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Korean activities in the Arctic in the year 2003

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This briefly introduces field activities we conducted in the Arctic seas and at our Arctic facility *Dasan Station* which was opened at Ny-Alesund, Svalbard on April 2002. Korea Polar Research Institute (KOPRI, the former 'Polar Sciences Laboratory of Korea Ocean Research & Development Institute') is the operating agency of the national Arctic program as well as Antarctic program (Director, Dr. Yeadong Kim, ydkim@kordi.re.kr). Oceanographic studies in the Arctic waters (the Barents, Okhotsk, and Chukchi Seas) spanned from marine biology, geology and geophysics to paleoceanography, in collaboration with China and Russia. The studies at *Dasan Station* focused on marine biology, environmental monitoring and upper atmospheric physics. As a member of International Arctic Science Committee (IASC), we'll endeavor to contribute to protection of the Arctic environment. We also plan to design some of these studies as comparative studies with Antarctic regions in preparation for the 2007/1008 International Polar Year.

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A. Oceanographic studies in Barents, Okhotsk, and Chukchi Seas

(1) Distribution and abundance of phyto- and zooplankton communities in the Barents Sea

Phytoplankton biomass and species composition were investigated in the Barents Sea from August 9 to August 21, 2003. The phytoplankton biomass (chl-*a*) were higher at the middle than at the surface and bottom layers. Phytoplankton communities were composed of diatoms, dinoflagellates, cryptophyceae, silicoflagellate and prymnesiophyceae, and showed 53 taxa in surface and 27 taxa in bottom. Leading groups for primary production were pico/nano-phytoplankton. The most abundant species was pico-phytoplankton in all stations and water depths. Phytoplankton abundance ranged 3.73×10^5 to 2.5×10^6 cells/l, showing some resemblance between the surface and bottom. In summary, (1) phytoplankton primary production was more active in middle layer than those of surface and bottom, (2) micro-phytoplankton species were dominated in surface, but phytoplankton standing crops analogous to each other. (**Dr. Sung-Ho Kang, shkang@kordi.re.kr**)

Protozooplankton was investigated in the central Barents Sea during August 2003. Biomass of heterotrophic nanoflagellates ($>10 \mu\text{m}$) ranged 0.8 - 7.1 $\mu\text{gC l}^{-1}$ with the mean of 3.1 $\mu\text{gC l}^{-1}$, accounting for 3-34 % of the whole protozooplankton (the mean 10 %). Biomass of ciliates ranged 5 - 33 $\mu\text{gC l}^{-1}$ with a mean of 15 $\mu\text{gC l}^{-1}$, accounting for 26-61 % of the whole protozooplankton (the mean 49 %). Biomass of heterotrophic

dinoflagellates (HDF) was in the range of 5 - 24 $\mu\text{gC l}^{-1}$ with the mean of 12 $\mu\text{gC l}^{-1}$, and this accounted for 23-56 % of the whole protozooplankton (the mean 41 %). Ciliates and HDF accounted for > 90% of the whole protozooplankton biomass. Biomass of protozooplankton and ambient chlorophyll level displayed a significant correlation ($R^2=0.51$, $p<0.001$). This implies a prey-predator relationship between phytoplankton and protozooplankton, which suggests that protozooplankton can play a significant role in the carbon cycle in the Barents Sea.

Distribution and abundance of zooplankton were also investigated during the post-bloom, the late summer period. Copepods were the dominant members of zooplankton assemblage sampled by WP2-net, however, amphipods and chaetognaths occurred in high numbers at some waters. Abundance of zooplankton was considerably high. Distribution of 3 major calanoid copepods reflected that of water masses. Distribution of *Calanus finmarchicus*, an Atlantic, warm water species and *C. glacialis*, a cold water species displayed a north to south gradient. *Metridia longa* also tended to be abundant in Arctic waters. Abundance of copepods didn't seem to be directly related to the distribution and level of ambient chlorophyll. Distribution of copepodites and nauplii was not exactly corresponded to that of adults. Copepodites and nauplii were highly abundant at a few stations of low surface salinity, which might imply a recent retreat of sea ice. (Dr. Hyung Chul Shin, hcshin@kordi.re.kr)

Meiofauna were sampled from 6 August to 26 August 2003 at 20 stations. Meiofauna community consisted of ten taxa with a mean abundance of 432 indiv./10cm². Nematods were the dominant group and show highest value in the frequency of abundance with 83.1% of total Meiofauna, followed by copepods (8.4%) and Sarcostygophorans (5.3%). The vertical distributions of meiofauna are affected mainly by nematods. The N/C ratio and the N/K ratio have similar patterns during the study periods, and can be the possible indications for the environmental monitoring in the area. (Dr. WonChol Lee, wlee@hanyang.ac.kr)

(2) Phytoplankton biomass and distribution in the Chukchi Sea

Distribution and biomass of phytoplankton were investigated in the Chukchi Sea during the 2nd Korea-China Arctic Expedition, from Aug. 2003 to Sept. 2003. Total of 82 discrete water samples were collected for the phytoplankton related measurements. Chl-*a* value ranged from 0.1 to 2.16 mg chl-*a* m⁻³ (mean of 0.65±0.66 mg chl-*a* m⁻³) in the overall surface stations. The highest values of the chl-*a* concentration (0.52~2.16 mg chl-*a* m⁻³) were found in the Chukchi Sea ice-edge region and near the Bering Strait. Micro-phytoplankton (>20 μm) were more important contributors for the increase of the chl-*a* in the Chukchi Sea. Micro-phytoplankton and pico/nano-phytoplankton(<20 μm) accounted for 66% and 34%, respectively. Vertical values of chl-*a* ranged from 0.3±0.23 to 3.94±3.14 mg chl-*a* m⁻³ (mean of 1.22±1.06 mg chl-*a* m⁻³). Micro-phytoplankton and pico/nano-phytoplankton accounted for 67% and 33%, respectively. During the expedition, sea surface temperature ranged from 2 to 8°C. We suggest that the continuous studies on the biological factors (zooplankton grazing pressure, bacterial decomposition and protozoan top-down control), chemical factors (nutrients, iron input) and physical factors (temperature, salinity and vertical stability) which affect

phytoplankton species composition, biomass and productivity should be supported for understanding of Arctic marine ecosystem to control global environmental changes. **(Dr. Kyung-Ho Chung, khchung@kordi.re.kr)**

(3) An organic geochemical study on late Quaternary paleoenvironment of the Saint Anna Trough, Kara Sea in the Arctic

Changes in sedimentological environment in Kara Sea with respect to past climate changes has been investigated using stable isotopes of organic carbon and nitrogen in three sediment core samples collected from the Saint Anna Trough. The C/N ratio extremely decreased at the depth (which seems like deglaciation). Total organic carbon and total nitrogen contents continuously increase after Holocene, showing low C/N ratio. The stable isotopes ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) also increase after deglaciation associated with paleoceanographic change. In addition, it is notable that both values were significantly higher than others at 2 and 3 times. This oscillation might be a kind of periodical variations of Arctic paleoclimate. The larger variation ranges of $\delta^{15}\text{N}$ than $\delta^{13}\text{C}$ seem to be due to the comprehensive factors such as terrestrial organic matter input and also marine productivity (nutrient supply). The estimated contribution rates of terrestrial organic matter were higher than 60% at the all three sites. The difference of terrestrial organic matter contribution rates between at LGM and after LGM indicate about 10% at St. 25, 20% at St 26 and 30% (the highest value) at St. 34. **(Dr. Kyung-Hoon Shin, shinkh@hanyang.ac.kr)**

(4) Marine geological research of Barents Sea

For the five gravity cores obtained from the central Barents Sea during August 2003 (AR03 cores), photograph and X-radiograph were taken, and water content and magnetic susceptibility were analyzed. The preliminary result for the cores suggests that Late Quaternary paleoenvironment of Barents Sea had been variable with time and locality. **(Dr. Jae Il Lee, leeji@kordi.re.kr)**

(5) High-resolution seismic, hydroacoustic and geochemistry study in gas hydrate area of the Sea of Okhotsk: Preliminary results of the CHAOS 2003 international research expedition

As the sea connecting with the East Sea, the Sea of Okhotsk is the most potential area of gas hydrates in the world. The CHAOS (hydro-Carbon Hydrate Accumulation in the Okhotsk) international research expedition was carried out in August 2003. In the expedition, high-resolution seismic and geochemical survey was also conducted to examine shallow sub-surface structures of gas hydrate-bearing sediments. Sparker seismic profiles show only diffusive high-amplitude reflections without BSRs at BSR depth. It means that BSR appears to be completely different images on seismic profiles obtained using different frequencies. Many acoustic chimneys rise from BSR depth toward seafloor. The chimneys can be divided into two groups with different seismic characteristics; wipe-out and enhanced reflections. Different seismic responses in the chimneys would be associated with absorption or enhancement of reflection energy controlled by the amount of gas-bearing pore water or thermal condition. In addition, a

lot of gas flares extended from seafloor to sea water, which could enable us to examine interaction between gas flares and geological structures. To analyze geochemical properties of gas hydrates in the study area, we will conduct the studies on sulfate reduction and methane oxidation and sea water chemistry using isotope analysis. (Dr. Young Keun Jin, ykjin@kordi.re.kr)

B. Research Activities in Ny-Ålesund area

(1) Influence of glacial runoff on physico-chemical characteristics of Kongsfjorden seawater

Water column characteristics (temperature, salinity, dissolved oxygen, PAR, turbidity and chl-*a*) were measured *in situ* in Kongsfjorden using SBE 19plus CTD, and water samples at the surface was obtained during the summer. TAW (Transformed Atlantic Water; >2.0 °C, >34.70 psu) of bottom water in the outer basin was caused by extensive input of AW (Atlantic Water; >4.0 °C, 34.90 psu) of continental shelf off west Spitsbergen. PSWw (Polar Surface Water warm), surface and middle water, was occupied due to active glacier melting. Glacial discharge loaded with large amount of terrigenous sediments (>70 mg l⁻¹) was introduced from Kongsvegen glacier. Subglacial meltwater contributed to decrease salinity and to supply with dissolved oxygen off the fjord through the mid water depth; however, most of suspended sediment particles were deposited within the inner bottom basin and surface suspended materials above halocline was transported off the outer fjord. Off the fjord was the main source of phytoplankton whose growth and distribution was limited by <30.0 psu of salinity. (Dr. Sung-Ho Kang, shkang@kordi.re.kr)

(2) Distribution of zooplankton community in Kongsfjorden

Zooplankton was sampled by vertical hauls of net with mouth diameter of 45 cm and mesh size of 200 μm at six stations in Kongsfjorden in August 6, 2003. Zooplankton community consisted of hydrozoans, nematodes, chaetognaths, copepods, amphipods, euphausiids, isopods, appendicularians, gastropods and larvae. Larvae belong mainly to cirripeds, cumaceans, echinoderms, polychaetes and fish. Copepods were dominant group, accounting for 88.1% of total zooplankton. Copepods were identified into 7 species, which were composed of *Acartia* sp., *Calanus glacialis*, *Metridia* sp., *Pseudocalanus acuspes*, *P. minutus*, *Oithona atlantica* and *O. similis*. The abundances of zooplankton, which were dominated by immature copepods, ranged from 365 inds.m⁻³ (st. 3) to 585 inds.m⁻³ (st. 6), with average value of 437 inds.m⁻³. It showed increasing trends from the center of Kongsfjorden to outer and inner station, respectively. As a result of cluster analysis, stations could be divided into two groups, station 6 and other stations, suggesting that innermost station is separated from outer stations. (Dr. Woong-Seo Kim, wskim@kordi.re.kr)

(3) Benthic flora and fauna in Kongsfjorden

Specimens of chlorophyte, phaeophyte, and rhodophyte were collected and examined over the period from July to August 2003 from shallow subtidal waters of Kongsfjorden. A total of 28 genera and 32 species (5 chlorophytes, 18 phaeophytes, and 9 rhodophytes) was identified and described. A green alga *Enteromorpha linza* (Linnaeus) J. Agardh, a brown alga *Asperococcus compressus* Griffiths ex Hooker, and three red algae *Gracilaria gracilis* (Stackhouse) Steentoft *et al.*, *Rhodomenia pacifica* Kylin and *Schizochlaenion rhodotrichum* Wynne et Norris were recorded in Svalbard Islands for the first time. (Dr. Hosung Chung, hchung@kordi.re.kr)

Sublittoral meiobenthic organisms were collected by SCUBA and Van veen grab in July 28 and August 14 2003, and subsequently acryl subcorers of 34mm in internal diameter were taken from each upper sediment sample. A total of 24 meiofaunal groups were identified in a tidal flat. Nematodes were the most dominant. Sarcomastigophorans, benthic harpacticoids, polychaeta, and nauplius larvae of crustaceans were also important members. All of these five faunal groups comprised more than 90% of total meiofauna at every station. The total density of meiobenthos at each stations was the highest at station MeG 1 (4,750 inds./10cm²), and the lowest at station MeG 9 (27 inds./10cm²). The meiobenthos followed the general trends reported from other studies: densities decreased with depth in relation to the more limited supply of degradable organic matter at greater depths. (Dr. Dong-Sung Kim, dkim@kordi.re.kr)

(4) Pollution monitoring in Kongsfjorden using some common brown seaweed

Macroalgae were collected from shallow subtidal waters (<20m) of Kongsfjorden during the late July to early August of 2003. Concentrations of Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn were determined in four arctic brown algae (*Laminaria saccharina*, *L. digitata*, *Alaria esculenta*, *Desmarestia aculeata*) in an attempt to examine for their metal accumulation capacity and also to assess their contamination levels. Metal concentrations highly varied between sampling sites, species and blade parts. Input of melt-water laden with terrigenous sediment particles seemed to cause elevation of some metals of lithogenic sources (Al, Fe, Mn, Pb etc.). There were also significant concentration differences between blade parts. While Al, Fe, Mn, Pb were higher in the old parts, Cd and As concentrations were significantly higher in the young blades. The highest metal concentrations were found in *D. aculeata*, followed by *A. esculenta*. The lowest concentrations in the two *Laminaria* spp. are likely in part related to their thick blades which lead to low surface/volume ratios. We have found little signs of contamination in the brown algal species analyzed, and the metal concentrations we observed can be considered as baseline levels. Added to this, the results of the present studies suggest the potential utility of *L. saccharian*, *L. digitata* and *A. esculenta* as biomonitors for metal pollution monitoring in this area. (In-Young Ahn, iahn@kordi.re.kr)

(5) Isolation of microorganisms in Ny-Ålesund area

We isolated the Arctic microorganisms, identified using 16S rDNA sequences, and preserved in deep-freezer as a genetic bank. We collected marine microorganisms from various habitats at Ny-Ålesund. The collected samples were diluted in distilled seawater, and spread on marine agar plates. The samples and plates were transferred to the laboratory at KORDI. They cultured at 10°C, colonies were succeedingly cultured on Zobell agar plates at 10°C. The pure colonies were inoculated into nutrient agar liquid media, and genomic DNA were extracted from the liquid-cultured strains. The total 282 viable microorganisms and their genomic DNAs were preserved in deep-freezer. After screening, we found that 63 strains among the 282 strains were protease-producing bacteria. The 16S rDNAs of 28 protease-producing strains were amplified, sequenced, and phylogenetically analyzed. Out of 28 strains, 17 strains were overlapped and 11 microorganisms were identified: 4 species of *Psychrobacter* genus, 2 species of *Staphylococcus* genus, a *Bacillus* sp., a *Carnobacterium* sp., a *Paracoccus* sp., a *Pseudoaltermonas* sp., and a *Pseudomonas* sp. Among the 11 strains, 5 bacteria are candidates for new species. We expect that these Arctic microorganisms isolated in this study can be used for screening to develop new industrial enzymes. **(Dr. Hong Kum Lee, hklee@kordi.re.kr)**

(6) A Study on the development of novel substances from the Arctic

During the course of our search for bioactive metabolites from Arctic organisms, 11 plants, 14 marine algae, 2 marine sponges, 251 marine microorganisms were collected from Svalbard, Norway. Some of these organisms have anticancer and antifungal activities, and one metabolite was isolated from the Arctic plants *Cassiope tetragona*. The structure has been determined by combined spectral studies. **(Dr. Hee Jae Shin, shinhj@kordi.re.kr)**

(7) Operation of Fourier Transform Spectrometers (FTS) in Ny-Alesund for Comparative Studies with Antarctic regions in Upper Atmospheric physics

We have operated Fourier Transform Spectrometer (FTS) in Ny-Alesund (79° N), Svalbard since November 2002 and another one in Kiruna (68° N), Sweden since October 2001. We are interested in performing measurements from these two arctic places in collaboration with British Antarctic Survey (BAS) operating the same instruments in Halley (75°S) and Rothera(68°S) stations in Antarctica, nearly conjugate points of Ny-Alesund and Kiruna, respectively. Long-term measurements of atmospheric emission features are expected to reveal the information on the energy balance and the dynamics behavior (such as gravity waves, tides) of the lower thermospheric and upper mesospheric region of the atmosphere. **(Dr. Young-In Won, yiwon@kordi.re.kr)**