2008 OECOS Workshop in Dalian

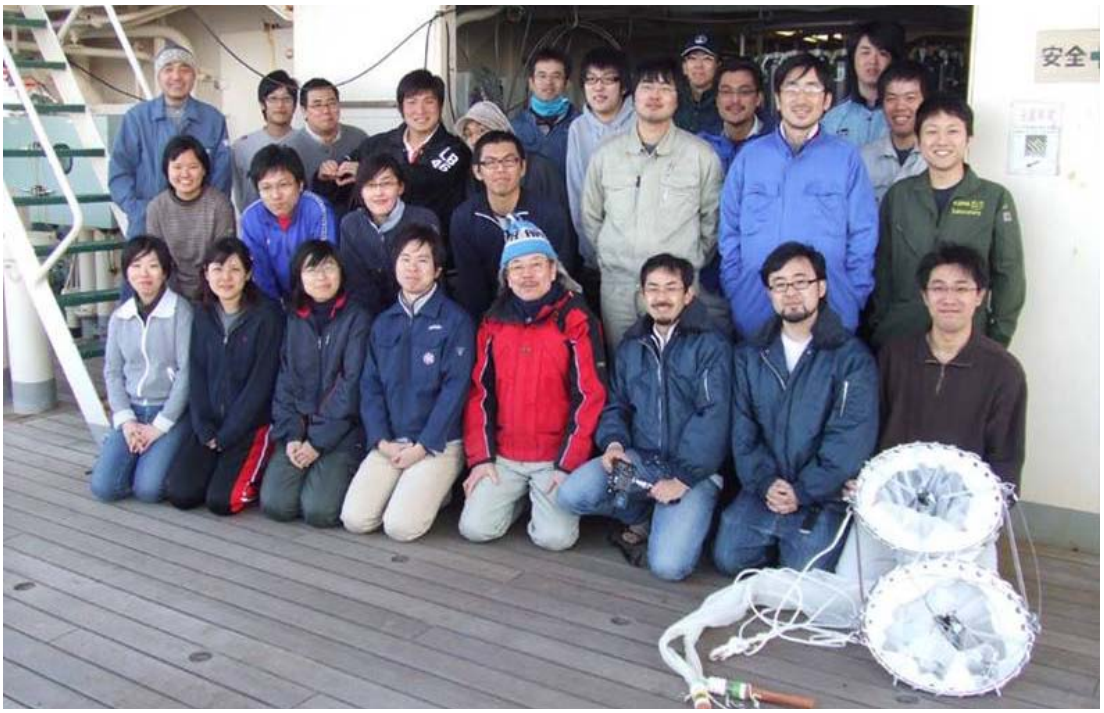
by Charles B. Miller

The 2008 PICES Annual Meeting in Dalian, China, included a 1-day workshop, held on October 26, for presentation and discussion of the Japanese OECOS expeditions in the Oyashio region during the spring bloom of 2007. OECOS is an acronym for **O**ceanic **E**codynamics **CO**mparison in the **S**ubarctic Pacific. It is a PICES program originally intending a comparison of processes in the Oyashio and in the oceanic Gulf of Alaska during the spring increase of phytoplankton production rates. These areas share similar mesozooplankton communities, particularly four species of interzonally migrating copepods. However, the Oyashio supports a strong spring bloom, while the Gulf of Alaska is consistently "HNLC" (High Nitrate, Low Chlorophyll) with continuously low chlorophyll levels, usually less than about 0.6 mg m^{-3}. The observational goals were spring time series in both areas, exceeding one month duration. A team from Japan, led by Professor Tsutomu Ikeda, obtained funding for the Oyashio work which was carried it out in March to May 2007. A North American team failed to convince government agencies to fund its proposal. The workshop was an opportunity for initial, international presentations of the Oyashio results and of some insights gained by the Gulf of Alaska workers from programs other than OECOS.

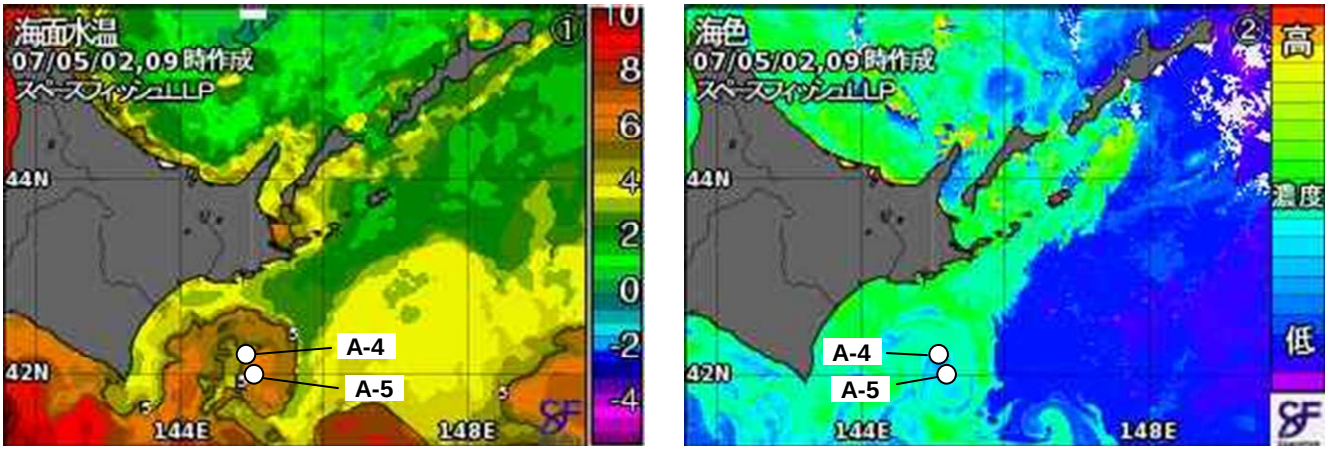
The workshop was chaired by Drs. Atsushi Yamaguchi (Graduate School of Fisheries, Hokkaido University) and Charles Miller (Oregon State University). Fortunately, all of the registered participants were able to attend the workshop. Affiliations of the presenters are listed in the meeting program. The workshop presentations can be summarized as follows:

Dr. Yamaguchi reviewed the history of the successful Japanese expeditions to the Oyashio region from March 8 to March 15, 2007 (onboard T/S *Oshoro Maru*) and from April 5 to May 1, 2007 (onboard R/V *Hakuho Maru*). He reported that the Japanese team of "OECOS–West" has held two conferences after the expeditions to discuss the results.

Dr. Tokihiro Kono described the hydrographic conditions during the cruises. Stations occupied were along the A-line extending southeast from Hokkaido's east coast, with much of the station work concentrated at station A-4. Frequent CTD casts during both cruises showed strongly shifting proportions of offshore Oyashio Water (OYW) – a northern influence, coastal Oyashio Water (COW) from over the Hokkaido shelf and modified Kuroshio Water (MKW) that appeared in satellite images as a Kuroshio loop or boundary eddy. MKW was most prevalent at station A-5, but mixtures of all three types were present throughout the April cruise. Highest chlorophyll concentrations were associated with greater proportions of COW. The importance of advective variation was evident in all variables (T, S, chlorophyll and other biology).



Group photo of 26 participants of the R/V Hakuho-Maru *cruise (April 5 to May 1, 2007). In front row: Prof. Tsutomu Ikeda in red jacket and Dr. Atsushi Yamaguchi holding the nets.*



Satellite images of temperature (left) and chlorophyll (right) during the OECOS cruises. Samplings were conducted at stations A-4 (42˚15'N, 145.07'E) and A-5 (42˚00'N, 145˚15'E) on the A-line. A warm water eddy can be seen at the stations. Chlorophyll peaked on April 9, 2007.

Dr. Kenshi Kuma reported measures of dissolved and total (including particulate) iron concentration. Dissolved iron values were remarkably similar between pre-bloom and bloom periods, 0.3–0.5 nM and 0.4–0.6 nM, respectively. However, total iron shifted sharply upward from the March values of 3–5 nM during strong, deep vertical mixing to 10–25 nM during the intrusions with highest chlorophyll (10–23 μg/l) in April. At stations along the A-line, iron supply appeared to vary with the sources of advection.

Dr. Tomonori Isada detailed the ambitious set of phytoplankton observations completed during the cruises. Flora in the bloom period was strongly dominated by diatoms, shifting from *Thalassiosira* species initially to *Chaetoceros* species. There were several species of each in the two successive bloom phases. Nano- and picophytoplankton became progressively more important toward the end of the cruise. There were signs in the physiology of diatoms (F_v/F_m and flavodoxin/ferrodoxin ratio) that iron stress was significant despite high total iron and abundant macronutrients.

Results of dilution experiments to measure phytoplankton growth and microzooplankton grazing rates were presented by Dr. Takashi Ota. Grazing rates were very low, mostly 5–15% of initial chlorophyll stock per day, or 10–30% of primary production. Phytoplankton growth rates were high during the events with highest chlorophyll stocks, up to 0.52 d^{-1}.

Dr. Yamaguchi described the time series sampling for mesozooplankton using three different net systems. Most of the *Neocalanus* stock was in the upper water column with no discernible vertical migration, while *Metridia pacifica* migrated in early April but stopped (except for C6-females) toward the end of the cruise, staying during night at the daytime depth. The reason was not clear. Developmental progression was obvious for *Neocalanus flemingeri* (C1–C4) and for *N. cristatus* (C2–C4). Only part of the *Eucalanus bungii* population migrated into surface layers at night, the females producing eggs near the surface. Spawning rates were determined for that species only.

Dr. Toru Kobari reported that gut content chlorophyll of *N. cristatus* and *E. bungii* varied with water column chlorophyll levels, with extreme amounts in the diets associated with the highest bloom levels. The overall copepod community feeding rate was estimated as 0.1 to 1.2 gC m^{-2} d^{-1}. This was a significant fraction of the primary production, reported by Dr. Isada as 0.5 to 3.5 gC m^{-2} d^{-1}. Copepod grazing was not sufficient to prevent further development of the bloom at any point, but phytoplankton must have been the major constituent of the copepod diet, unlike the situation in continuously oligotrophic areas farther seaward. Establishing this point was a major goal of OECOS.

Doctoral candidate Hye Seon Kim reported on the metabolism and growth of two species of euphausiid abundant in the Oyashio: *Euphausia pacifica* and *Thsanoessa inspinata.* Euphausiid abundance varied with the chlorophyll concentration, suggesting that supply to the A-line stations was affected by the varying water sources. Length distributions of both species indicated only slight growth during the April cruise. It was noted that all *T. inspinata* less than the modal size were male; all those larger were female. This suggests protandrous hermaphroditism, a unique finding for euphausiids but occurring in some decapod crustaceans. Metabolic rates did not vary much with the temperature or food availability during the two-cruise series, even though chlorophyll levels were very different between March and April.

Mid-water trawl and acoustic estimates of mesopelagic fish were reported by Mr. Tadanori Fujino. Scattering layers at 200 m appeared to stay in that vicinity day and night. Dominant species captured with a 16 m^2 trawl were *Diaphus theta* and *Stenobrachius leucopsaurus.* The estimated abundance of the two species, 6.9 g m^{-2}, was characterized as less than typical for the region.

Three papers were presented by participants in the failed "OECOS–East" attempt to obtain funding for a parallel study in the Gulf of Alaska. Drs. Michael Dagg and Suzanne Strom reported results from the GLOBEC Northeast Pacific program work on the Alaskan shelf. In apparently iron-limited waters at the shelf edge, Dr. Dagg found that grazing by *Neocalanus* spp. could be (1) keeping large phytoplankton from blooming – balancing their slow growth rate with grazing, and (2) releasing nano- and picophytoplankton from predation by microherbivores. Dr. Strom reported on the lower trophic level community composition in shelf-edge waters, showing the parallel to definitively iron-limited communities farther seaward. Events are observed in which iron limitation is relieved at and beyond the shelf edge by both river discharges laden with sediment and by wind-borne dust plumes.

Dr. Miller reviewed the original OECOS–East plan to investigate the likely causal correlates of sub-seasonal variation in phytoplankton stock abundance at Station P. He stressed that detailed evaluation of relations at the lowest trophic levels *without* supplementing the iron availability is needed to reveal the ecodynamics of HNLC systems. The key is to determine the phase relations of physics, nutrients, floristics, microherbivores and macrozooplankton to the sub-seasonal variation of chlorophyll and to more explicit measures of phytoplankton biomass.

It is clear from the reports that OECOS-West produced excellent results and valuable insights about ecosystem function during the Oyashio spring bloom. Another attempt at such a time series should consider moving farther away from Hokkaido and from the Kuroshio–Oyashio frontal region. Such a project might well be undertaken under Russian auspices some place well offshore from Sakhalin or southern Kamchatka. The work proposed by OECOS–East remains to be done and will be eminently worthwhile.

PICES Calendar

- PICES Harmful Algal Bloom Training Course, January 15–23, 2009, Manila, Philippines;
- Third Argo Science Workshop: The future of Argo (co-sponsored by PICES), March 25–27, 2009, Hangzhou, China;
- 11th Salmon Ecology Workshop (related to the development of the North Pacific Ecosystem Status Report for the Alaska Current, California Current and the Bering Sea), April 7–8, 2009, Juneau, U.S.A.;
- North Pacific Ecosystem Status Report Workshop on "*Status and Trends in East Asian Marginal Seas*", April 21–22, 2009, Busan, Korea, in conjunction with the 15th Pacific–Asian Marginal Seas (PAMS) meeting "*Observations, Understanding, and Prediction of Climate Variability in PAMS*", April 23–25;
- Inter-sessional Science Board and Governing Council meetings and Workshop to develop an Implementation Plan for the new PICES integrative scientific program, FUTURE, April 26–29, 2009, Qingdao, China;
- 3rd GLOBEC Open Science Meeting (co-sponsored by PICES), June 22–26, 2009, Victoria, Canada;
- Third PICES Summer School on "*Satellite Oceanography*", August 25–28, 2009, Seoul, Korea;
- 6th International Conference on Marine Bioinvasions (co-sponsored by ICES, PICES, U.S. National Sea Grant College Program, Pacific States Marine Fisheries Commission and Portland State University), August 24–27, 2009, Portland, U.S.A.;
- ICES/PICES Symposium on "*The Effects of Environmental Variability on Cephalopod Populations*", (CIAC'09), September 3–11, 2009, Vigo, Spain;
- OceanObs'09 Conference—*Ocean information for society: Sustaining benefits, realizing the potential* (co-sponsored by PICES), September 21–25, 2009, Venice, Italy;
- ICES/PICES Theme Sessions on "*Climate Impacts on Marine Fishes: Discovering Centennial Patterns and Disentangling Current Processes*" and "*Global Ocean Observing Systems*" at the ICES Annual Science Conference, September 21–25, 2009, Berlin, Germany;
- PICES Eighteenth Annual Meeting (PICES-2009), October 23–November 1, 2009, Jeju, Korea;
- International Symposium on "*Rebuilding Depleted Fish Stocks: Biology, Ecology, Social Science and Management Strategies*" (primary sponsors: ICES, PICES and UNCOVER; co-sponsoring organizations: NAFO, DFO and IMR), November 3–6, 2009, Warnemünde Germany;
- North Pacific Ecosystem Status Report Synthesis Workshop, December 1–3, 2009, Honolulu, U.S.A. (by invitation);
- PICES/ICES Symposium on "*Forecasting Climate Change Impacts on Fish and Shellfish*", April 26–29, 2010, Sendai, Japan;
- 26th Lowell Wakefield Symposium on "*Ecosystems 2010: Global Progress on Ecosystem-based Fisheries Management*", spring or fall 2010, Anchorage, U.S.A.;
- PICES Nineteenth Annual Meeting (PICES-2010), October 2010, Portland, U.S.A.;
- ICES/PICES Symposium on "*Carrying Capacity: What does it mean in a Changing Ocean?*", 2010, Lisbon, Portugal;
- 5th International Zooplankton Production Symposium (primary sponsors: PICES and ICES), March 2011, Pucon, Chile;
- PICES Twentieth Annual Meeting (PICES-2011), October 2011, Russia.