Field Measurements of the Material Properties of Sea Ice at Chukchi Borderland

Seong-Yeob Jeong and Seong Rak Cho
Korea Ocean Research & Development Institute – Daejeok
Daejeon, Korea

ABSTRACT

A field experiment was conducted on August 11 and 12 of 2011 with the Korean icebreaking research vessel "Araon" at Chukchi Borderland to investigate the sea ice properties. In this research, the field survey data including snow depth, thickness, freeboard, temperature, density, salinity, and crystal structure of ice were investigated. Brine volume and flexural strength of ice were calculated by empirical formula. The average ice thickness was 1.81 m and salinity was 0.23 to 1.78‰. The sea ice density of upper layer was 0.770 g/cm³, middle layer was 0.896 g/cm³, and lower layer was 0.916 g/cm³, and then the calculated average flexural strength of ice was about 360 kPa. The apparent conductivities derived with the electromagnetic induction instrument (EMI) were compared to drill hole measurement results. In addition, it is shown that the good relation between in-situ measurement results and estimated data from empirical relation between total thickness and apparent conductivity for the EMI.

KEY WORDS: Field experiment; sea ice property; apparent conductivity; electromagnetic induction instrument.

INTRODUCTION

In the Arctic, sea ice conditions are influenced by global warming and increase of greenhouse gas. The Arctic sea ice cover is consistently diminishing, the amount of perennial ice has decreased, and the ice thickness has thinned. Arctic ice extent in December 2011 averaged 12.38 million square kilometers. This is the third lowest December ice extent in the 1979 to 2011 satellite data record (NSIDC, 2011). Especially sea ice thickness is one of the most important parameters for prediction of future climate changes and navigation via the Northern Sea Route. The field survey of Arctic sea ice by icebreaking vessel is very difficult and expensive tasks therefore many of new technologies being developed for dynamic and thermodynamic sea ice research and properties in the Europe and Asia. Arctic sea ice properties also have been considered a key indicator in the structural design criteria of icebreaking vessels and arctic offshore platforms to estimate design ice load and resistance for their safety management in the Arctic Ocean.

In the previous research, Cox and Weeks (1974) studied the salinity distribution in the varying thicknesses and ages at various Arctic and sub-Arctic location. Warren et al. (1999) measured the snow depth and density at the Soviet drifting stations for climatic studies. Alexandrov et al. (2010) studied the relation between sea ice thickness and ice freeboard in the Arctic to describe technique of ice thickness retrieval from freeboard measurements provided by the CryoSat radar altimeter. Ice thickness measurements with electromagnetic induction instrument were also performed in the Arctic (Haas et al., 1997; Kovacs and Morey, 1988; Prinsenberg et al., 2002; Tateyama et al., 2006). In this research we conducted ice field measurement at Chukchi Borderland on August 11 and 12 of 2011, and ice temperature along the depth, ice thickness, freeboard, snow depth, density, salinity and crystal structure were investigated. Brine volume and flexural strength of sea ice were calculated by empirical equation. In this paper the material properties of sea ice are investigated and their properties during short summer period at Chukchi Borderland are analyzed.

FIELD MEASUREMENT

2011 Arctic cruise of icebreaking research vessel “Araon” covered the Chukchi Borderland in July to August and the ice field measurements were performed around 77°N, 173°E. Ocean dynamics, transformations of water mass, dynamic-thermodynamic of ice, and atmosphere-ocean-ice interaction analysis researches were performed during this cruise. However, this paper is focusing on sea ice properties of Arctic summer at Chukchi borderland. The sea ice concentration appears to be rapidly decreasing during this cruise. Ice condition seems to be thick first-year ice and second-year ice and then, a lot of melt ponds were observed in the surface of ice floe (See Fig. 1). Ice navigator from the Arctic and Antarctic Research Institute (AARI) assist us to determine the suitable ice condition for safety navigation during this cruise.

Field Area

Sea ice is melting during June to August and refreezing from October, and sea water freeze when sea water temperature is below -1.89°C. In this research field tests of sea ice were performed at two old ice floes...