Mem. Natl Inst. Polar Res., Spec. Issue, **54**, 331-336, 2001

Report

Scientific achievements in the First Chinese Expedition to the Arctic Ocean

Zhaoqian Dong[1] and Weijia Qin[2]

[1]*Polar Research Institute of China, Shanghai 200129, China*
[2]*Chinese Arctic and Antarctic Administration, Beijing 100860, China*

Abstract: The First Chinese Arctic Expedition to the Arctic Ocean was carried out from July 1 to September 8, 1999, aboard the icebreaker R/V Xuelong supported by two helicopters and a boat, organized by the Chinese Arctic and Antarctic Administration, State Oceanic Administration. Twenty five scientists in the scientific disciplines of physical oceanography, marine chemistry, marine biology, biogeochemistry, marine geology, glaciology, atmospheric science and fisheries from ten research institutions and universities in China, as well as scientists from the National Institute of Polar Research, Japan and the Korean Ocean Research and Development Institute, took part in the field investigations and cooperative research. The working areas covered the Canadian Basin, Chukchi Sea in the Pacific sector of the Arctic Ocean, and the Bering Sea.

The following data and samples were obtained during that expedition. For oceanography, operations of more than 100 CTD deep stations and 70 XBT and XCTD probes (to the depth of 1000 m) were completed, and 1423.6 Mb model VM ADCP (Acoustic Doppler Current Profiler) data were obtained. For geology, sediment samples by box sampler and multi-tube sampler in 41 locations and 47.92 m of column sediment samples in 17 locations were collected. Vertical and horizontal trawls in 110 locations were made for biology and ecology, and EK-500 and 792DSG fish-finder in over 5800 nautical miles and 19 trawls were operated. A variety of samples of sea water, air and snow and sea ice cores etc. for research on chemistry, isotopes, primary productivity, microbiology, phytoplankton, nanoplankton, aerosols and samples from sediment traps were obtained at two stations on ice floes. Boundary and upper-air observations including ozone and ice-radar measurements of ice thickness were also made. The northernmost station was at 77°N in the Canadaian Basin.

All samples and data are now being analyzed and results of scientific research have been published. Cooperative research on our data and samples obtained by the expedition with foreign scientists is most welcome.

1. Introduction

Chinese Arctic research goes back to the 1950s. Before the present expedition, Chinese scientists in a variety of scientific disciplines had been involved in Arctic scientific and social research, by cooperation and participation with many Arctic research programs of several Arctic countries, including the former Soviet Union, Norway, Germany, Canada, Japan and the U.S.A. And valuable scientific results in geology and geophysics, atmo-

sphere and space physics, oceanography, glaciology, social and cultural science were published. To prepare for our National Arctic Scientific Expeditions, scientists and management staff were sent to several Arctic countries for training before a non-governmental Arctic expedition in 1995, with logistic support being provided by foreign countries.

In 1996, China became a member of the International Arctic Science Committee (IASC), The Chinese Arctic & Antarctic Administration (CAA), the State Oceanic Administration started to prepare a national long-term Arctic research plan and make more contributions to the IASC and international Arctic research programs.

Implementation of the plan started with the First Chinese Arctic Expedition to the Arctic Ocean from July 1 to September 8, 1999, aboard icebreaker R/V Xuelong, supported by two helicopters and a boat to make observations at drifting ice stations. The expedition was organized by the Chinese Arctic and Antarctic Administration, State Oceanic Administration (1999, 2000). It included a comprehensive Arctic research program mainly on Arctic Ocean-Atmosphere-Ice interactions and the environment. Twenty-five scientists in the scientific disciplines of physical oceanography, marine chemistry, marine biology, biogeochemistry, marine geology, glaciology, atmospheric science and fisheries from ten research institutions and universities in China as well as scientists from NIPR, Japan and KORDI, Korea took part in the field investigations. The working areas included the Canadian Basin and Chukchi Sea in the Pacific sector of the Arctic Ocean, and the Bering Sea.

2. General scientific objectives and research priorities

There are three major scientific objectives in the science program of the First Chinese Expedition to the Arctic Ocean. The research priorities are listed under each objective item.

2.1. The role of the Arctic in relation to global change and its influence on climate in China

(1) Structure at the boundary layer between the ocean, sea-ice and the atmosphere, and physical mechanism of energy and material exchanges in the Arctic region.
(2) Thermodynamic interactions among ocean, ice and the atmosphere in the Arctic sea ice zone.
(3) Atmosphere and radiation balance at different surfaces in response to weather systems.
(4) Vertical exchange of energy and material between stratospheric and troposphere layers and its influence on the climate in China.
(5) Vertical ozone profile in the stratosphere, troposphere and boundary layers and its relation to UV-B radiation.
(6) Study of atmospheric components, pollen, sedimentary minerals and aerosols.
(7) CO_2 flux at the sea surface and carbon balance in the ocean-sea ice-atmosphere system.
(8) Physical structure of sea ice, chemical properties of ice and snow and the relation to climate and human activities.
(9) Present sedimentary processes in the Chukchi Sea and analysis of environmental change records.
(10) Detection of volatile fatty acids, hydrocarbons and other organic pollutants at the surface water of the Arctic Ocean and their role in organic geochemistry.

(11) UV-B radiation effects on physiology and ecology of phyto-plankton, biochemical processes and primary productivity in the Arctic Ocean.

2.2. Water mass exchange between the Arctic Ocean and the northern Pacific Ocean and its influence on the circulation in the northwest Pacific

(1) Water masses, their structure and formation mechanism in the Bering Sea and in the Chukchi Sea and Canadian Basin of the Arctic Ocean.
(2) Vertical convection and horizontal circulation, and their role in transporting material and energy in the Bering Sea, and in the Chukchi Sea and Canadian Basin of the Arctic Ocean.
(3) Water exchange processes in the Arctic Ocean and their relation to northwest Pacific and conditions of China seas.

2.3. Ecosystems in the Arctic Ocean and Bering Sea and their relation to Chinese fisheries

(1) Ecological structure in the Arctic Ocean and Bering Sea, structure of biological communities and bio-diversity in Arctic sea ice.
(2) Primary productivity and new productivity in the Arctic Ocean and Bering Sea.
(3) Plankton structure and its relation to fisheries.
(4) Fishery resources in the Arctic Ocean and the Bering Sea.

3. Investigation area, time and vessel

3.1. Area

- Bering Sea: 54–61°N, 174°E–174°W.
- Chukchi Sea and Canadian Basin: 66–76°N, 165–175°W.
- Ice Station: 76–77°N, 170°W.

3.2. Time

From July 1st to September 8th, 1999.

3.3. Observation platforms

The major observation platform is our icebreaker R/V Xuelong, managed by Polar Research Institute of China in Shanghai, State Oceanic Administration, with two helicopters and a boat for scientific observation. The total investigation distance was 14113.6 nautical miles and took 1238 hours.

A 0.3×1.0 km ice floe with thickness of 4.5 m in the Canadian Basin was used as a natural platform for our Ice Station. Comprehensive observations of the atmosphere, sea ice ecology, carbon cycling, physical oceanography, snow and ice sampling, coring and radar sounding were successfully carried out for six days. Another ice floe in the same basin was also used for an observation platform for two days. And then it was broken.

4. Data and samples obtained

4.1. Physical oceanography

One hundred and ten hydrographic deep stations were completed and the following data were obtained.

- Deep Mark IIIc CTD: 50 Mb (reached the bottom).
- FSICTD(MCTD): 30 Mb (0–200 m).
- VM-ADCP: 1423.6 MB (75 kHz, sampling interval: 30 or 60 s).
- XBT & XCTD: 70 probes in 55 locations above 1000 m.
- Automatic SST records on the track of the Xuelong.

4.2. Chemical oceanography

Water sampling was successfully carried out and the following samples were obtained for chemical analysis such as dissolved oxygen and nutrients.

- At 175 depths in the Chukchi Sea, water was sampled in 33 locations and 239 oxygen and nutrients data were obtained.
- At 336 depths in the Bering Sea, water was sampled in 29 locations and 2016 oxygen and nutrients data were obtained.
- At 27 depths in four locations trace element measurements of sea water were carried out.

4.3. Marine geology

A QNC-2-2 Sediment Box Sampler, A DDC4-2 Sediment Gravity Sampler (Sediment Core length: 350 cm), Gravity Corers and DSC-2 Multi-corers were used to obtain bottom sediment samples for a variety of analyses including ^{14}C, $\delta^{13}C$, $\delta^{18}O$, ^{210}Pb, Sr, organic matter, $CaCO_3$, SiO_2, trace matter, micro-paleorganism and segment minerals.

- Sediment samples by Box Sampler and Multi-Tube Sampler were obtained in 41 locations.
- Total 47.92 m column sediment samples were obtained in 17 locations.

4.4. Snow and sea ice

- 47 surface snow samples.
- 13 sea ice cores (Total length: 46.3 m) for analysis of sea ice structure, ice algal assemblages and inorganic ions.
- Ice thickness and structure measurements at 29 sections in 7 locations by PulseEKKO 100A radar (made in Canada).
- Snow and sea ice temperature measurements at many locations.

4.5. Atmospheric sciences

- 150 air samples for study of atmospheric chemistry and pollutants.
- 180 samples of aerosol and gases HNO_3, SO_2, NH_3 in the atmosphere in 1860 hours by four-stage open face sampler (made in U.S.A.).
- 8804 data of underway routine air observations and ozone sounding at 16 locations (altitudes up to 20000 m) by DigiCora II MW15 GPS wind finder sounding system, Väisalä RS80-25GE Radiosonde and 6A ECC Ozonesonde, made by Science Pump

Corporation, U.S.A.

- 136 hour observations at boundary layer between air/sea/snow & sea ice.

4.6. Marine biology and fisheries

- 71 nanoplankton samples.
- Phytoplankton samples at 14 stations.
- 45 microbes samples.
- Chl-a samples at different depths in 49 hydrological stations and 20 surface samples on the track of the Xuelong.
- 792DSG color fish finder (ATLAS, Germany) was operated for 423 hours (distance about 5800 nautical miles), and 19 trawls were made.
- 72-hour observation of short-term fluxes of diatom and particulate organic carbon in pack ice area.

4.7. Carbon cycling

- 4 sets of sediment traps each for 70 hours sampling.
- 2 bottom column samples of sediment at water depth of 2090 m for analyzing particulate organic matter.
- 26 Samples for analyzing C, N, P, Si and contents of suspended particle organic carbon.
- Samples at different levels in 46 locations and 29 bottom surface sediment for study of marine bacteria.

4.8. The role of sea-ice- atmosphere interaction

- Several Mb of solar radiation, albedo, etc. at different surfaces.
- More than ten Mb of routine data by auto-weather station.
- 8000 Mb of satellite sea ice distribution and thickness data.

4.9. Mapping

- 4200 sets of data in Epoch 15 for GPS positioning at two locations on Arctic sea ice.
- Absolute and relative gravity measurements at two locations.
- Collected information for Arctic digital mapping.

5. Some preliminary results

- All data obtained during the expedition are being processed.
- Net radiation seems to vary daily and absorption of radiation energy may reach to 100W/m^2 on the air/snow interface; turbulent heat flux shows obviously daily change and momentum flux has no notable daily change, which is different from observations at an interface between air and land.
- A great temperature inversion around an altitude of 400 m at 73.4°N, 165°W was observed during the expedition.

Acknowledgments

The authors thank the organizers, scientists and the crew of the R/V Xuelong in the expedition for information making this report possible.

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(Received May 15, 2000; Revised manuscript accepted August 22, 2000)