TEMPORAL AND SPATIAL VARIATION OF NIGHTTIME FISHING GROUND DERIVED FROM SATELLITE IMAGERY

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ABSTRACT

We examined the relationship between the 50m temperature estimated by remote sensing sea surface temperature (SST) and fishing ground (squid fishing ground) detected by nighttime visible channel defense meteorological satellite program (DMSP) / operational linescan system (OLS) images in the East/Japan Sea during 1993-2000. The results are as follows: The numbers of nighttime fishing boat were distributed the highest in October, and the lowest in April during this study. A nighttime fishing grounds have concentrated in the East Korea Warm Current region, coastal regions of Honshu Island, and Polar front region. Fishing grounds have distributed 11-18℃ of estimated 50m temperature from the satellite data. Relationship between estimated 50m temperature and the distributed fisheries boats showed that the north boundaries of fishing grounds have distributed the temperature of below 12℃ from 1996 to 2000 and that of 13-15℃ during 1993-1995 and 1997-1999. Stable fishing grounds appeared near the Korea/Tsushima Strait from January to March. The center of fishing grounds in spring (April-Jun) have moved to the northward than that in winter, and variations appeared largely in winter. In summer (July-September), center of fishing grounds have formed near the Uleung Island in the south east coast of Korea, and in autumn maximum fishing ground appeared in October, the fishing ground southward from November.

KEY WORDS: SST, DMSP/OLS, East/Japan Sea, Nighttime fishing ground

1. INTRODUCTION

Since the early 1970s the U.S. Air Force Defense Meteorological Satellite Program (DMSP) has operated polar orbiting platforms carrying cloud imaging satellite sensors capable of detecting clouds using two broad spectral bands: visible-near infrared (VNIR) and thermal infrared (TIR). The OLS (Operational Linescan System) sensors began flying in 1976 and are expected to continue flying until –2010. The DMSP program was declassified in 1972 and shortly after this the low-light detection of cities, fires, fishing boats and gas flares was described by Croft (1978, 1979). A digital archive for the DMSP-OLS data was established in mid-1992 at the NOAA National Geophysical Data Center.

Large clusters of heavily lit fishing boats by DMSP/OLS were detected in the waters surrounding East/Japan Sea, including the Yellow Sea and East China Sea. In the most cases, squid fishing boats operate at night, using powerful lights to attract the squid. These lights can be observed on nighttime OLS images. Although there have been some studies conducted all over the world, relatively fewer studies have been done on the variations of nighttime fishing grounds around Korean Peninsula.

In short-lived squids, recruitment success most likely depends on the physical and biological environments at the spawning and nursery grounds. Common squids (*Todarodes pacificus*) catch using a fish gathering light at nighttime and are one of the main fisheries resources in the East/Japan Sea. In general, inhabitation temperature range of common squids has from 4 to 27° C. Optimum temperature range of that is from 14 to 19° C and main catch depth is surface to 50 m. Common squids are classified by winter cohort, summer cohort, and autumn cohort. Annual catches of common squid, *Todarodes pacificus*, in Korean waters have markedly increased since the late 1980s, and recent catches have equalled those of the 1960s (Fig. 1). Sakurai et al. (2000) suggested that the winter spawning area of *T. pacificus* in the East China Sea shrank when adult stocks decreased during a cool regime that occurred before 1988, and that its fall and winter spawning areas extended and overlapped in the East/Japan Sea and East China Sea when adult stocks increased during a warm regime that occurred after 1989.

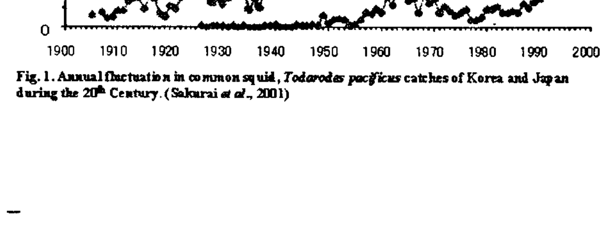

Fig. 1. Annual fluctuation in common squid, *Todarodes pacificus* catches of Korea and Japan during the 20th Century. (Sakurai *et al.*, 2001)

In the present study, we examined the relationship between the 50m temperature, which is main catch depth of common squid, estimated by satellite remote sensing sea surface temperature (SST) and squid fishing ground detected by nighttime visible channel DMSP/OLS images in the East/Japan Sea from 1993 to 2000.

2. MATERIALS AND METHODS

DMSP/OLS data were supported by National Geophysical Data Center (NGDC). The low-light sensing capabilities of the OLS at night permit the measurement of radiance down to 10-9 W cm–2 sr–1 μm. (Elvidge et al. 1997a). However, the OLS is sensitive to scattered sunlight, which saturates the visible band data (Elvidge et al. 1997b). The visible band of DMSP/OLS data has a 6-bit quantization, producing digital numbers (DN) ranging from 0 to 63 (Elvidge et al. 1999). The spatial resolution is 2.7 km at night. A search for available images on the NGDC and Agriculture, Forestry and Fisheries Research Information Center in Japan (AFF) Web sites, resulted in 1027 usable nighttime images from 1993 to 2000. In particular, higher temperature and corresponding increases in water vapour cause the paucity of usable summertime images in April and August. Image noise, such as edges of sensor scans and high digital numbers caused by glare, was systematically removed manually, and monthly and annually composite images were then processed as shown in Fig. 2.

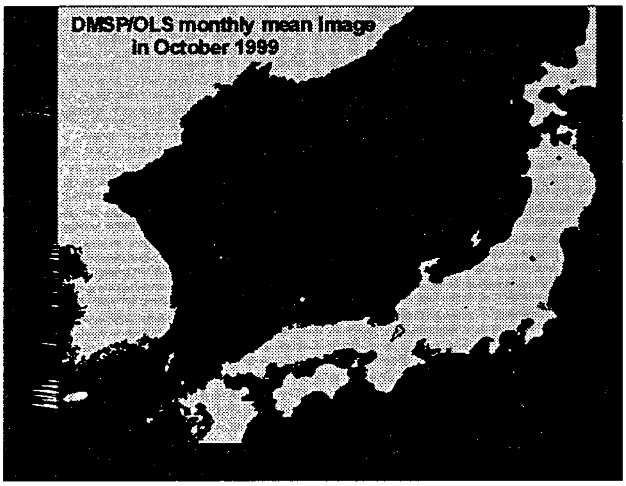

Fig. 2. Annual composite image derived from DMSP/OLS in October 1999.

Sea surface temperature (SST) data utilized the AVHRR Oceans Pathfinder data through the PO. DAAC.FTP Web site podaac.jpl. nasa.gov. These data products are monthly global composite images of SST, each with 4 km x 4 km spatial resolution from 1993 to 2000. SST images for the estimate of 50 m depth water temperature are available for the East/Japan Sea as shown in Fig. 3.

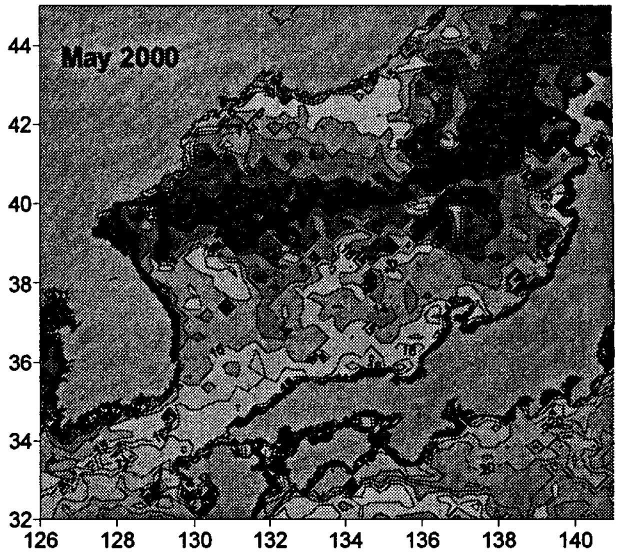

Fig. 3. Study area in the East/Japan Sea derived from SST images in May 2000.

In order to derive the 50m temperatures estimated by satellite remote sensing SST, a monthly and bimonthly report of in-situ temperature data on major important serial oceanographic data by supported National Fisheries Research & Development Institute (NFRDI) and Japan Oceanographic Data Center (JODC) are used for this study. NFRDI serial oceanographic observations data included the temperature and salinity etc. as the bimonthly (February, April, June, August, October, December) data regularly conducted in the adjacent seas to the Korean Peninsula. We employed 50 m water temperature as the East/Japan Sea from 1993 to 2000.

3. RESULTS

Relationship between the 50m temperature, which is main catch depth of common squid, estimated by satellite remote sensing sea surface temperature (SST) and nighttime fishing ground in the East/Japan Sea have been investigated using monthly and annual composite images of the DMSP/OLS and SST images from 1993 to 2000.

The results are as follows: The numbers of nighttime fishing boat were distributed the highest in October, and the lowest in April during this study (Fig. 4). A nighttime fishing grounds have concentrated in the East Korea Warm Current region, coastal regions of Honshu Island, and Polar front region. Fishing grounds have distributed 11-18℃ of estimated 50m temperature from the satellite data. Relationship between estimated 50m temperature and the distributed fisheries boats showed that the north boundaries of fishing grounds have distributed the temperature of below 12℃ from 1996 to 2000 and that of 13-15℃ during 1993-1995 and 1997-1999. Stable fishing grounds appeared near the Korea/Tsushima Strait from January to March (Figures not showed). The center of fishing grounds in spring (April-Jun) have moved to the northward than that in winter, and variations appeared largely in winter. In summer (July-September), center of fishing grounds have formed near the Uleung Island in the south east coast of Korea, and in autumn maximum fishing ground appeared in October, the fishing ground southward from November.

Acknowledgements

This study was funded by the research project "The application of satellite data for fisheries oceanography" of the Korea Ocean Research and Development Institute (KORDI) and the Korea Aerospace Research Institute (KARI).

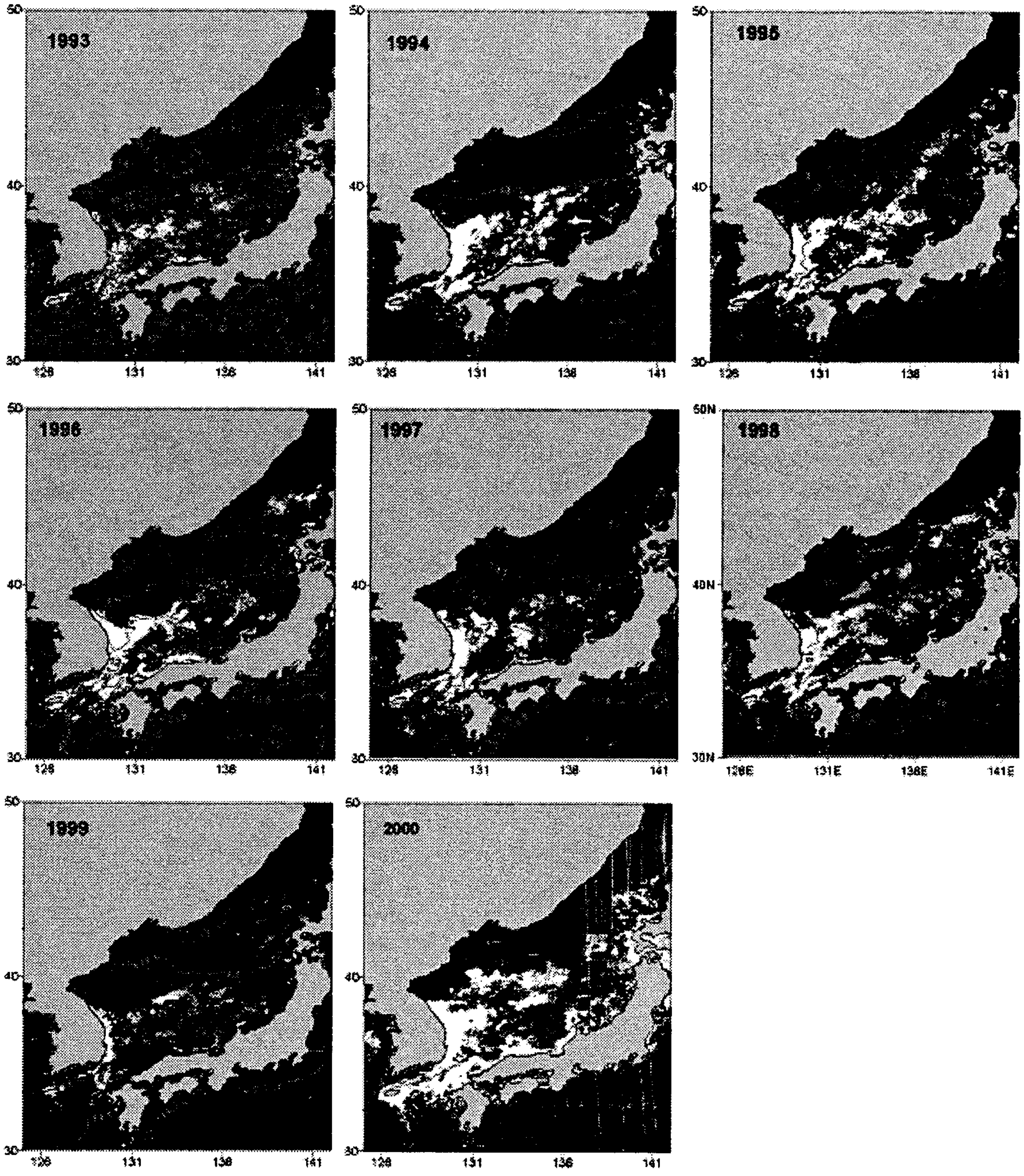

Fig. 4. Relationship between satellite remote sensing estimated 50 m temperature and annual composite OLS images from 1993 to 2000.

References

Croft, T.A., 1978. Night-time images of the earth from space. Scientific American 239, 68-79.

Croft, T.A., 1979. The brightness of lights on Earth at night, digitally recorded by DMSP satellite. Stanford Research Institute, Menlo Park, CA, Final Report Prepared for the U.S. Geological Survey, Palo Alto, CA.

Sakurai, Y., Kiyofuji, H., Saitho, S., Goto, T. and Hiyama,Y., 2000. Changes in inferred spawning areas of Toderades pacificus (Cephalopoda: Ommastrephidae) due to changing environment conditions. ICES Journal of Marine Science, 57, 24-30.

Elvidge, C.D., Baugh, K.E., Hobson, V.H., Kihn, E.A., Kroehl, H.W., Davis, H.W., Cocero, D., 1997a. Satellite inventory of human settlements using nocturnal radiation emissions: a contribution for the global toolchest. Global Change Biology 3(5), 387-395.

Elvidge, C.D., Baugh, K.E., Kihn, E.A., Kroehl, H.W., Davis, E.R., 1997b. Mapping of city lights using DMSP Operational Linescan System data. Photogrammetric Engineering and Remote Sensing 63(6), 727-734.

Elvidge, C.D., Baugh, K.E., Dietz, J.B., Bland, T., Sutton, P.c., Kroehl, H.W., 1999. Radiance calibration of DMSP-OLS low-light imaging data of human settlements. Remote Sensing of Environment 68(1), 77-88.