);
- Study the role of episodic dust storms on the productivity of the JES;
- Explore flow (mesoscale activity)-topography interactions in providing productive ecosystems;
- Develop a community three-dimensional physical circulation model of appropriate vertical and horizontal resolution that can be used for biogeochemical and ecosystem studies;
- Develop a community biogeochemical (and ecosystem) model coupled to a physical circulation model;
- Couple observational system data with models (data assimilation) of physical, biogeochemical and ecosystem processes.

Workshop summary and future activities

Overall, the first CREAMS/PICES workshop on East Asian Seas Time-series was successful in establishing a solid framework for developing a detailed implementation plan for future integrated multi-national time-series observations and accompanying process research in the JES. The overview talks of the first day provided strong evidence for the value of time-series programs from diverse regions of the North Pacific. The presentations from the second day described many past, ongoing, and planned time-series programs in the JES, and provided valuable fodder for the subsequent group discussions which are summarized above. The next step in this process is to form a leadership body that will prepare a draft implementation plan, using the information from this workshop as a basis for future observing programs in the JES.

The hospitality of our Korean hosts was unmatched. The venue was well organized, well staffed, and the workshop enabled old friends to reconnect and new friendships to be formed. All in all, an excellent (fun and productive!) workshop.

Dr. Harold (Hal) Batchelder (hbatchelder@coas.oregonstate.edu) is a Professor (Senior Researcher) at the Oregon State University, and Executive Director of the U.S. GLOBEC Northeast Pacific Regional Coordinating Office. Previously he served for 6 years as the Scientific Director of the National U.S. GLOBEC Steering Committee Office. He is Co-Chairman of the Climate Change and Carrying Capacity Program of PICES. His research uses models to examine the interactions of plankton populations and physical flow fields, using in particular Lagrangian-Eulerian approaches that allow coupling of complex biological states and behaviors with lower trophic levels.

Dr. Alexander Bychkov (bychkov@pices.int) has been the Executive Secretary of PICES since 1999. He graduated from the Moscow State University, received his Ph.D. in Chemistry from the USSR Academy of Sciences, and then spent more than 20 years working as a Research Scientist at the Pacific Oceanological Institute in Vladivostok. In pre-PICES life, his scientific interests focused on the carbon cycle in the North Pacific and its marginal seas. He was involved in regional (national and international) cooperation related to the Joint Global Ocean Flux Study (JGOFS), and was a member of the JGOFS Scientific Steering Committee (1996-2003), the Co-Chairman of the JGOFS North Pacific Task Team (1997-2001) and the Chairman of the JGOFS North Pacific Synthesis Group (2001-2003).

Dr. Kyung-Ryul Kim is a Professor of the School of Earth and Environmental Sciences, Seoul National University (SNU), Korea, and is Director of the Research Institute of Oceanography at SNU. Kyung-Ryul received his B.S. and M.S. degrees in Chemistry from Seoul National University, and his Ph.D. in Oceanography from the University of California, San Diego. He has been involved in CREAMS (Circulation Research of the East Asian Marginal Seas) since 1993. His research has focused on the material cycle and circulation by various chemical tracers in the Japan/East Sea. His scientific interests also include the carbon cycle and its relation to climate change.