

## Measurements of the Surface Currents in Offshore Waters along the West Coast of Kyushu and Tusima Strait

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*Keywords* : Surface Current, Tide Stream

### Abstract

The distributions and conditions of surface currents are described on the basis of the data obtained by the ship-board Doppler current meter observation in coastal waters between Kagoshima and Busan passing through off the southwest of Kyusyu to the Tusima Strait from the 28th of April to the 5th of May, 1989. Off the coast of Makurazaki, the current to the east had the maximum speed of about 1 knot near the time of low water in the neap tide but its direction reversed to the west-southwest before the spring tide. Off the coastal area between Bono Misaki and Noma Misaki, there were offshore currents at the early period of flood stream in the neap tide and onshore currents at the last period of flood stream and then the current flowed to the south near the time of low water before the spring tide. In the Amakusa Nada, there were onshore currents at the time of high water in the neap tide and offshore current at the last period of flood stream before the spring tide. In the west channel of Tusima Strait, the currents flowed to the north-northwest with a speed of about 0.5 knots at the time of flood stream in the neap tide but its direction turned to the south-southeast before the spring tide.

It is the well-known fact that the offshore area of the west coast of Kyushu is one of the important areas for spawning, nursery and fishing ground of pelagic fishes. However, little is known on the current conditions in this area. The objective of the report is to describe the distributions and conditions of the surface currents from the offshore area of the southwest coast of Kyusyu to the Tusima Strait on the basis of the data obtained by the Doppler current meter on board of the Keiten Maru.

The general current conditions of offshore area of the west coast of Kyusyu and the Tusima Strait are described in the Coast of Kyusyu Pilot (Sailing Direction 105)<sup>1)</sup> published by the Maritime Safety Agency of Japan (1985). The Tusima Current, which is branched from the Kuroshio, flows to the north~northwest offshore side of the west coast of Kyusyu and it is separated into two branches off the west coast of Goto Islands; the one branch flows to the northwest off the south coast of Jeju Do and enters into the Yellow Sea, known as the Yellow Sea Warm Current, and the other branch gradually turns to the northeast and enters into the Japan Sea through the east channel or west channel of Tusima Strait.

In the offshore area of the west coast of Kyusyu, a branch of the Tusima Current turns southward off the south coast of Goto Is., then flows to the south near the Koshiki Is., and joins the branch of the Kuroshio. On the other hand, the general current condition in the coastal area

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is largely affected by the tidal conditions, because the tidal range is large in the west coast of Kyusyu.

Studies concerning the tides in adjacent sea to Tusima were published by Suda (1938)<sup>2)</sup>, Miita (1989)<sup>3)</sup>, Ogawa et al. (1978)<sup>4)</sup>, Miita and Ogawa (1984)<sup>5)</sup>, and Odamaki (1989)<sup>6)</sup>. It is very important for the fisheries production, the oceanography and the coastal navigation to gain the detailed informations of the current and the tidal conditions. Miita (1976)<sup>3)</sup> studied the structure and the transport of the current by the method of Eulerian measurement. Ogawa et al. (1978)<sup>4)</sup> commented upon variation of the current on the basis of the results obtained by the method of Lagrangian measurement. Miita et al. (1984)<sup>5)</sup> mentioned the horizontal distribution and the seasonal changes of the current and the volume transport from the data by the current meter and drifters. Odamaki (1989)<sup>6)</sup> reported the tides and tidal currents in the Tusima Strait and re-edited the cotidal charts.

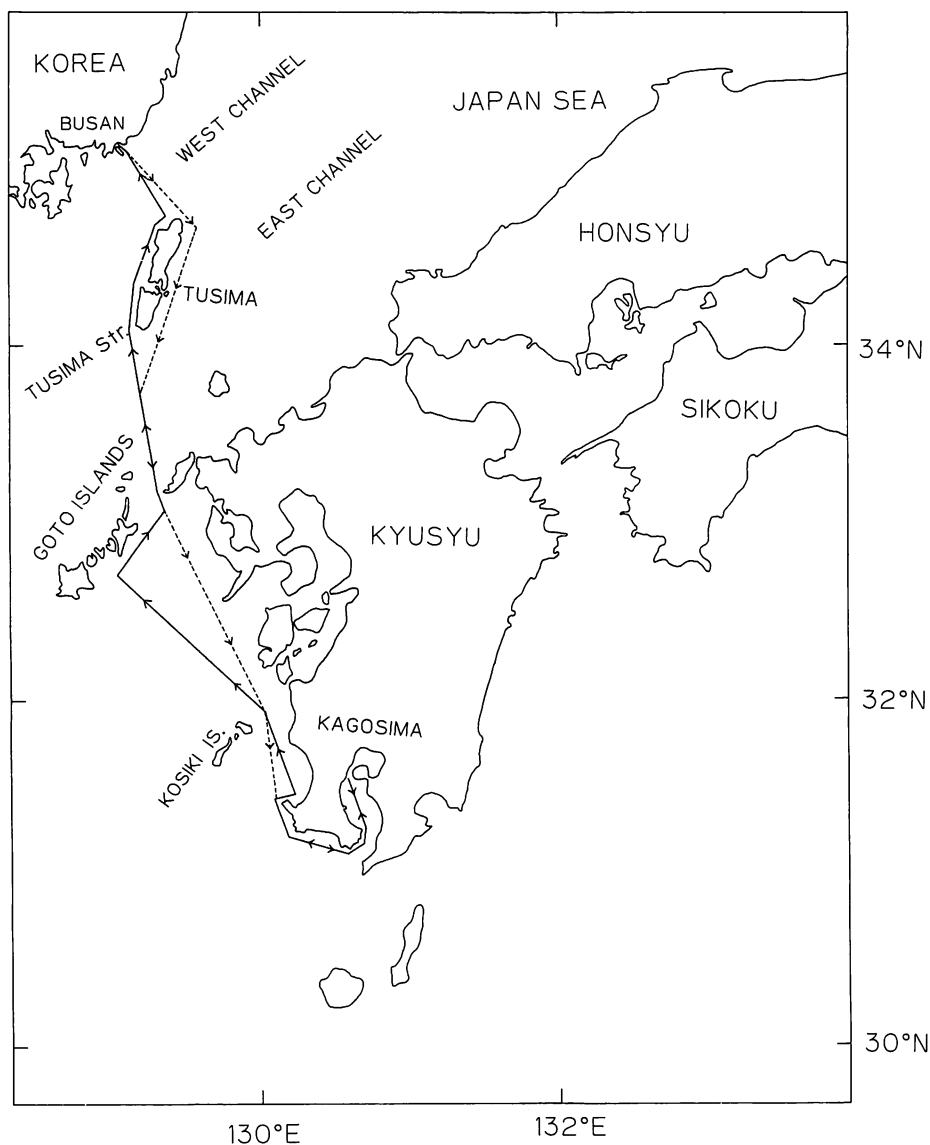
### Oceanographic Observation

The Keiten Maru (860 tons) took a cruise between Kagoshima and Busan for cadets' training, passing through the west coast of Kyusyu to Tusima from the 28th of April to the 1st of May on the outward cruise and from the 4th to the 5th of May on the return cruise. The ship trace is shown in Fig. 1. The surface currents were observed by the supersonic current meter of Doppler Color Graph manufactured by the Kaijo Denki Co., Ltd. The obtained data were printed on the recording paper every 15 minutes. The distance of interval of observation was about 3 miles. The vectors of the surface currents were shown on three parts; off the southwest coast of Kyusyu, between Amakusa Nada and Goto Islands, and near the Tusima Strait.

The tidal conditions in this cruise were as follows; corresponding to the time of neap tide, the last quarter was on the 29th of April with the moon's age of 22.9 and the moon's declination of  $16^{\circ}-57'.4$  S ( $U=12$  hr), and the new moon on the 5th of May with the moon's age of 28.9 and the moon's declination of  $20^{\circ}-57'.8$  N ( $U=12$ hr) but the time of spring tide on the 6th of May.

According to the Tide Tables Volume 1, 1989, published by the Maritime Safety Agency of Japan (1988)<sup>7)</sup>, the tidal range of the principal ports along the coast between Kagoshima and Busan are shown in Fig. 2. The tidal range of neap tide on the outward cruise has the maximum value of about 145 cm at Tomioka, Kumamoto prefecture, and the minimum value of about 25 cm at Aziro, Tusima Is. Those of the spring tide on the return cruise has the maximum of about 345 cm at Tomioka and the minimum of about 110 cm Aziro.

In general, the tidal current flows to the south at the time of flood stream and to the north at the time of ebb stream, and turns to the north and south near the time of high water or low water near the Tusima Is. Off the west coast of Kyusyu, the tidal current flows to the south or north along the coast area facing the open sea, and is directed to the north within from 2~3 hr after the low water to 2~3 hr after the high water, and to the south within from 2~3 hr after the high water to 2~3 hr after the low water (Sailing Direction 105).



**Fig. 1.** Map showing the trace of ship between Kagoshima and Busan. The solid and broken lines are outward and return cruises.

## Results and Discussion

### *Surface current off the Southwest coast of the Satuma Peninsula*

The current vectors off the southwest coast of the Satuma Peninsula on the outward and return cruises are shown in Figs. 3(a) and (b).

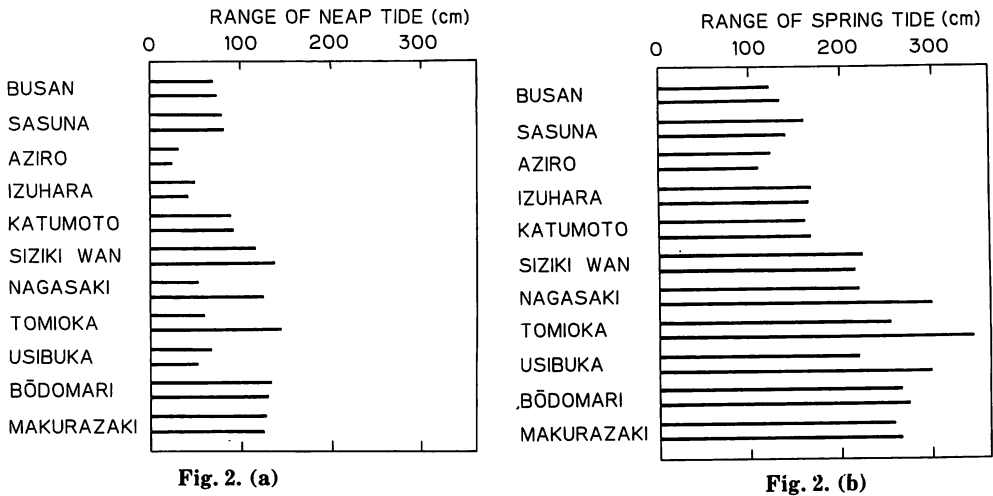
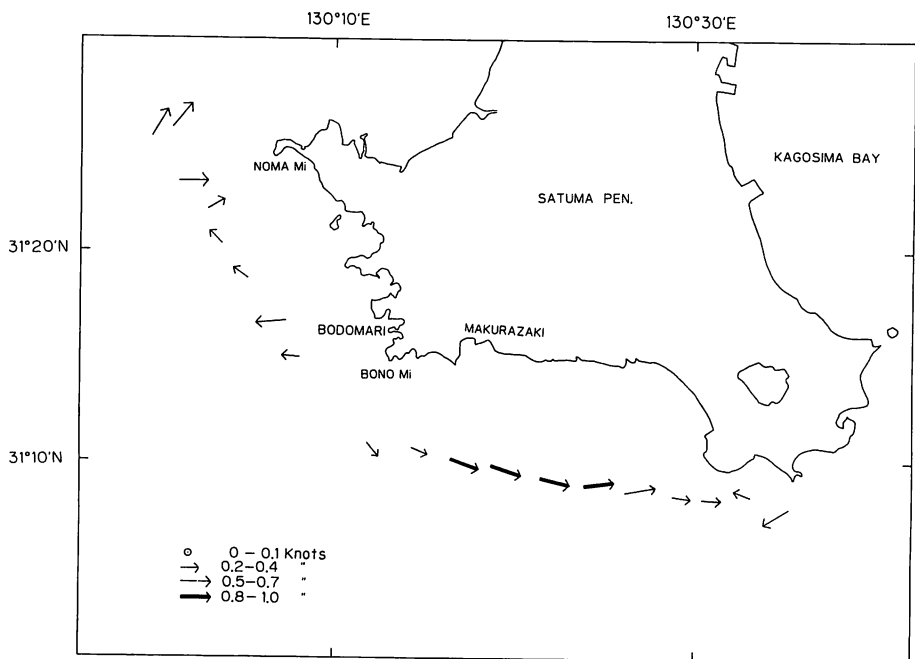


Fig. 2. Tidal range in the principal ports along the coast between Kagoshima and Busan.  
(a) Neap tide. (b) Spring tide.

On the outward cruise, off the southern coast of the Satuma Pen., the currents flowed to the east along the coast line with a speed of about 0.8~1.0 knots. In the offshore area of the west and south of the Satuma Pen., the current generally dominated to the south and the east along the coast of the Peninsula (Sailing Direction 105). The offshore area between Noma Misaki and Bono



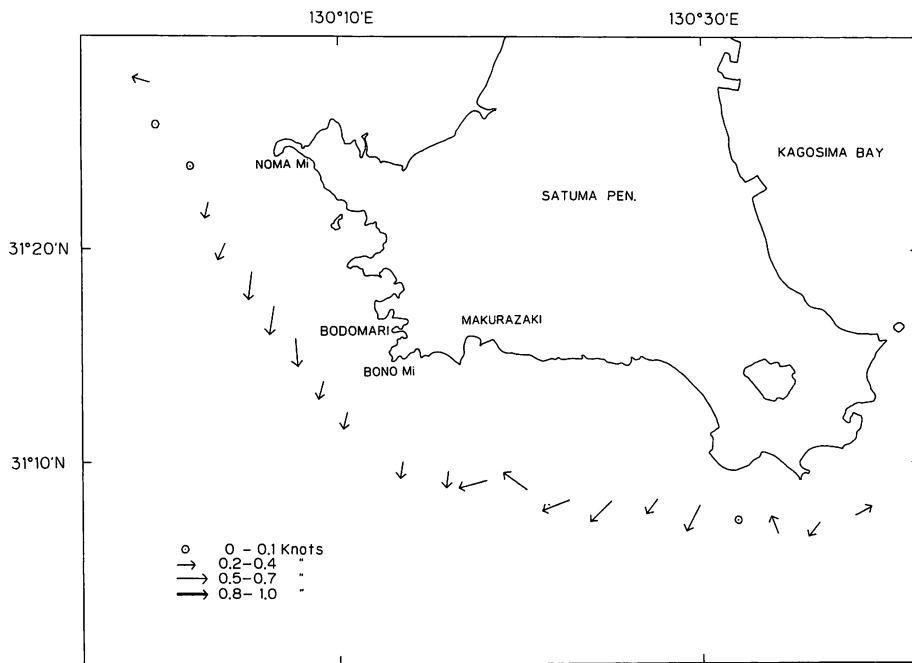


Fig. 3. (b)

Fig. 3. Current vectors off the south west coast of the Satuma Peninsula.  
(a) Outward cruise. (b) Return one.

Misaki, the currents flowed to the west~west-northwest~north-northeast with a speed of about 0.5~0.7 knots. Such currents were not common. This might be attributed to the tidal condition. The time of observation in the area was 3.5~4.5 hours after low water.

On the return cruise, the currents to the south~southwest with a speed of about 0.6 knots were observed near the time of low water, when the offshore current were present along the south coast of the Satuma Pen. In the offshore area between Noma Misaki and Bono Misaki, the currents flowed to the south with a speed of about 0.5 knots. These currents were different in direction from those in the outward cruise.

#### *Surface current in the area between Koshiki and Goto Islands*

The current vectors in the area between Koshiki and Goto Islands on the outward and return cruises are shown in Figs. 4(a) and (b). On the outward cruise, the currents mostly flowed to northeast, onshore current with a speed of about 0.4 knots, which were observed at the time of high water. In the return cruise, the Keiten Maru took a more inshore course, as compared with that in the outward cruise. Off the coast of Nagasaki, the currents were weak with a speed of 0.1~0.2 knots, and its directions were changeable; the tidal condition in the time of observation was the flood stream. In the Amakusa Nada, there were offshore currents directed to the southwest with a speed of about 0.4 knots, when observations were carried out in the last period of flood stream. In the area between Koshiki and Goto Islands, the surface current was largely

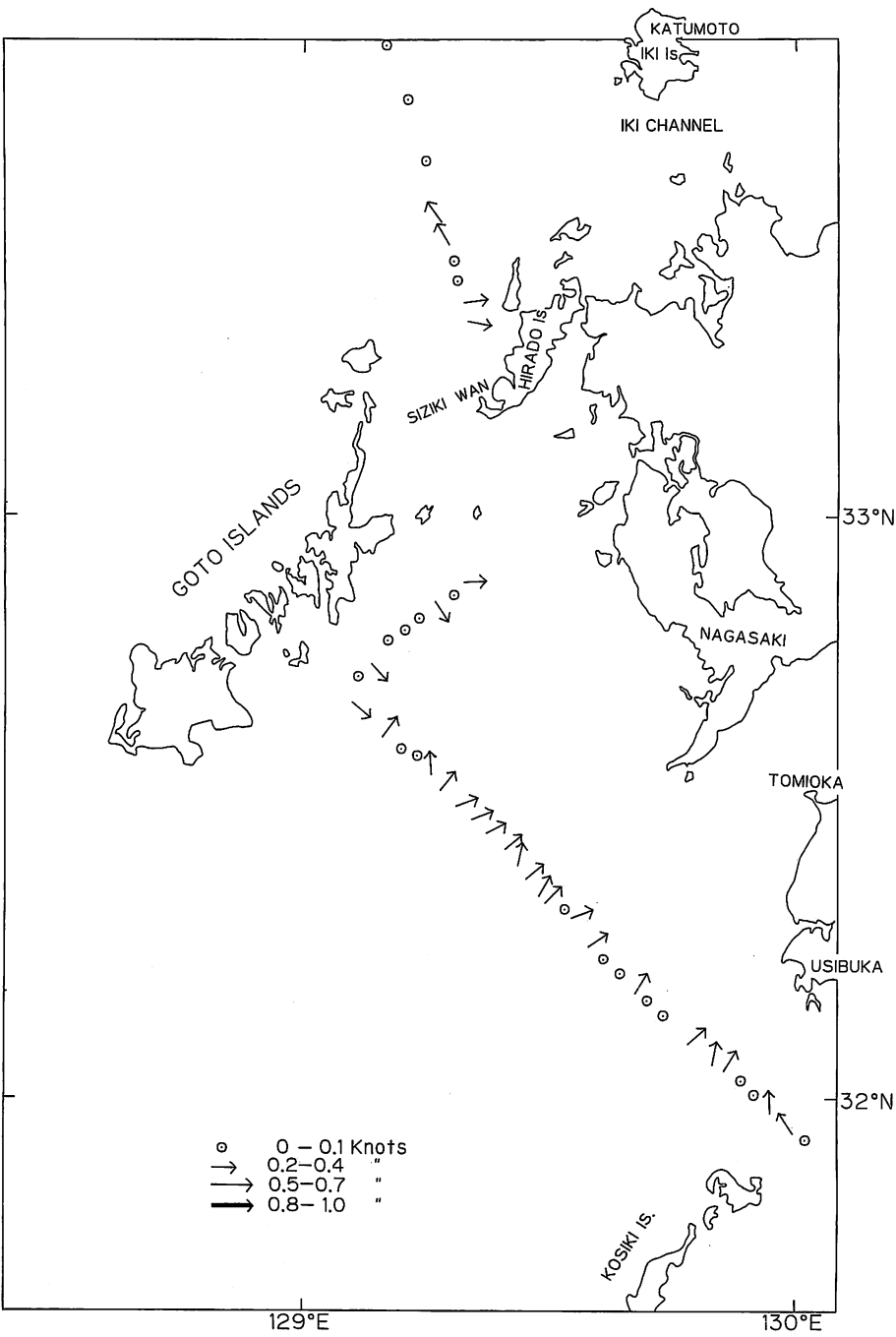
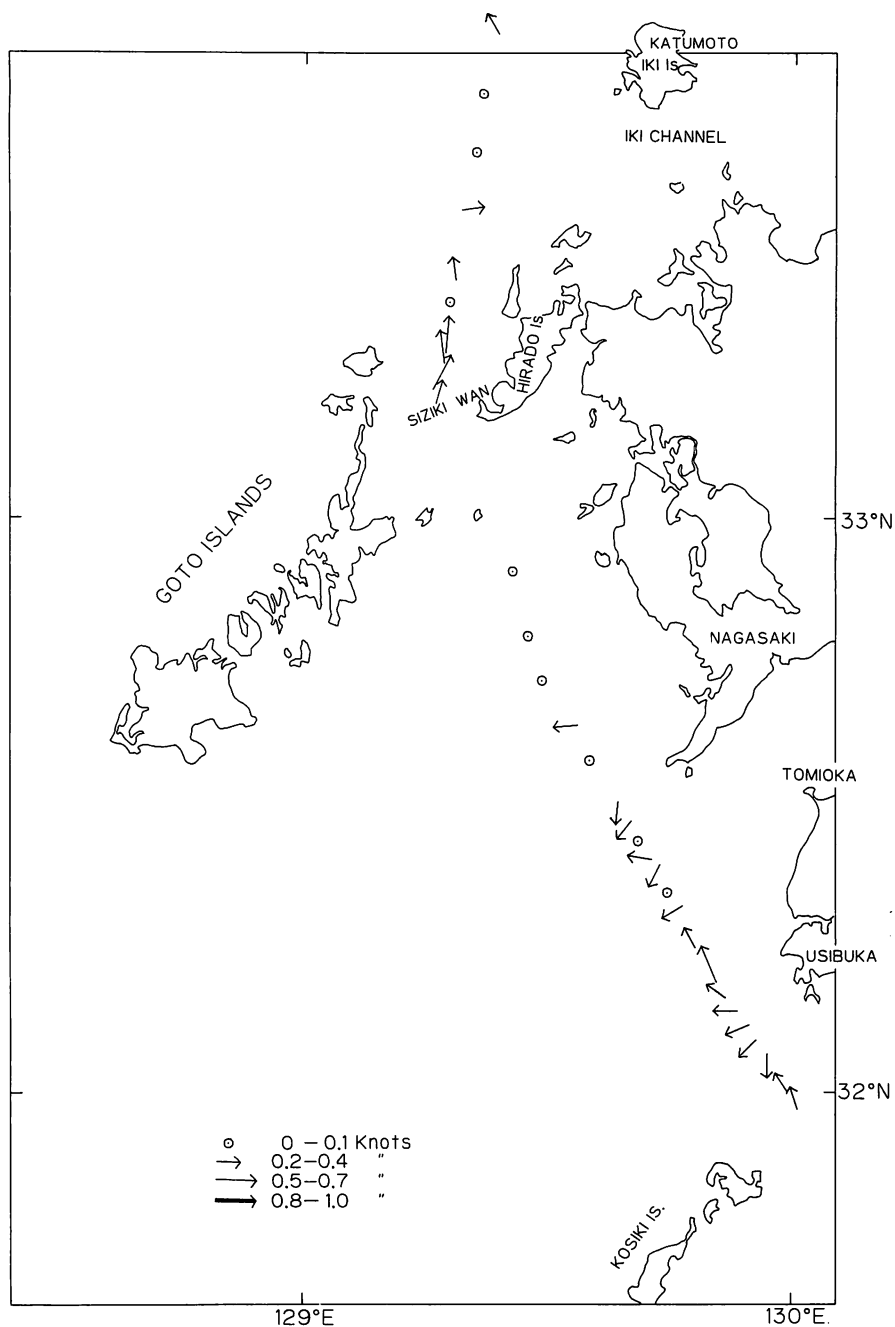


Fig. 4. (a)

**Fig. 4. (b)**

**Fig. 4.** Current vectors in the area between Kosiki and Goto Islands.  
 (a) Outward cruise. (b) Return one.

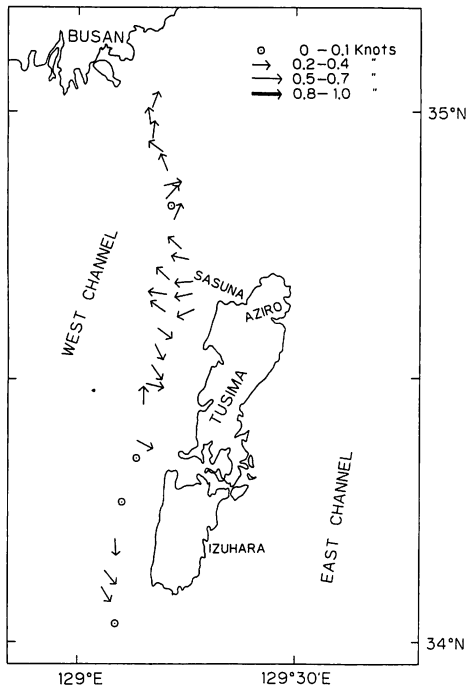


Fig. 5. (a)

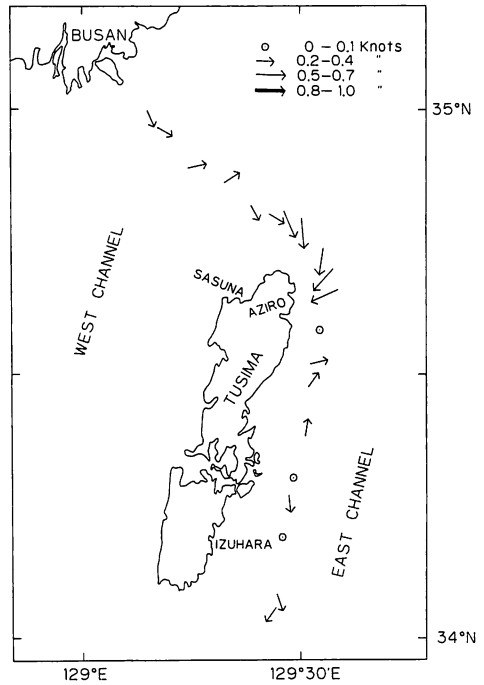


Fig. 5. (b)

Fig. 5. Current vectors near the Tusima Islands.  
(a) Outward cruise. (b) Return one.

dependent on the tidal condition.

#### *Surface current near the Tusima Islands*

The current vectors near the Tusima Islands on the outward and return cruises are shown in Figs. 5(a) and (b).

On the outward cruise, the current flowed to the south-southeast with a speed of about 0.2~0.3 knots at the time of flood stream off the west coast of Tusima Island. The southward component of the current off the west coast of Tusima Is. might be the Countercurrent of Tusima Warm Current. Off the northwest coast of Tusima Is., the currents flowed to the west with a speed of about 0.3 knots at the time of high water or low water, suggesting the turns of tidal stream. In the west channel of Tusima, the currents flowed to the north-northwest with a maximum speed of about 0.5 knots at the time of flood stream; this might correspond to the Tusima Warm Current entering into the Japan Sea through the off the coast of Busan. On the return cruise, the currents flowed to the south-southeast with a speed of about 0.4 knots in the west channel of the Tusima, but the currents observed on the outward cruise were in the opposite direction. Off the north coast of Tusima Is., the currents flowed to the south-southeast with the maximum speed of about 0.7 knots. Off the east coast of Tusima Is., the currents were weak with the direction to the north and the south components, or slacks. It is interesting to note that the current off the north end of Tusima Is. on the return cruise was stronger than that on the



outward one.

## Summary

The surface currents were observed by the supersonic current meter of Doppler Color Graph on board the Keiten Maru in coastal waters between Kagoshima and Busan from the 28th of April to the 5th of May, 1989. In general, the surface currents near the shore were largely dependent on the conditions of surface winds, tides and offshore currents. The tide on the outward and return cruises were the neap and spring tide, respectively. The large tide ranges were found in the spring tide at the west coast of Kyusyu. The observed current direction and speed were different in the outward and return cruises. It was difficult to calculate tidal effects, because the only current was observed at this point. However, the current distributions at the time of observation were clearly obtained.

The main current conditions observed are as follows:

Off the south coast of the Satuma Pen., the current flowed continuously to the east with a speed of 0.8~1.0 knots in the neap tide, and the offshore currents were observed near the time of low water before the spring tide.

In waters between Amakusa Nada and Goto Islands, the onshore currents with a speed of about 0.4 knots were observed at the time of high water in the neap tide. The offshore currents with a speed of 0.2~0.4 knots were observed at the last period of flood stream before the spring tide.

In the west channel of Tusima Is., the currents flowed to the north-northwest having a maximum speed of about 0.5 knots at the time of flood stream; this might correspond to the Tusima Warm Current entering into the Japan Sea. The southward component of the current of the west coast of the Tusima Is. might be the Countercurrent of the Tusima Warm Current.

## Acknowledgement

The authors wish to express their hearty thanks to Dr. M. Chaen, the Faculty of Fisheries of Kagoshima University, for his kind guidance and encouragement.

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