Quaternary International 344 (2014) 200–210

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Sea surface temperature and salinity changes near the Soya Strait during the last 19 ka

S.W. Bae [a], K.E. Lee [a, *], Y. Park [a], K. Kimoto [b], K. Ikehara [c], N. Harada [b]

[a] Division of Marine Environment & Bioscience, Korea Maritime and Ocean University, Busan 606-791, South Korea
[b] Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology, Japan
[c] Geological Survey of Japan, AIST, Japan

ARTICLE INFO

Article history:
Available online 3 July 2014

Keywords:
Alkenone
Oxygen isotope ratio
Sea surface temperature
Sea surface salinity
Subpolar front
East Sea/Japan Sea

ABSTRACT

Past sea surface temperature (SST) and salinity (SSS) changes in the northeastern East Sea/Japan Sea since 19 cal ka BP have been reconstructed by using an alkenone unsaturation index and the oxygen isotope ratio of planktonic foraminifera *Neogloboquadrina pachyderma*(s) in Core MR0604-PC03B. Coretop alkenone temperature and calcification temperature correspond to the temperature of seawater in summer and spring at the depth of 10–30 m, respectively. Based on the records from this core and previous studies, spatio-temporal changes in alkenone temperature of the East Sea/Japan Sea have been reconstructed to investigate changes of surface circulations and the subpolar front (SPF) position. During the transitional period from the glacial to the Holocene, the SST was lower (about 2–3 °C) than that of today and the SSS dramatically increased at that time in the entire East Sea/Japan Sea but it was still lower than that of today. However, the northern SSS was higher than that of the southern part. The source of the cold and saline seawater could have been the Oyashio Current (OY, inflow from the north), not the Tsushima Warm Current (TWC, inflow from the south). Probably, sea level rose rapidly at that time. There might be no strong development of the SPF during the transitional period due to the restricted inflow of the TWC. During the early Holocene, the SST and SSS of the East Sea/Japan Sea increased compared to the transitional period due to increased seawater exchange through straits. The SPF was tilted orienting from southwest to northeast because the inflow of the TWC was not fully developed due to lower sea level. Subsequently, the surface condition of the East Sea/Japan Sea was similar to that of today at 6 cal ka BP. The Forerunner of Soya Warm Water (FSWW) that flowed out through the Soya Strait in early spring did not affect the formation of the Okhotsk Sea Intermediate Water and the North Pacific Intermediate Water during the glacial and interglacial periods.

1. Introduction

The East Sea/Japan Sea (ES/JS) is a semi-closed marginal sea which is located in the northwestern Pacific. It is surrounded by Korea, Japan, and Russia and connected to open ocean through narrow and shallow straits, the Korea (water depth, 130 m), Tsugaru (130 m), Soya (55 m) and Tartar straits (12 m). In the area, the Tsushima Warm Current (TWC) flows northward along east coast of Korea and west coast of Japan (Fig. 1). Eventually it drains out through the Tsugaru and Soya straits. The cold currents such as the Liman Cold Current (LCC) and the North Korea Cold Current (NKCC) flow southward along the northern and northwestern boundaries of the sea. The subpolar front (SPF) is located between 38°N and 40°N where the warm (TWC) and cold (NKCC) currents meet.

Previous studies have shown that eustatic sea level change and resultant change in surface circulation of the ES/JS significantly influenced changes of sea surface temperature (SST) and salinity (SSS) during the late Quaternary (Lee et al., 2008; Fujine et al., 2009; Choi et al., 2012). For example, Choi et al. (2012) reconstructed spatial and temporal variations in alkenone temperature of the ES/JS since 130 ka. They demonstrated that SPF position had changed in response to the volume transport of the TWC. However, they considered the SPF changes during the period only from the last interglacial (MIS 5) to the glacial (MIS 2). It is not clear how the SPF position had changed from the last glacial to the Holocene. The sedimentary cores that were used for their study were restricted to the southern part. Thus, only seawater exchange through the Korea Strait was considered. However, it is important to investigate

* Corresponding author.
E-mail address: kyung@kmou.ac.kr (K.E. Lee).

http://dx.doi.org/10.1016/j.quaint.2014.06.014
1040-6182/

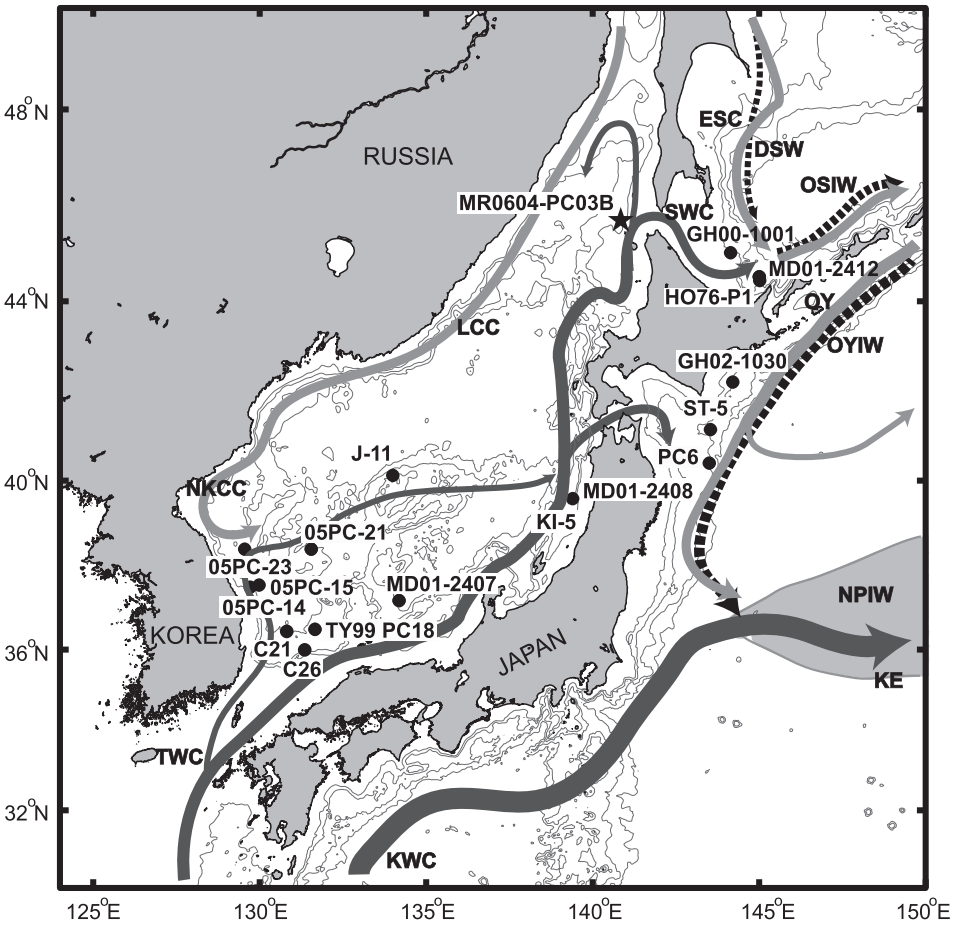

Fig. 1. Bathymetric map and surface currents around the northwestern Pacific. The black dots indicate the location of sediment cores. (MR0604-PC03B (in this study), MD01-2407, MD01-2408 (Fujine et al., 2009), TY99PC18 (Lee, 2007), KI-5 (Crusius et al., 1999), J-11 (Gorbarenko and Southon, 2000), C21, C26 (Kim et al., 2000), 05PC-21 (Lee et al., 2008), 05PC-23, 05PC-14, 05PC-15 (Choi et al., 2012), MD01-2412 (Okazaki et al., 2005; Harada et al., 2006), GH00-1001 (Itaki et al., 2008), HO76-P1 (Itaki and Ikehara, 2004), GH02-1030 (Shibahara et al., 2007; Inagaki et al., 2009), ST-5 (Ohkushi et al., 2003), PC-6 (Minoshima et al., 2007)). KWC: Kuroshio Warm Current, TWC: Tsushima Warm Current, NKCC: North Korea Cold Current, LCC: Liman Cold Current, SWC: Soya Warm Current, ESC: East Sakhalin Current, DSW: Dense Shelf Water, OSIW: Okhotsk Sea Intermediate Water, OY: Oyashio Current, OYIW: Oyashio Intermediate Water, NPIW: North Pacific Intermediate Water, KE: Kuroshio Extension.

changes in all straits together. At the present, seawater enters into the ES/JS through the Korea Strait, and flows out through the Tsugaru and Soya straits. Volume transport is approximately 2.5 ± 0.5 Sv for the Korea Strait, 1.5 Sv for the Tsugaru and 1 Sv for the Soya (Na et al., 2009). Hence the amount of inflow is equal to that of outflow to maintain sea level. However, a great change of volume transport during the glacial, transitional, and interglacial periods may play an important role in transport of heat and salt into the sea and local sea level change.

The Soya Strait is one of the major outlets of the TWC. It is located between the Hokkaido of Japan and the Sakhalin of Russia. The Soya Warm Current (SWC) transports warm and saline water from the ES/JS to the Okhotsk Sea through the Soya Strait along the northern coast of the Hokkaido, influencing the formation of the Okhotsk Sea Intermediate Water (OSIW) and possibly the North Pacific Intermediate Water (NPIW) (Itoh et al., 2003). Glacial and interglacial changes in the OSIW (e.g., Itaki and Ikehara, 2004) and NPIW (e.g., Ohkushi et al., 2003) have been reported elsewhere. However, seawater exchange through the Soya Strait and its influence on the OSIW and NPIW had not been identified.

In this study, we reconstructed SST and SSS from the sediment core (MR0604-PC03B) recovered from the northeastern ES/JS near the Soya Strait. Degree of unsaturation of alkenones and the oxygen isotope ratio of the planktonic foraminifera *Neogloboquadrina pachyderma*(sinistral) were used for the reconstruction of the alkenone-based SST, calcification SST, SSS, and density of the northern seawater. The reconstructed northern SST and SSS were compared to those of southern part to investigate changes in ocean circulation, SPF position and seawater exchange through all straits. In addition, changes in northern surface condition over the last 19 ka were compared to proxy records of the OSIW and NPIW to investigate possible influence of the SWC changes on those of the OSIW and the NPIW.

2. Oceanographic setting

In order to investigate changes of seasonal mean SST and SSS around the Soya Strait, data from Japan Oceanographic Data Center (JODC, observed from 1906 to 2003) were examined (Fig. 2). Monthly averaged values of SST and SSS were averaged again for each season. The lowest SST (4.9 °C) and the highest SSS (34.1‰) occur in winter season (December–February), whereas the highest SST (15.6 °C) and the lowest SSS (33.9‰) occur in summer season (June–August). The annual mean SST and SSS are 10.1 °C and 34‰, respectively.

Although the SWC is a continuous flow occurring throughout a year from the ES/JS to the Okhotsk Sea, there are seasonal changes of water mass character and its transport rate. According to the