MFR PAPER 1131

Fishing Fleet Activities Revealed by Night-Time Data from the Defense Meteorological Satellite Program (DMSP)

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The effect of ocean thermal boundaries on the distribution of fish is well known in the fishing industry. Laevastu and Hela (1970) additionally describe the role of oceanic current convergences in bringing about a concentration of forage organisms and small fish highly attractive to pelagic tuna. They show a weekly, combined surface temperature and oceanic chart published by Japanese newspapers for the benefit of the fisheries, which locates the meander of the various zones in their area.

Figure 1 shows the major physical oceanographic features surrounding Japan and Korea (Gong, 1971). A notable convergence zone is the zone of mixing between the cold Liman Current and the warm Tsushima Current in the Sea of Japan. Figure 2 is a Very High Reslution (½ km) infrared depiction of the convergence zone obtained from the sensors of the Defense Meteorological Satellite Program (DMSP) on the night of 26 September 1974. In this depiction the warm areas are black; progressively cooler areas are lighter shades of grey, culminating in white for very high and very cold cirrus cloudiness. The warmer waters in the southern portion of the Sea of Japan are readily distinguishable from the colder waters to the north. According to the previous reasoning, the convergence zone, or zone of mixing separating these two areas, should be a very good place to fish for tuna, saury, and other pelagic varieties of fish. Figure 3 suggests that the fishermen in that area were not caught off their guard and were very active in exploiting the fishing potential of this convergence zone. The depiction is from the visual scanner (3-km resolution) of the DMSP, which is capable of acquiring night-time data with illumination as low as ¼ moonlight. This depiction was acquired simultaneously with that of the infrared depiction shown in Figure 2. The city lights of Seoul, Korea on the west coast and Pusan on the southeast tip of Korea, along with others, are readily apparent. City lights in Japan, shining through overcast

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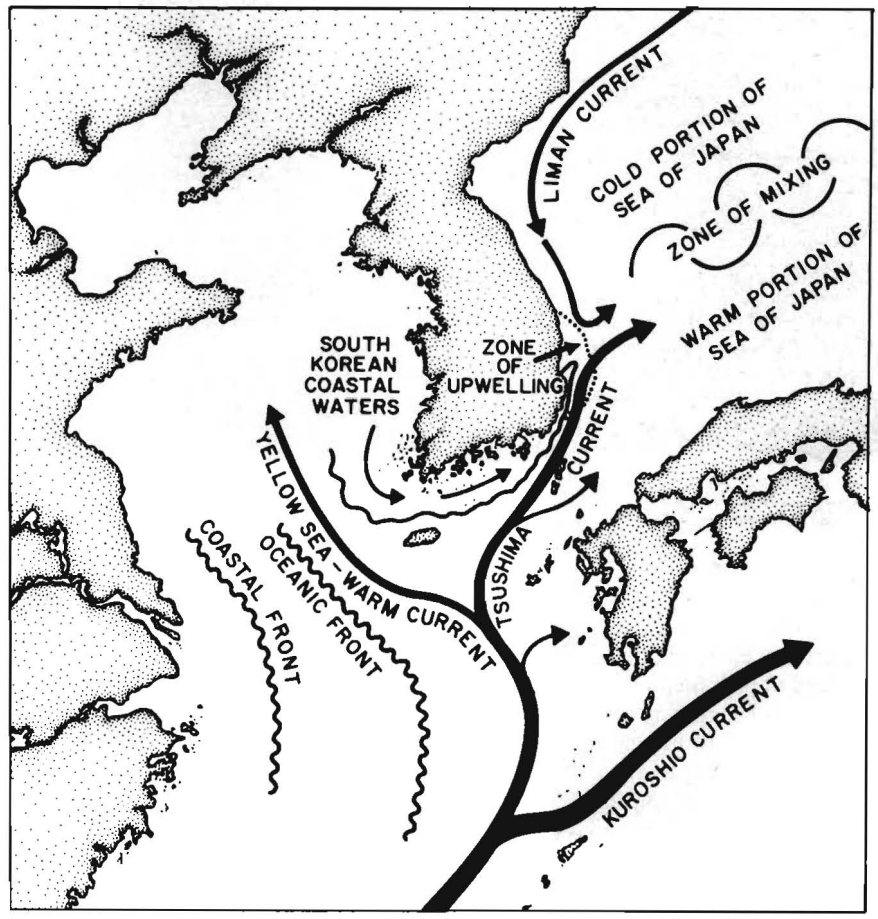

Figure 1.—Physical Oceanographic Features: (Photograph, courtesy of Gong, Kang, Cho, 1972 and U.S. NAVOCEANO.)

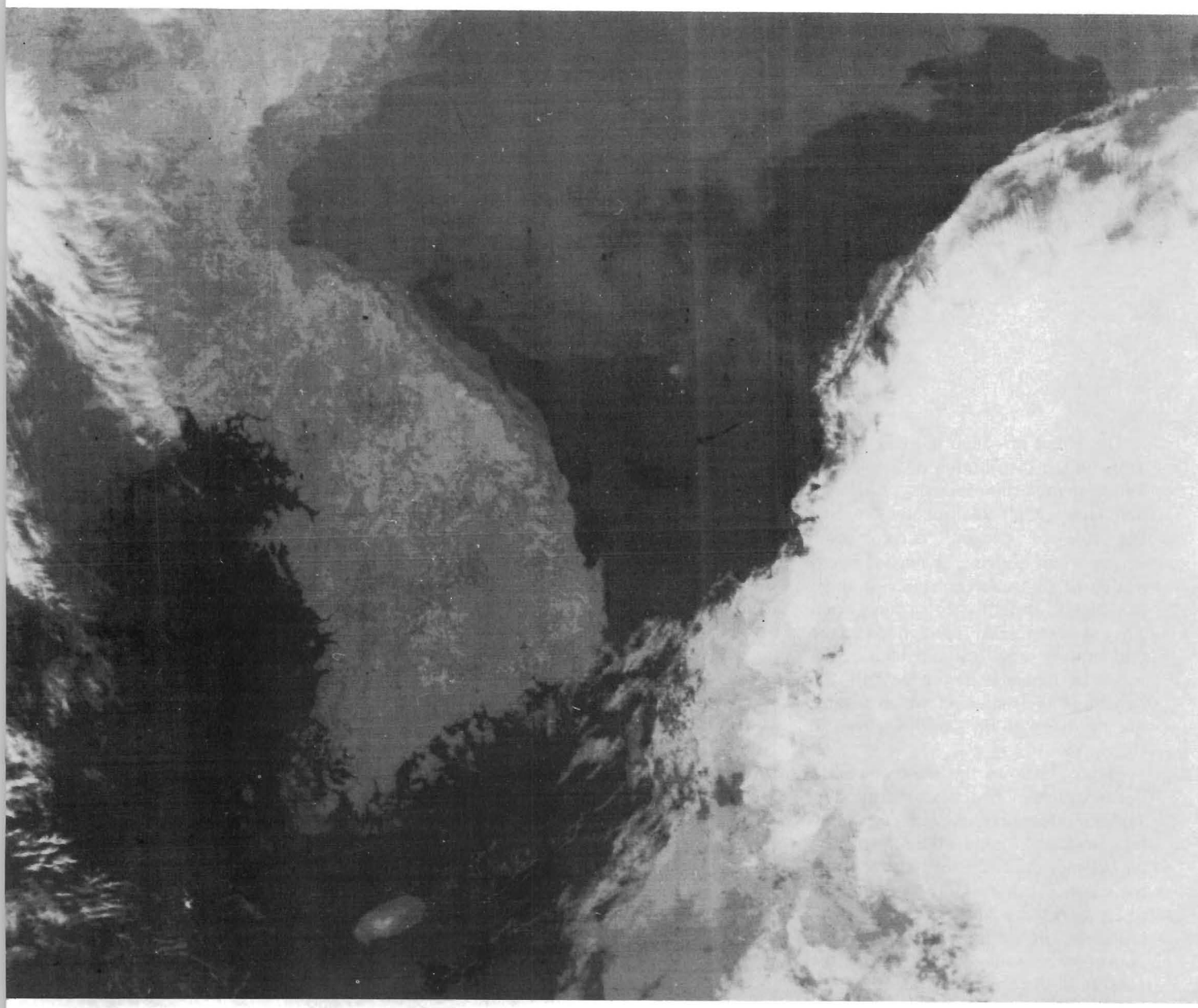

Figure 2.—A DMSP Very High Resolution infrared depiction on 26 September 1974, at 1555 GMT.

cloudiness, are apparent to the southeast and east. But there are no cities under the lights covering the Sea of Japan! Revealed are lights from what appears to be a heavy concentration of vessels cruising along the convergence zone, or zone of mixing in the Sea of Japan, attempting to exploit the potential of this area for productive fishing. The intensity of the lighting is unusually strong, suggesting that the vessels are using exterior alluring lights in quest for Pacific saury, a species which prefers to congregate in waters near sharp thermal gradients. It has been found that at night, at the surface, saury will form dense schools under rather intense artificial lights; 5 kw searchlights are commonly used in the search process to scan the surface waters for saury schools (Inoue and Hughes, 1971). The alluring lights, according to this reference, include incandescent lamps mounted on reflectors, in addition to colored fluorescent lighting with a combined power output of 30 kw or more. Such lighting can be quite brilliant, as shown by the photograph in Figure 4 of a fishing vessel searching for saury with alluring lights on. Lower intensity lighting is sometimes concurrently used when fishing for squid. As can be seen from the picture, reflection of the lights off the surface of the water and into the spacecraft sensor may have been a factor accounting for the heightened intensity of illumination observed.

Such a possibility seems especially important in this instance since a pronounced ridge of high pressure extended over the Sea of Japan and maximum winds in the area were only 1-1½ m/sec^{-1} (2-3 knots). The satellite tracked almost directly over the Sea of Japan so that atmospheric attenuation was minimized and specular reflection could be received from ship lights off the smooth surface of a gently rolling sea.

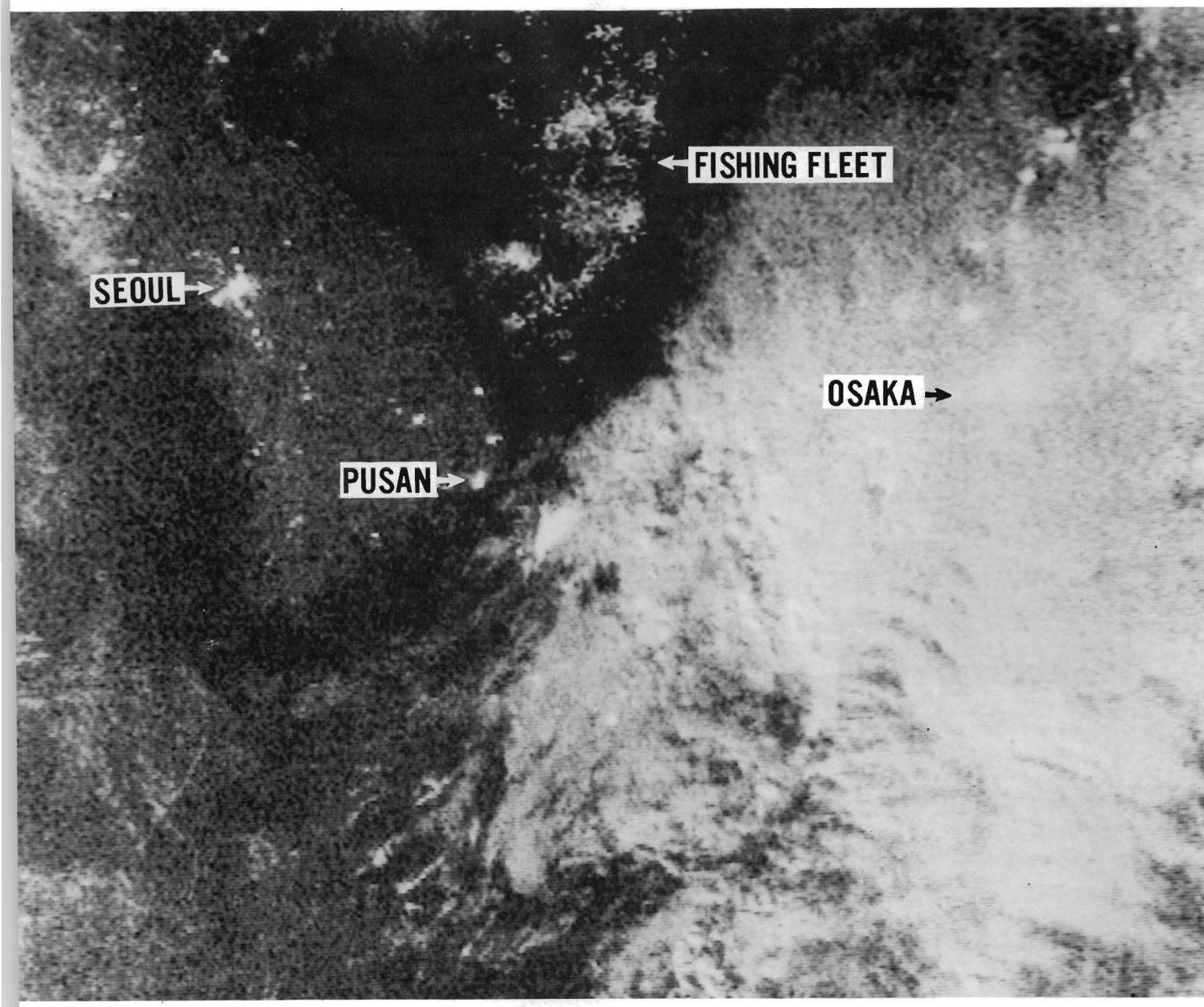

Figure 3.—A DMSP visual depiction of night-time data acquired on 26 September 1974, at 1555 GMT.

To account for the number of scan spots illuminated would require a minimum of 500-1,000 fishing vessels in the area. Private conversation with S. Hughes (Northwest Fisheries Center, NMFS, Seattle, WA 98102), co-author of the referenced saury study (Inoue and Hughes, 1971), indicates that such a figure or higher is not unrealistic, based on knowledge of Inoue's personal experiences with the saury fleet.

A possible alternative to the fishing fleet hypothesis is that the area was illuminated as a result of bioluminescense—the production of light by marine animals and organisms. This theory is discounted for several reasons.

First, surface bioluminescence is normally a small-scale effect occurring as a result of agitation in turbulent waters, along beaches, and in the wakes of ships or around other obstacles in the sea (Sverdrup et al., 1942). The area shown illuminated in the Sea of Japan is a huge area under almost calm wind conditions, which would not favor a bioluminescent display.

Second, bioluminescence is most pronounced in the warmer waters of the world. The DMSP data indicate that the lighted areas are concentrated mainly on the cooler side (north) of the mixing zone where the saury should be more abundant due to their predilection for cooler waters in the temperature range of 18°-20°C (Inoue and Hughes, 1971). Similar effects have not been observed by satellite in the warmer waters of the world where bioluminescence is commonly reported.

Finally, the intensity of bioluminescence, per unit area, is much less than that developed by the lighting systems of the saury fishing vessels. A bioluminescent effect, if visible, should appear more as a diffuse streak or diffuse area of rather limited extent than as a point source or series of point source concentrations of light, as revealed in the

Figure 4.—Saury fishing vessel (Inoue and Hughes, 1971).

DMSP data.

It is of interest that such a concentration of lights over the Sea of Japan is not commonly seen. Saury respond to alluring lights only during a short period each year in the spring and in the fall (Inoue and Hughes, 1971). Lights were again noted in data acquired on the following day (27 September 1974), but in diminished numbers as a strong tropical storm system moved northward toward Japan. They were not noted again in a perusal of selected data extending to early December 1974, although IR (infrared) data, at times, again revealed the presence of a strong oceanic frontal boundary.

Assuming that the results of this suggested fishing activity were positive, this example appears to offer rather dramatic evidence that meteorological satellites can be of great value in assisting the fishing industry through monitoring the location and changes in location of important oceanic convergence zones throughout the world.

ACKNOWLEDGEMENTS

The author expresses his gratitude for helpful discussions and guidance from T. Laevastu, Environmental Prediction Research Facility, Calif.; and J. Johnson and S. Hughes, National Marine Fisheries Service, NOAA.

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MFR Paper 1131. From Marine Fisheries Review, *Vol. 37, No. 4, April 1975. Copies of this paper, in limited numbers, are available from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235.*