ANNUAL CHANGE OF THE BOTTOM TEMPERATURE AT THE TEST FISHING POINTS FOR HANASAKI CRAB

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Tabl. – 1, fig. – 7, ref. – 3.

1. INTRODUCTION

The Nemuro City Fisheries Research Institute measured the vertical structure of the temperature at the test fishing points for Hanasaki crab from 1995 to 2000 in order to know relationship between catch of Hanasaki crab and environmental water temperature. The observation was made twice a month, but the observation was made only in fishing season from April to October (Liaison Conference for Maintenance and Improvement of Hanasaki Crab Resource in Nemuro Area, 2002). However, if we want to discuss the environmental condition for various stages of crab including their larva stage, and if we want to know relationship of oceanic conditions between fishing ground and offshore sea, we need to know annual variations of environmental parameters throughout year. So, we tried to make continuous temperature measure near the bottom of the test fishing points for Hanasaki crab from December 28, 2005.

2. OBSERVATION SITE, MEASURING SYSTEM AND PROCEDURE

Positions of the bottom temperature measurements are shown in **fig. 1,** together with the bottom topography near the observation points. The observation points are aligned along a north-south line off Sanrihama beach. The depth at St. 1 is 5m, and the depth increases from St. 2 through St. 8 as 10m, 15m, 20m, 30m, 40m, 50m, and 60m. Westward current appear to dominate in this region, and sites of St. 1 through St.4 would be inside of the current shadow zone of the Ochiishi Cape.

Fig. 1. *Positions of temperature measurement stations and bottom contour near the test fishing points for Hanasaki crab. The horizontal scale is shown near right and bottom corner*

Measuring system is shown schematically in **fig. 2.** We used data loggers with temperature sensor (UA-001-08 or TBI32-05-37), which were manufactured by the Onset Computer Cooperation Co. Ltd. Depths of the sensor are about 50cm high above the bottom. The observation was started on December 28, 2005. However, due to the severe storm which attacked the site October 7–9, 2006 the measuring systems were lost except at St. 1 and St. 2. The systems were reinforced by using bigger ropes after 2007. After 2007, we decided to collect the data more frequently, and the vertical profiles of temperature and salinity were observed at the times of data logger displacement by using STD (ATS200-PK) which was manufactured by the Alex Electronic Co.Ltd. The interval of the temperature measurement is 1 hour. Operation to replace the data logger needs about 2 hours. The gaps of the data less than 3 hours were filled by linear interpolation to get continuous data series. The systems are still under operation. It will be terminated at the end of the 2008 fiscal year. Periods of data acquisition are shown in **fig. 3,** and the dates of the STD observations are listed in **table.**

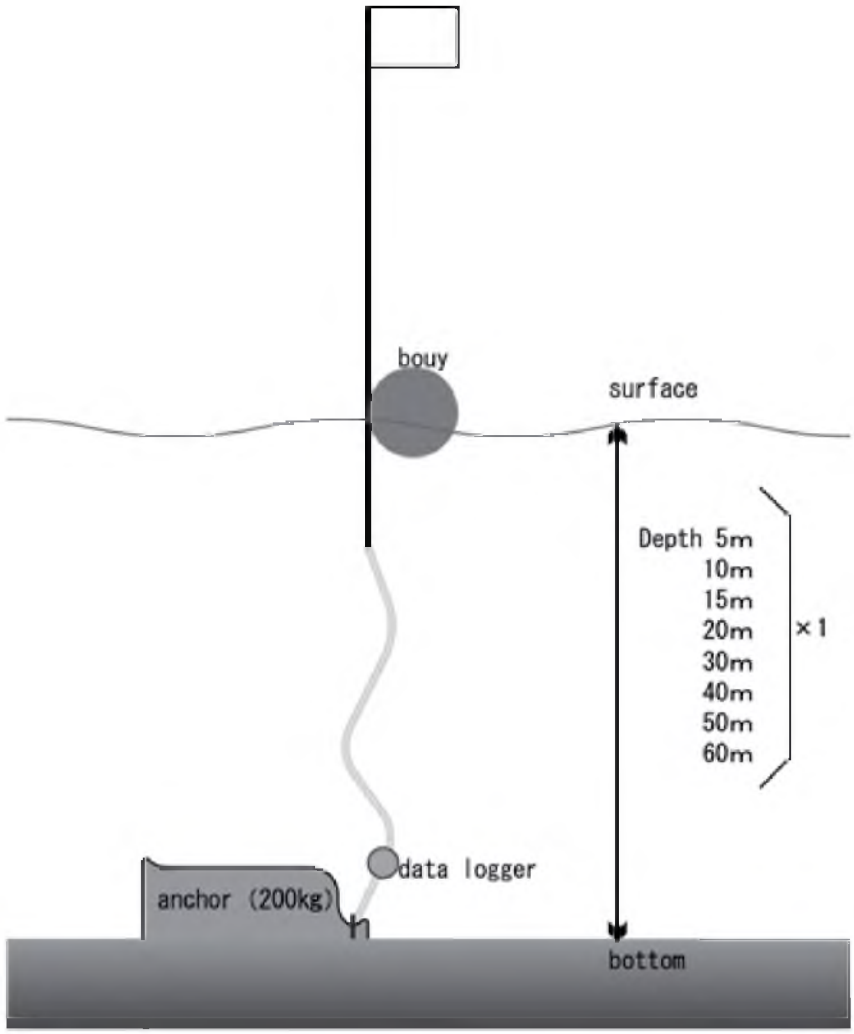

Fig. 2. *Schematic view of the temperature measuring system. Temperature is measured about 50cm above the bottom*

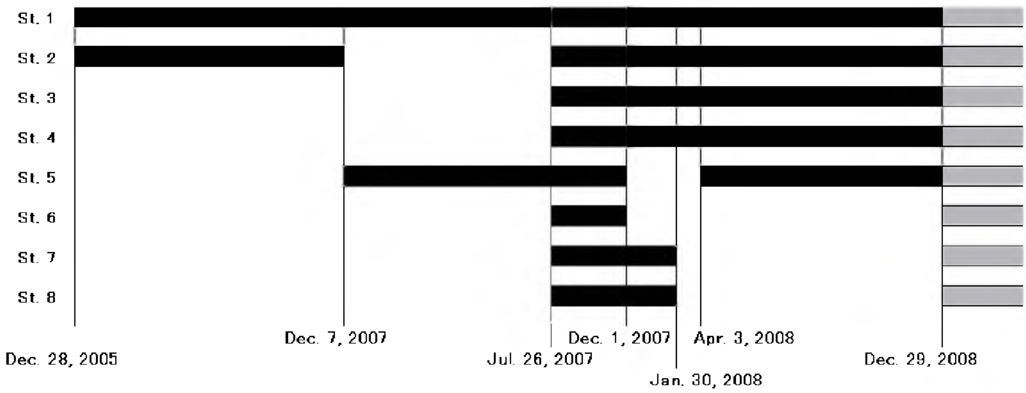

Fig. 3. *Periods of data acquisition for each observation station*

Table

List of STD observation dates

	2007	2008	2009
January		January 30	January 29
February			
March			
April		April 3, April 30	
May	May 28	May 28	
June		June 27	
July	July 26	July 31	
August		August 28	
September		September 26	
October	October 1	Ocrober 29	
November		November 26	
December	December 1	December 29	

3. RESULTS OF THE OBSERVATION

In 2006, we obtained bottom temperature at only two stations (St. 1 and St. 2) which are nearest to the shore. However, it was found that the temperature at 5m (St. 1) tends be a little higher that at 10m (St. 2) in the period of temperature increase from May to July. On the other hand, the temperature at 5m tends to be lower than that at 10m in the period from late November to winter. The oceans are usually well stratified, especially in subtropical area, and temperature tends to decrease with depth. If the temperature increases with depth, salinity would increase with depth to compensate the temperature effect on water density and to stabilize the ocean.

These interesting phenomena are confirmed by the observations in 2007. The seasonal temperature variations at 8 stations in 2007 are shown in **fig. 4.** As shown in fig. 3, simultaneous measurements all at 8 stations were succeeded in the summer in 2007. We could observe continuous record throughout year only at St. 1 (5m) and St. 5 (30m). It can be seen that the temperature at St. 1 is higher than that at St. 5 in the temperature increasing period from May to July, and that the temperature at St. 1 is lower than that at St. 5 in January and in the period from late November to the end of year. The observations in the 2008 fiscal year are still continuing, and the detailed analysis has not been completed, yet. However, the phenomena above mentioned are clearly seen also in 2008. The fact that these phenomena were recognized for all of the analyzed 3 years indicates that they are inherent and unique nature in the seasonal variations of the bottom temperature in the sea under consideration.

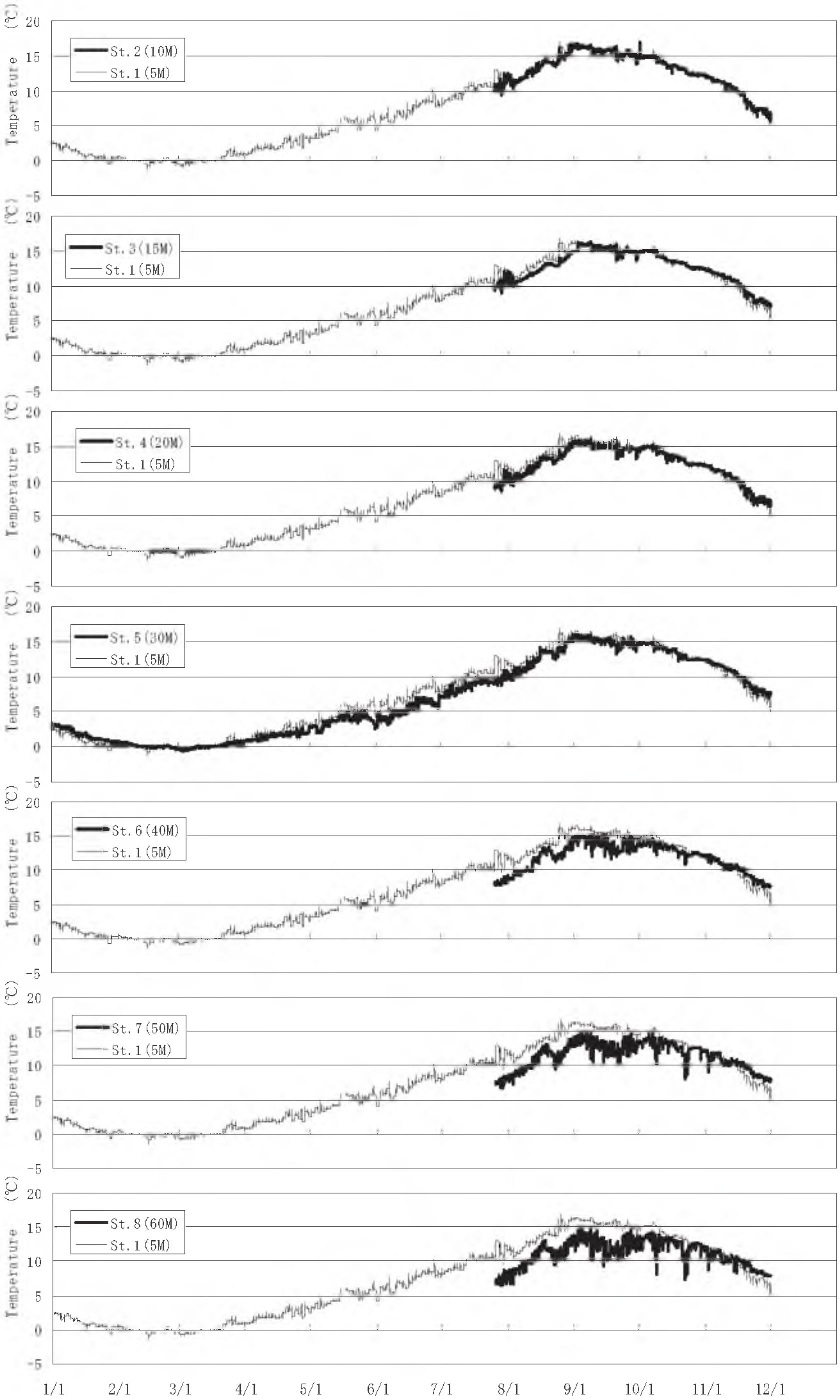

Fig. 4. *Annual changes (thick lines) of the bottom temperature measured at St. 2 through St. 8 from top to bottom. The annual change of the bottom temperature at St. 1 is shown in each figure with thin line for comparison*

One of the examples of the vertical profiles of temperature and salinity at the time that the temperature increases from inshore to offshore is shown in **fig. 5** from the STD observation conducted on December 1, 2007. In the figures, open symbols indicate 4 near-shore stations and closed symbols indicate 4 offshore stations. The salinity profiles are similar to one another and are almost identical (zigzag shapes are mainly cussed by too fine salinity scale). Temperature profiles are almost vertical, though some structures at St. 5 and at St. 7, showing that the stratification is very weak. However, temperature value significantly increases from inshore to offshore. This indicates that the increase of temperature towards offshore is not related to vertical temperature gradient, but to horizontal temperature gradient. Such structure was observed commonly in the temperature and salinity profiles observed in the period when the temperature increases as the observation position moves offshore.

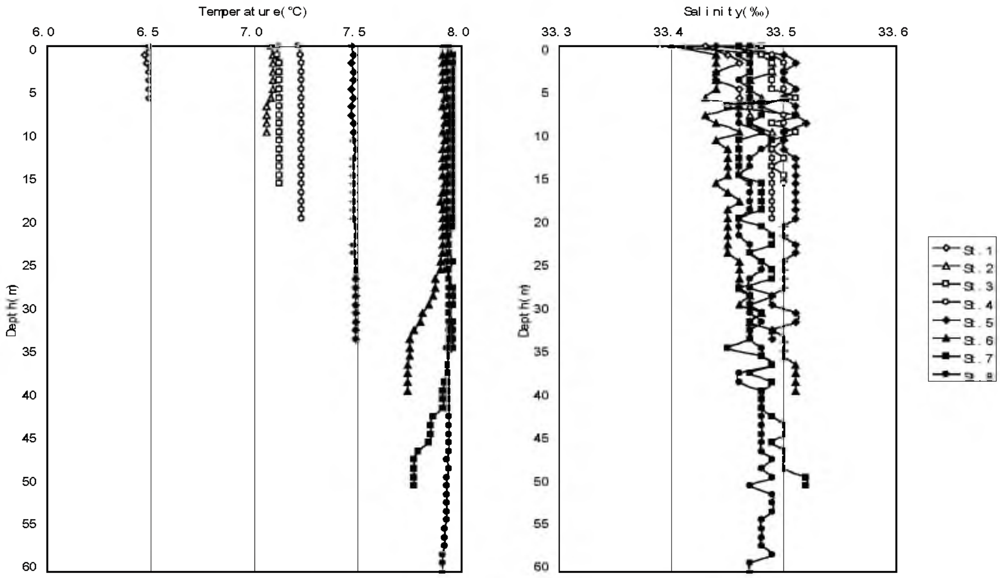

Fig. 5. *Examples of temperature (left) and salinity (right) profiles in the period when the temperature increases as the observation point moves offshore. The profiles are given from the STD observation conducted on December 1, 2007*

One of the examples of the vertical profiles of temperature and salinity at the time that the temperature decreases from inshore to offshore is shown in **fig. 6** from the STD observation conducted on May 28, 2007. In this season, seasonal thermocline is seen near sea surface due to atmospheric heating through sea surface or due to discharge of warm inflow of land water. The profiles in fig. 6 show considerable vertical temperature gradient in the surface layer shallower than about 10m depth. So the measured bottom temperature at St. 1 or at St. 2 may be influenced by the existence of the surface thermocline. However, the temperature and salinity profiles below the thermocline are almost vertical and have almost no vertical stratification. Thus, the phenomenon that temperature decreases from inshore to offshore is caused by horizontal temperature structure, again. The thickness of the thermocline is changeable month by month, but the temperature and salinity structures below show almost the same characteristics, if the STD observations were conducted in the period when the bottom temperature decreases as the observation position moves offshore.

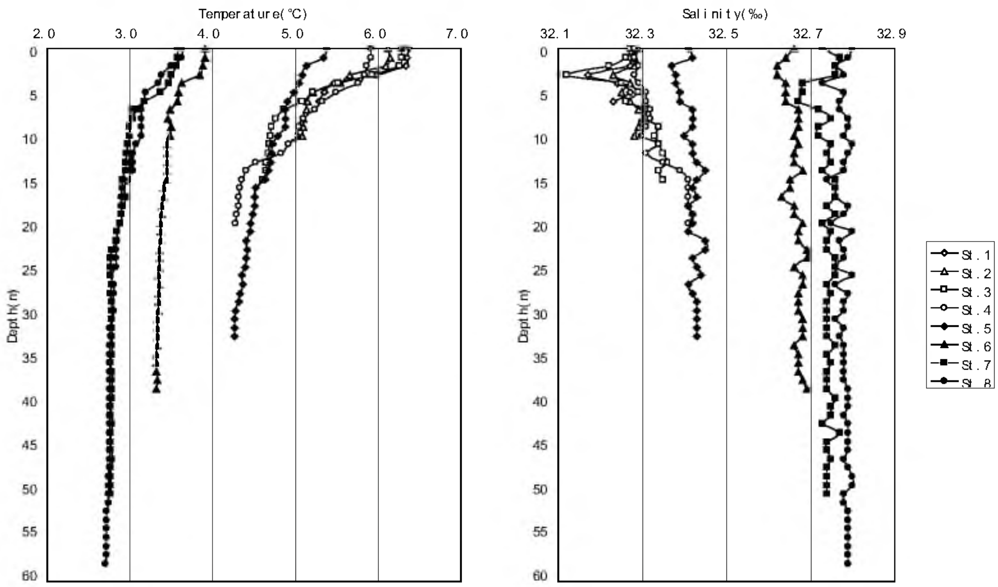

Fig. 6. *Examples of temperature (left) and salinity (right) profiles in the period when the temperature decreases as the observation point moves offshore. The profiles are given from the STD observation conducted on May 28, 2007.*

4. CHARACTERISTICS OF THE OCEANIC CHARACTERISTICS IN THE TEST FISHING AREA AND THEIR RELATION TO THE EAST HOKKAIDO COASTAL CURRENT

The East Hokkaido Coastal Current off the area under consideration flows southwestward along the east coast of Hokkaido. The water of the current is cold and less saline in the first half of the year and warm and saline in the second half of the year. So the former is called as the Coastal Oyashio, and the later is called as the East Hokkaido Warm Current (see the article “Seasonal variations of the East Hokkaido Coastal Current” in this report). In order to discuss about the relation between the oceanic status off Sannrihama Beach and the East Hokkaido Coastal Current, we would need to make further more investigation. However, the water depth of St. 8 is 60m, and the best reference level of the East Hokkaido Coastal Current is 50m depth. We may assume the oceanic state off Sanrihama Beach is related somewhat to the offshore East Hokkaido Coastal Current.

For example, the temperature increases horizontally shoreward in the East Hokkaido Warm Current. This may correspond that the temperature horizontally increases shoreward in the sea off Sanrihama in the period from May to October. The phase of the occurrence period appears to advance for the sea off Sanrihama than the East Hokkaido Warm Current: The former starts to appear in May, but the later start in August and is strongest in October. However, as seen in fig. 4, the ending time of the phenomenon shows some phase lag: it is terminated in the depth shallower than 30m in July (St. 5), but it can be seen until end of October for the depth range from 50m to 60m (St. 7 and St. 8). This might be understood that the East Hokkaido Warm Current extends just near to the coast.

Also, in the case of the Coastal Oyashio, the temperature decreases shoreward in the region of the Coastal Oyashio, and it decreases shoreward also in the sea off Sanrihama beach in the winter time. Phase lag of a few months between two phenomena. The phenomenon starts in November in the sea off the Sanrihama beach, but it starts from February (presumably from January) in the Coastal Oyashio. The coastal Oyashio appears to be strong in January and in February. If these two phenomena are related, the Coastal Oyashio would extend also very near to the coast. The phase lag suggests that the East Hokkaido Coastal Current (the Coastal Oyashio and the East Hokkaido Current) get its structure firstly near the coast and then it develops and increases its width toward offshore gradually.

The further investigation would be needed to get concrete results. If the horizontal contrast inside of the East Hokkaido Coastal Current is seen up to the coast, such a water mass cannot be brought directly from the Okhotsk Sea. This may give a support to the conclusion derived by Ikeda from the DNA analysis that the group of the Hanasaki crab to the east of Shiretoko Peninsula has different genetic nature to those of the group to the east of Shiretoko Peninsula.

5. MELTED WATER OF SEA ICE ORIGINATED FROM THE OKHOTSK SEA

We observed peculiar temperature and salinity profiles on April 3, 2008. The profiles are shown in **fig. 7.** Huge amount of sea ice was carried from the Okhotsk Sea through the Nemuro Strait in March, 2008, and it covered and piled up on the coast near Kushiro City. Due to the attack of the sea ice, 4 bottom temperature measuring systems at St. 5 through at St. 8 were lost on March 3. The systems were recovered on April 3.

It should be noted that both of the temperature and salinity profiles in fig. 7 have step-like structure near at the depth of 32m or so (step-like structure appears most clearly at St. 7). The thick homogeneous temperature and salinity layer is seen above this step-like structure, except in near surface layer. The salinity value in the homogeneous layer is smaller by 0.3 than that in the layer just below. This would be understood that the water in the homogenous layer would be the melted water of sea ice which was carried out from the Okhotsk Sea. No homogeneous layer was observed at the time of the STD observation on April 30.

Temperatures at St. 5, St. 6, and St. 7 are almost the same, and no horizontal temperature gradient can be seen in the homogeneous layer. The temperature of the homogeneous layer at St. 8 is a little colder than those at these stations. It should be noted that no tendency of temperature decrease from offshore to inshore is seen in the homogeneous layer. The temperature of the homogeneous water is warmer by 0.4°C than the water below the step. This would indicate that the temperature of the melted water cannot create the very cold water of the Coastal Oyashio, the temperature of which sometimes reaches near to –2.0°C.

The influence of the melted water of sea ice would be seen in the records of the bottom temperature. However, we could not identify it because of the short period noise of temperature record in the present stage.

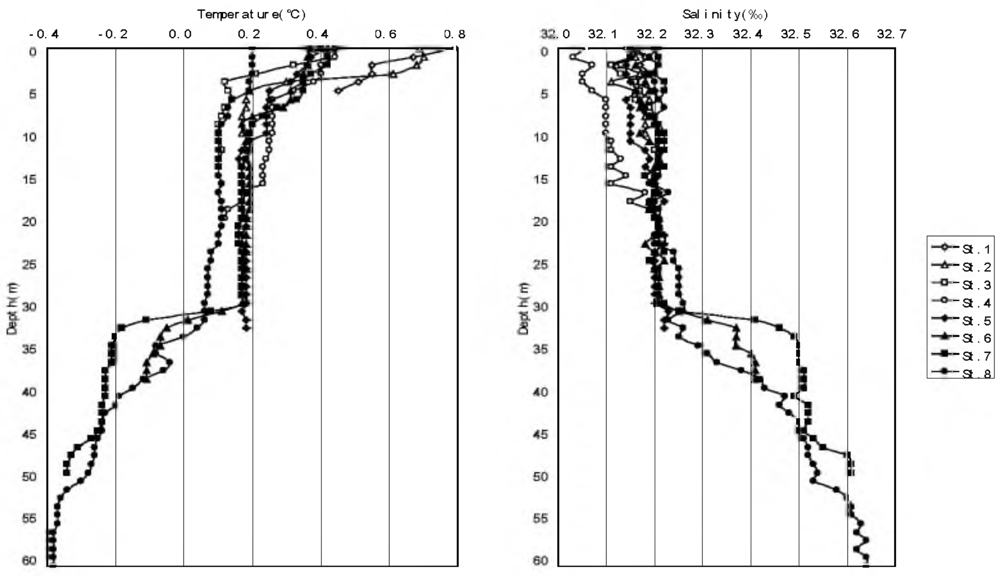

Fig. 7. *The temperature and salinity profiles observed on April 3, 2008*

6. CONCLUDING REMARKS

The original purpose of this investigation was to know the seasonal variations of the environmental temperature of Hanasaki crab in the Nemuro area. The basic variation nature of the seasonal variations can be clarified from the observations in past three years. We believe that our results would serve for the studies on ecology and behavior of Hanasaki crab. In addition, the knowledge on the peculiar and unique nature of the temperature structure and its seasonal variation would be giving a good reference for the studies of the East Hokkaido Coastal Current. Also, our results appear to support the results given by Ikeda that the group of the Hanasaki crab in the southern Kuril Islands and in the sea near Nemuro is separated from the group in Sakhalin area and in the sea to the west of Shiretoko Peninsula as they have different genetic property each other.

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