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**POLLUTED AND TURBID WATER MASSES IN OSAKA BAY AND ITS VICINITY
REVEALED WITH ERTS-A IMAGERIES**

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ABSTRACT

The heavy water pollution is one of the most serious problems in the Osaka Bay and its vicinity. However, the state of water pollution there has never monitored in the scale of whole Osaka Bay because the conventional point-to-point observations make it impossible to detect the periodical movement of water masses by the fairly strong tidal current.

ERTS-A took very valuable MSS imageries of Osaka Bay and its vicinity on October 24, 1972. In the MSS-4 and MSS-5 imageries a complex grey pattern of water masses can be seen. Though some of grey colored patterns seen in black and white prints of the MSS-4 and MSS-5 imageries are easily identified from their shapes as cloud covers or polluted water masses characterized by their color tone in longer wavelengths in the visible region, any correct distribution pattern of polluted or turbid water masses can be hardly detected separately from thin cloud covers in a quick look analysis.

In the present investigation, a simple photographic technique was applied using the fact that reflected sun light from cloud including smog and inclined water surfaces of wave have a certain component in the near infrared region, that is MSS 7, whereas the light scattered from fine materials suspended in the sea water has nearly no component in the channel of MSS 7 but has only the green and yellow component sensible in MSS 4 and MSS 5 channels. That is, combined prints were made from a positive imagery of MSS-4 or 5 together with a negative imagery of MSS-7 using a photographic enlarger. In the combined prints areas of clouds and smogs are shown as white or lighter grey, whereas polluted or turbid water masses are clearly represented with black or darker grey tone.

SIGNIFICANT RESULTS

Significant results are obtained as follows;

- 1) The simple method mentioned above is useful technique for detecting water masses distribution separately from cloud covers and also noise caused by the reflected sun light from wave surfaces.
- 2) The polluted water does not diffuse continuously into the oceanic water but forms masses of polluted water among masses of the oceanic water flown from the outer sea, that is, the Kuroshio area.
- 3) The polluted or turbid water mass in the just north of the Tomogashima Channel, the south outlet of the Osaka Bay, shows that the northward tidal current runs in a clockwise eddy at the tidal period when the imageries are taken. Such an eddy-like pattern of tidal current has never been revealed by the conventional oceanographic data.
- 4) A front between an oceanic water mass and a polluted water mass runs in the direction of NW-SE in the center part of the Osaka Bay.
- 5) The patterns of turbid water discharged from the Kii River and the Yoshino River show the northward tidal current in the North Kii Straits at the time of imageries taken.
- 6) The pattern of lighter turbid or polluted water located in the northwest region of the North Kii Straits suggests the existence of a clockwise eddy in the straits.

ILLUSTRATIONS

FIG. 1 Two examples of ERTS-1 MSS imageries taken on October 24, 1972. Cloud covers, heavy smog areas and turbid water masses are represented equally by grey color in imageries of MSS-4 and -5, because they have sensible components of light in these channels. On the other hand, there is no grey-colored image of turbid or polluted water mass but are the ones of cloud cover and smog area in MSS-7 (infrared) imagery since the infrared component of light is strongly absorbed by the sea water.

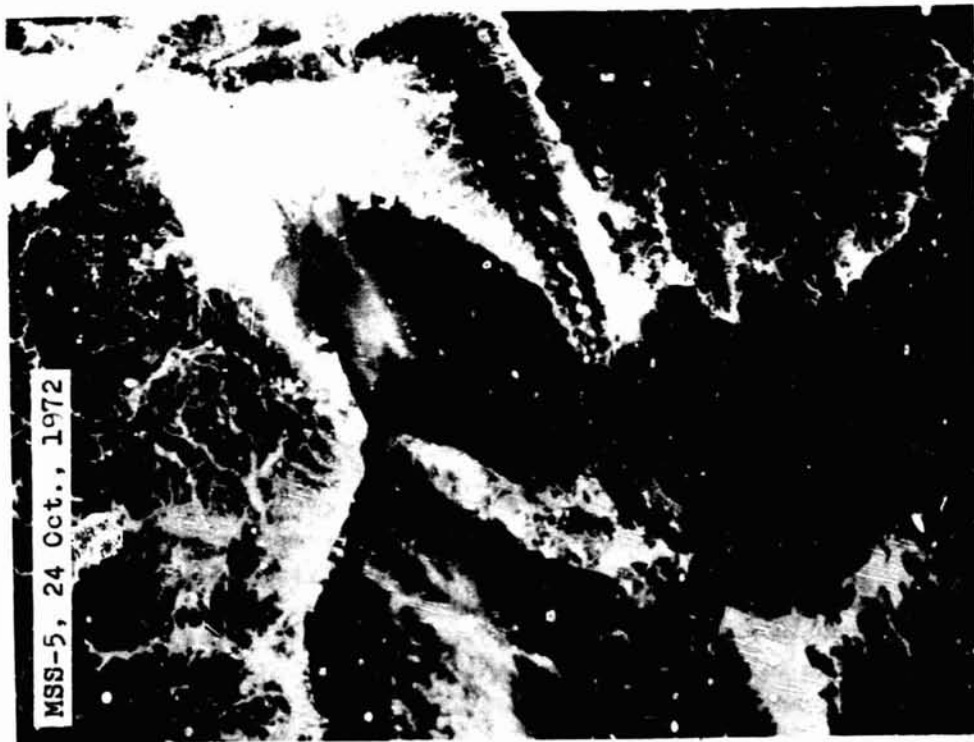
FIG. 2 Using the difference of grey-colored images over sea regions in MSS-5 (or -4) and MSS-7 imageries explained in Fig. 1, turbid or polluted water masses can be represented by darker images separately from cloud covers and smog areas which are represented by lighter grey images in a combined print made with a negative imagery of MSS-5 or MSS-4 together with a negative imagery of MSS-7 by a photographic enlarger.

FIG. 3 Turbid or polluted water masses distribution manually copied from the combined print (in Fig. 2). The darker is any area the heavier is the degree of turbidity or pollution in this chart. The pattern in this chart suggests that turbid or polluted waters diffuse into oceanic water masses flown from the outer sea without any continuous density variation in some short time, but form patches of turbid or polluted water masses. The major mass of polluted water is thought to locate under a cloud cover and smog areas off Osaka and Kobe ports. The patch of turbid or polluted water mass having an eddy-like pattern near the Tomogashima Channel (marked by T) is assumed to have departed from the major mass of polluted water off Osaka and Kobe ports in a former tidal time. Effluents from the Kii and Yoshino Rivers are clearly seen.

FIG. 4 Flow pattern of tidal current inferred from the combined print of Fig. 2.

As it was at the time of tidal current shown by the insetted curve at the upper left corner, most of flowing water directed nearly north except of the ones near the Akashi and the Naruto Channels. A clockwise eddy is strikingly revealed closely north of the Tomogashima Channel. A front of two different water masses runs NW-SE nearly in the center of the Osaka Bay. These phenomena have never been observed in any point-to-point observation by ship. North of the front a clockwise eddy can be inferred in this analysis which have already been observed by ship's surveys. There are seen two small eddies, one of which is counter clockwise and another clockwise, in the mouth of the Naruto Channel which is famous by the formation of numerous eddies at the time of maximum tidal current.

MSS-5, 24 Oct., 1972



Polluted and Turbid Water Masses
in the Osaka Bay and its Vicinity
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By Kantaro Watanabe

MSS-7, 24 Oct., 1972



Fig. 1

Combined Print
with a Negative of MSS-5
and a Positive of MSS-7,
24 October, 1972



Fig. 2

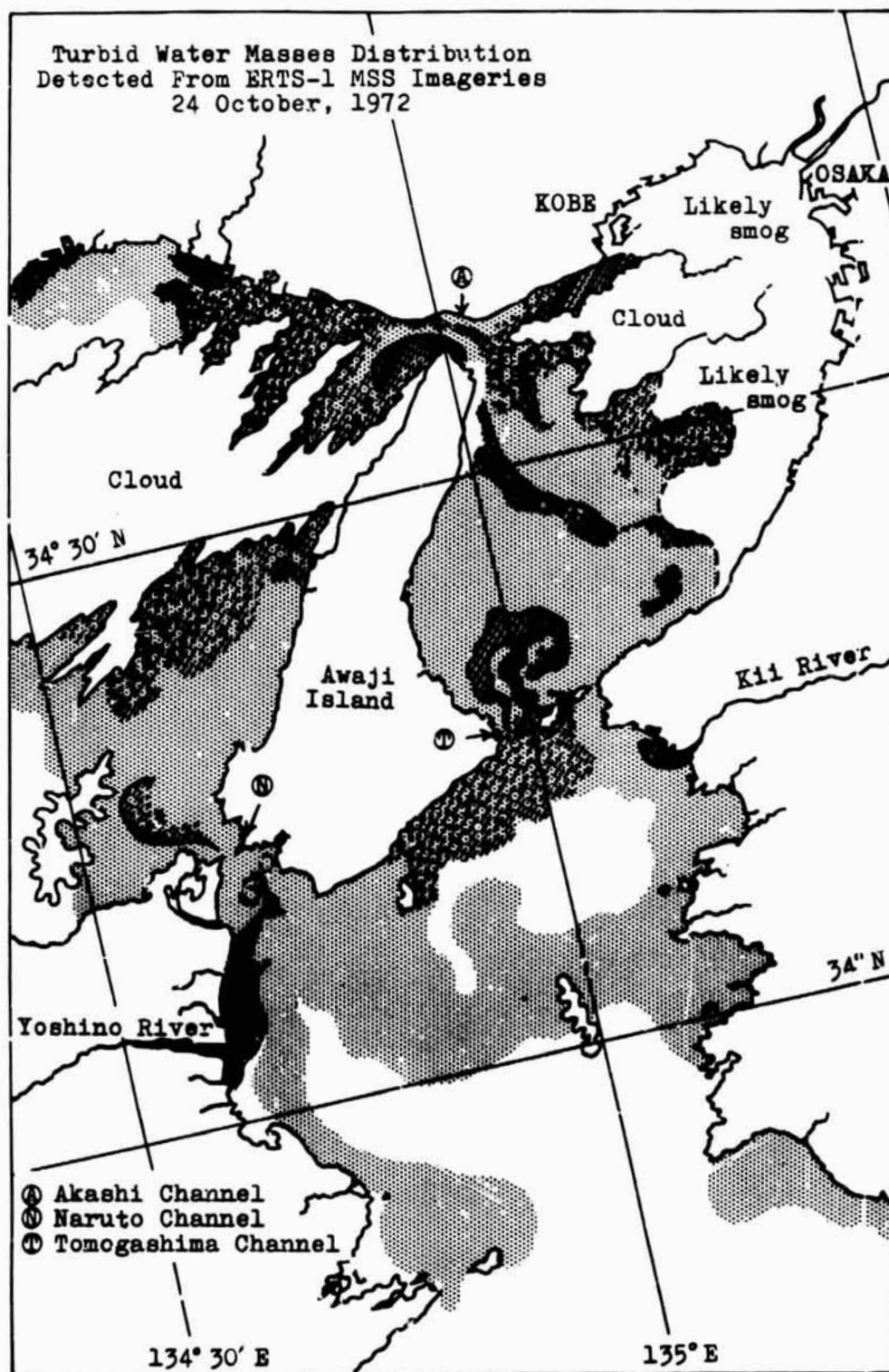


Fig. 3

Flow Pattern Inferred From
ERTS-1 MSS Imageries, 24 Oct. 1972

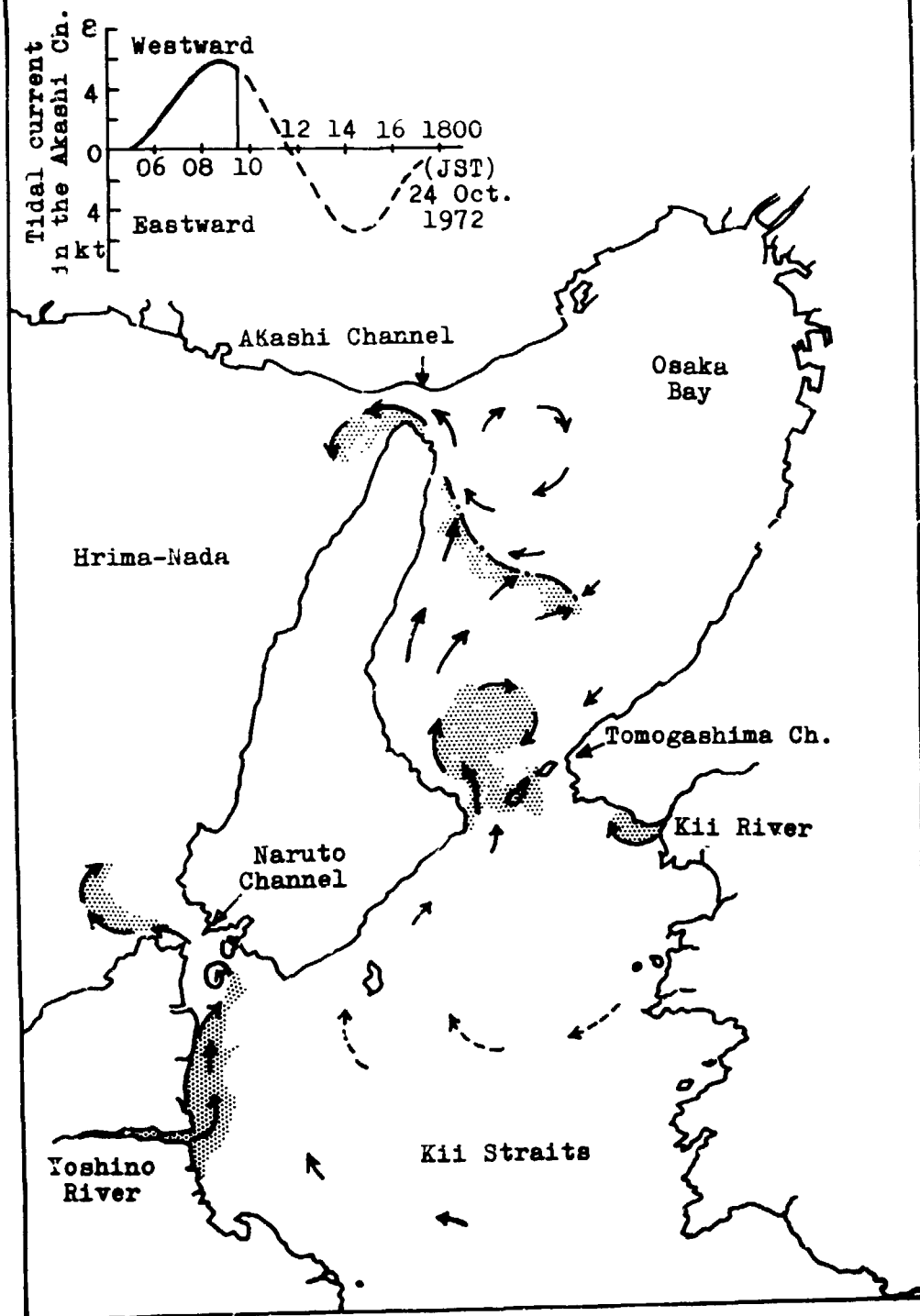


Fig. 4