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Oceanic structure in the vicinity of a seamount, the Komahashi Daisan Kaizan, south of Japan

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Abstract : The hydrographic observations in the vicinity of a seamount, the Komahashi Daisan Kaizan at west of Izu Ridge south of Japan have been carried out in July 1989. It is shown that there exist horizontal gradients of isotherms and isohalines in a layer deeper than the top of the seamount, which is similar to the structures at Daini Kinan Kaizan, Komahashi Daini Kaizan and Tosa–Bae, south of Japan. Various microstructures of the salinity fields are observed over the top of the seamount, which suggests occurrence of interleaving of different waters. Thickness of salinity minimum water less than 34.2 psu is relatively thin over the top of the seamount in comparison with that in the area far from the top of the seamount, suggested that the thin salinity minumum layer is formed by larger vertical mixing over the top of the seamount and/or by the topographic effect of the seamount which forces less saline water to flow along the isopleth of depth of the seamount. T–S relations of the intermediate water in the vicinity of the Komahashi Daisan Kaizan is close to those at south of the Izu Ridge rather than to those at west of the Izu Ridge. It is indicated that the less saline water over the vicinity of the Komahashi Daisan Kaizan comes from south of the Izu Ridge, flowing along the bottom contour of the Izu Ridge.

1. Introduction

Influence of the topographic effect of seamounts on the temperature, salinity and velocity fields has been studied from various view points. On the basis of the geophysical fluid dynamics, topographic effects of seamounts depend on the vertical structure of the Taylor Column formed on the seamounts (*e.g.*, PEDLOSKY, 1979 ; GILL, 1982), which have been investigated from observational and theoretical view points (HOGG, 1973, 1980 ; JOHNSON, 1977).

Various observations have been carried out in vicinity of some seamounts south of Japan. FUKASAWA and NAGATA (1978 ; 1980) observed the oceanic structure near the Shoal Kokushousone located in southwest of Kyushu. Upwelling along the northern slope of the shoal was shown by the temperature observation in February and October 1975 and December 1976 (FUKASAWA and NAGATA, 1978), while upwelling along southern slope was detected in June 1977 (FUKASAWA and NAGATA. 1980). KONAGA *et al.* (1980) observed that the detached cold eddy from the large meander of the Kuroshio, "Harukaze" (KONAGA and NISHIYAMA, 1978), thends to stay over the Daini Kinan Kazan (Fig. 1). SEKINE and HAYASHI (1993) observed a horizontally coherent microstructure over this seamount. YOSHIOKA *et al.* (1986) observed oceanic condition over the Tosa-Bae and showed that the temperature field in the layer shallower than 300 m has a frontal structure, whereas a cold dome-like structure is observed below 300 m. SEKINE and MATSUDA (1987) and SEKINE *et al.* (1994) observed a coupled warm and cold waters in the upper layer shallower than 500m. Furthermore, SEKINE *et al.* (1997) observed hydrographic conditions around Komahashi Daini Kaizan located in the Kyushu–Parau Ridge southeast of Kyushu (Fig. 1).

The present study is directed toward oceanic

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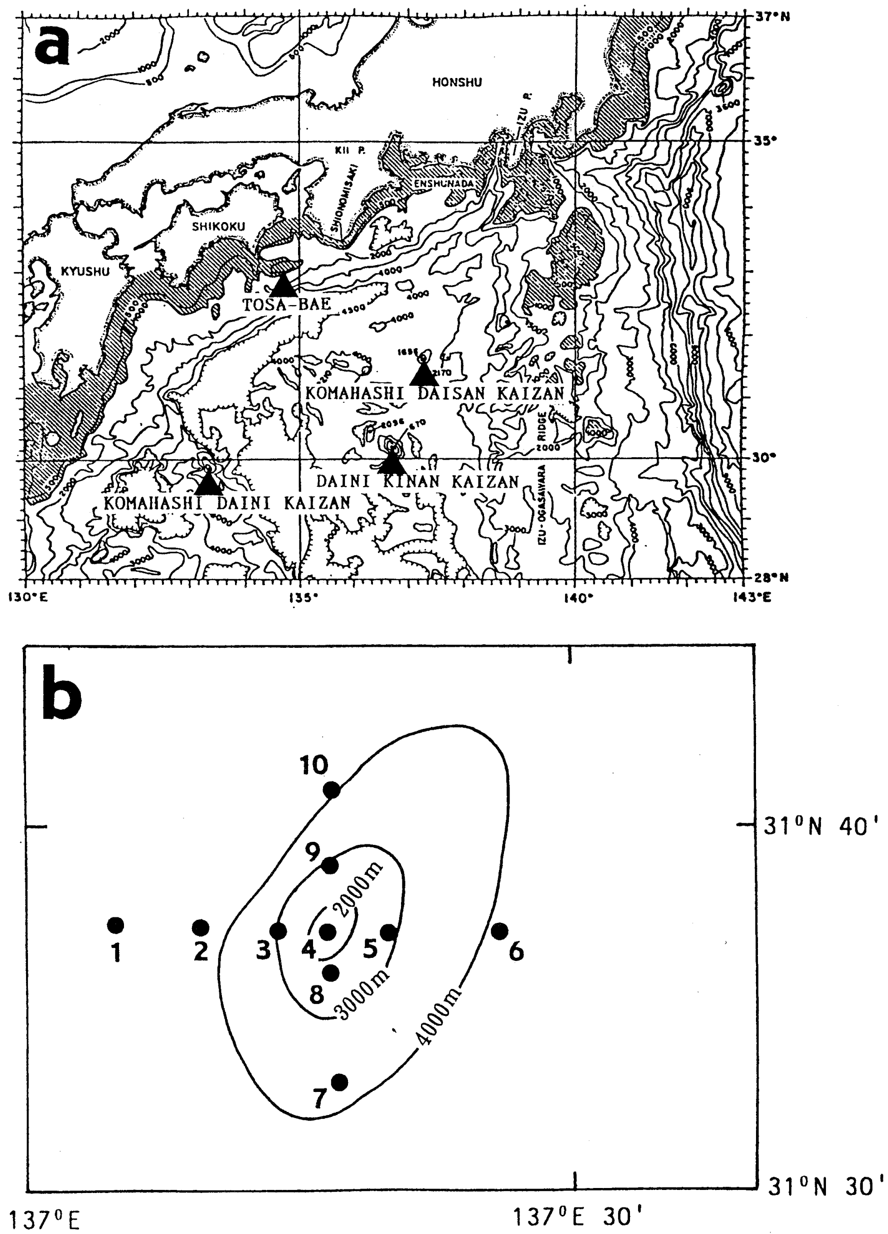

Fig. 1. (a) Isopleth of depth south of Japan (after TAFT, 1972) and locations of main seamounts so far observed. (b) Observational points of CTD of the present study in the vicinity of Komahashi Daisan Kaizan. Isoplethes of depth are also shown.

conditions in the vicinity of the Komahashi Daisan Kaizan located at a west of the Izu Ridge in the Shikoku Basin south of Japan (Fig. 1). The top of the seamount has a depth of 1696 m. Since main axis of the Kuroshio passes over or near this seamount in period of large meander path, there is a possibility that this seamount has influence on the Kuroshio flow.

Salinity minimum layer is observed in the Kuroshio region south of Japan (*e.g.*, SEKINE *et al.*, 1991). This less saline water in the salinity minimum layer corresponds to North Pacific Intermediate Water (*e.g.*, REID, 1965 ; TALLEY and NAGATA, 1991). If a topographic effect of this seamount is not negligible, the less saline water flowing over the vicinity of the seamount is forced to flow along isopleths of the seamount.

However, up to this time, no confined observations has been carried out focusing on the topographic effects of the Komahashi Daisan Kaizan. Then, we have observed temperature and salinity fields in the vicinity of this seamount in July 1989. Results of this observation are presented in this paper. In the following, details of the observation will be mentioned in the next section. Results of the observation will be described in section 3. Summary of the main results and discussion will be made in section 4.

2. Observations

The hydrographic observations by CTD were carried out on 25 and 26 in July 1989 by use of the Training Vessel Seisui-maru of Faculty of Bioresources of Mie University. The locations of the observational points are shown in Fig. 1b. Unfortunately, because of the trouble in the output system of CTD occurred at the station 2, the exact memory has not stored. However, as their record memory was printed out during the observation, their gross features were used in the data analysis.

The main axis of the Kuroshio during the later half of July 1989 presented by Maritime Safety Agency is shown in Fig 2. No meander path was formed and the distance between this seamount and main axis of the Kuroshio was relatively large. Therefore, topographic effect of this seamount on the Kuroshio flow is suggested to be relatively small in comparison with a period of large meander path in which main axis of the Kuroshio flows over this seamount. Thus, our focus is mainly placed on the influence on the less saline water in the salinity minimum layer, which corresponds to North Pacific Intermediate Water.

3. Results

The vertical distributions of temperature and salinity along two observational lines are shown in Fig. 3. Seasonal thermocline and halocline are formed in a surface layer shallower than 50 db. A thich subtropical mode water (MASUZAWA, 1969 ; 1972) with temperature of 18° C and salinity of 34.8 psu is detected in depths of 50 db–500 db. Along the meridional obsverational line, weak uplift of the isotherms are detected over the seamount in depths of 1200 db–1500 db. Since clear vertically coherent and/or vertically evanescent structures of the isotherms and isohalines are not seen in these variations, these vertical shifts are probably due to internal waves.

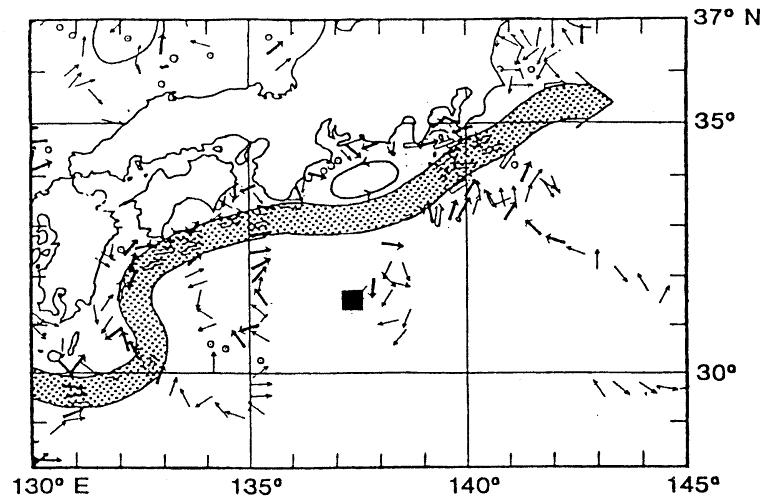

Fig. 2. Main Path of the Kuroshio (stippled region) in later half of July 1989 (after, Prompt Report of Oceanic Condition compiled by Maritime Safety Agency, 19899. Closed square shows the location of Komahashi Daisan Kaizan.

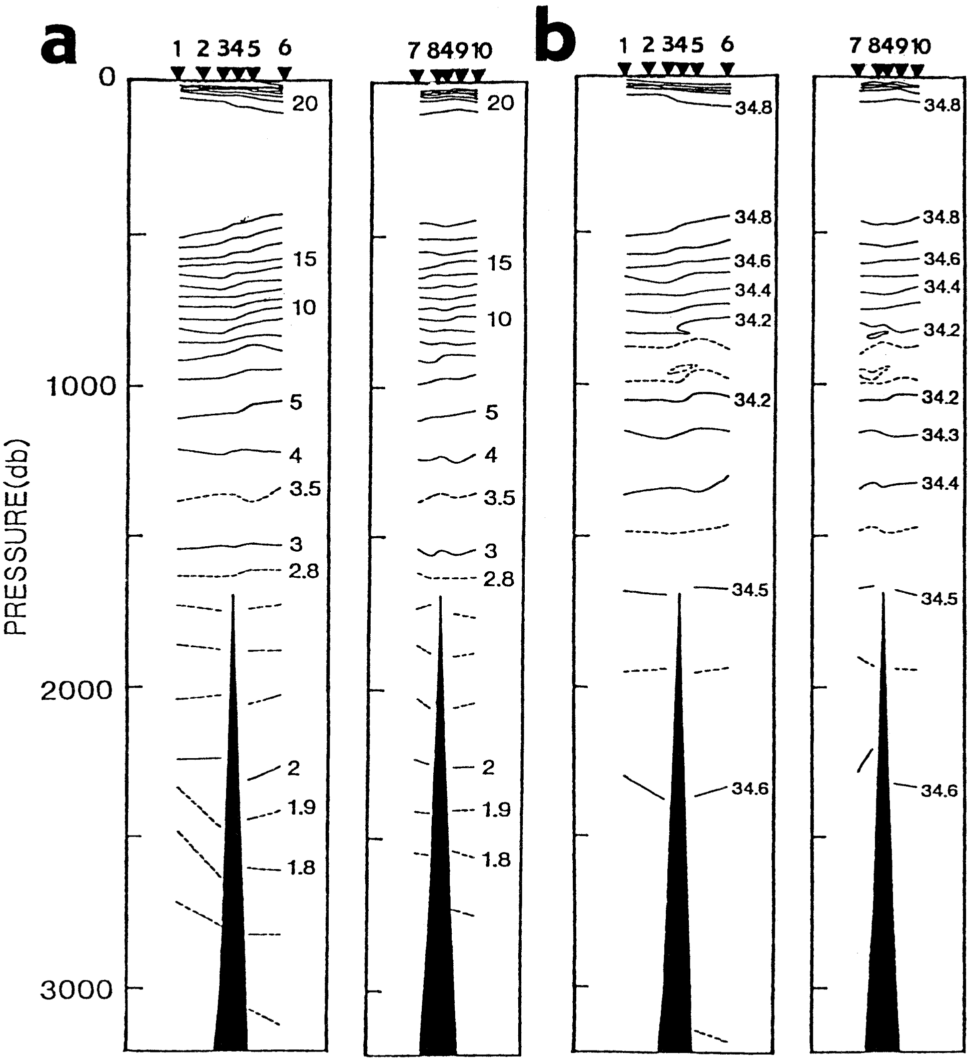

Fig. 3. (a) Temperature (in degree) and (b) salinity (in psu) sections along two observational lines. Locations of the observational stations are shown on the top.

Vertical shifts of the isotherms and isohalines are detected in the layers deeper than the top of the seamount, which are similar to the cases of Daini Kinan Kaizan (SEKINE and HAYASHI, 1993) and Tosa-Bae off Shikoku (YOSHIOKA *et al.*, 1986 ; Sekine and Matsuda, 1987 ; SEKINE *et al.*, 1994) and Komahashi Daini Kaizan (SEKINE *et al*, 1997). It is seen from Fig. 3 that downward shifts of the isotherms and isohalines are dominated at depths of 2400 db–2800 db in west of the seamount. Namely, warm and less saline water exists over the side slope of this seamount. However, weak upward shift of isotherms and isohalines are detected in the layer deeper than 3000 db, details of the water distribution are unclear.

The salinity minimum layer was observed at the depths of 800 db–1000 db. Isohalines in the salinity minimum layer are perturbed over the top of the seamount. To see this more clearly, vertical distribution of salinity in the salinity minimum layer is shown in Fig. 4. Thickness of

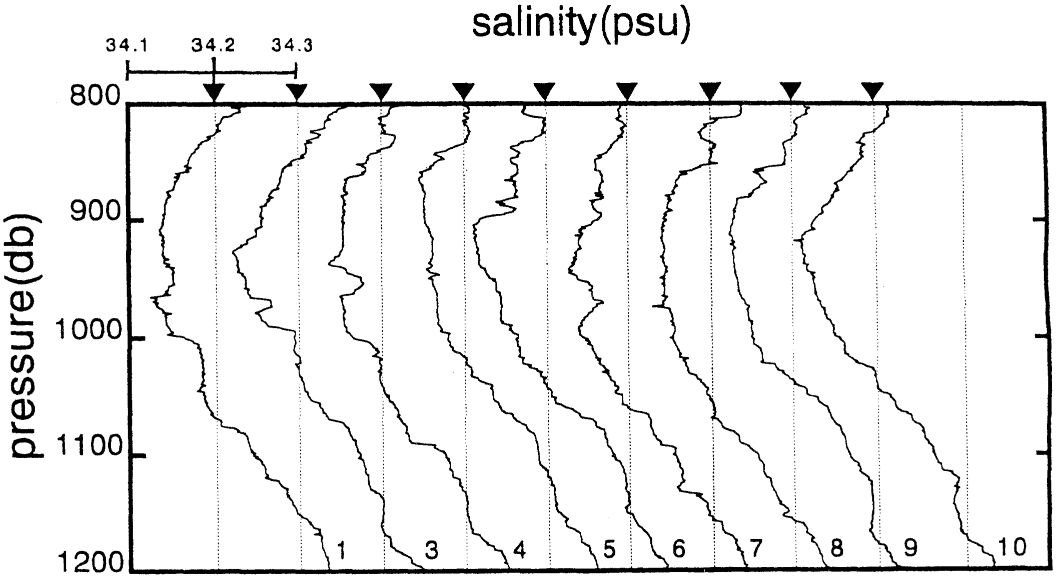

Fig. 4. Vertical distribution of salinity around the salinity minimum layer.

less saline water than 34.2 psu is relatively thin at stations 3, 4 and 5, while the thickness of the less saline water is thick at stations 1, 6 and 7. The former stations 3, 4 and 5 are located near the top of the sea mount (Fig. 1) and the latter stations 1, 6 and 7 exist relatively far from the top of the seamount. It is suggested that the thin layer of less saline water over the top of the seamount is formed by larger vertical mixing and/or by the topographic effect of the seamout which forces less saline water to flow along isopleth of depth of the seamount.

Various kinds of microstructures are seen in Fig. 4. Thin saline water intrusions at depths of 970–990 db at station 3 and 940–960 db at station 4 are detected, while a thick and complicated saline water intrusion at depths of 810–900 db is seen at stations 6 and 7. Although the details of the formation process of the microstructures of the salinity distribution are not well analyzed, occurrences of the horizontal and/or oblique interleaving of different water are suggested.

T–S diagram near the salinity minimum layer is shown in Fig. 5. Here, two envelopes are also plotted to see the pathorigin of water. One envelope in relatively saline area corresponds to the T–S relations at observational stations in west of the Izu Ridge (Fig. 6) observed in summer of 1993 and 1994 (SEKINE *et al.*, MS). The other envelope in less saline water corresponds to the T-S relations at south of the Izu Ridge observed in October 1985 (SEKINE *et al.*, 1991). Because the less saline envelope corresponds to North Pacific Intermediate Water (*e.g.*, REID, 1965; TALLEY and NAGATA, 1991), the less saline water is originated from the subarctic circulation in North Pacific locating northeast of the Izu Ridge. It is shown from Fig. 5 that the T–S relations in the salinity minimum layer is relatively close to the envelope of less saline water observed at south of the Izu Ridge (Fig. 6). It is suggested from the T–S relations that a salinity minimum water over the vicinity of the Komahashi Daisan Kaizan includes relatively large volume of a less saline water which comes from south of the Izu Ridge.

4. Summary and discussion

The hydrographic observations in the vicinity of the Komahashi Daisan Kaizan south of Japan were made by the Training Vessel Seisui maru of Mie University in July 1989. Main results of the observations are summarized as follows.

(1) Vertical shifts of the isotherms and

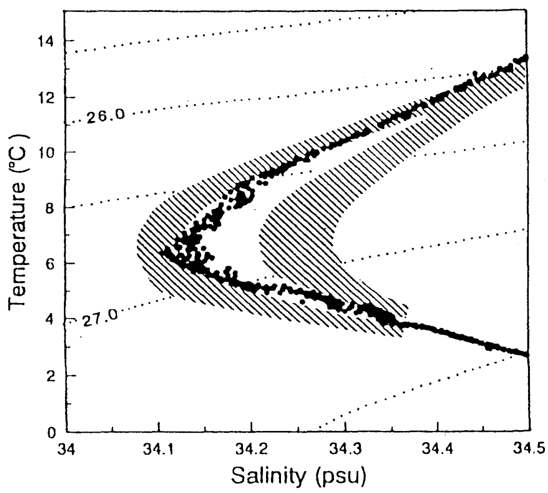

Fig. 5. T–S diagrams near the salinity minimum layer. Left (right) oblique lines shows the envelope of T–S diagram of water at stations in south (west) of the Izu Ridge shown by closed squares (closed circles) in Fig. 6.

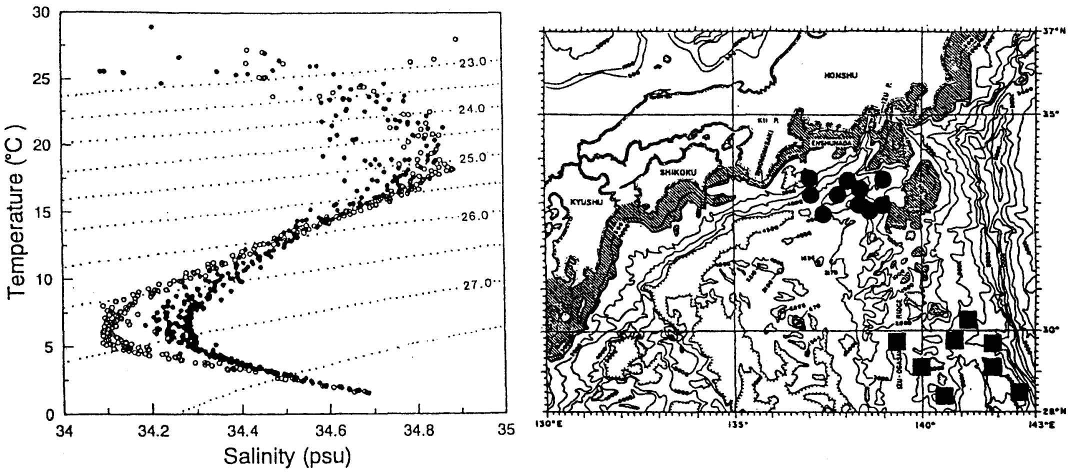

Fig. 6. T–S diagram of the Kuroshio water at west of the Izu Ridge (closed circles) and at south of the Izu Ridge (open circles). The observational stations of the west and south of the Izu Ridge are shown by closed circles and closed squares, respectively in the right.

isohalines are observed in the layers deeper than the top of the seamount, which is similar to cases of other seamounts in the Shikoku Basin shown in Fig. 1. Various kinds of microstructures of the salinity distribution are observed in the salinity minimum layer, which suggests occurrence of the horizontal and/or oblique interleaving of two waters with different salinity.

(2) The salinity minimum layer was observed at the depths of 800–1000 db. Thickness of salinity minimum water less than 34.2 psu is relatively thin over the top of the seamount, which is suggested to be formed by larger vertical mixing and/or by the topographic effect of the seamout, which forced less saline water to flow along isopleth of depth of the seamount.

(3) The T–S relations in the vicinity of the Komahashi Daisan Kaizan are relatively close to those at south of the Izu Ridge rather than those at west of the Izu Ridge. From this, it is

indicated that a less saline water over the vicinity of the Komahashi Daisan Kaizan comes from south of the Izu Ridge.

It is noted from Figs. 5 and 6 that a less saline water over the vicinity of the Komahashi Daisan Kaizan dominantly includes a water which comes from the south of the Izu Ridge. Because the less saline water at south of the Izu Ridge comes from the subarctic circulation in North Pacific, it is suggest that the less saline water comes to the Shikoku Basin after going around the bottom topography of the Izu Ridge. YANG *et al*., (1993a, b) showed that a less saline Oyashio Water goes over the ridge into Sagami Bay in the northern area of the Izu Ridge. However, since less saline water is not observed in west of the Izu Ridge, which is shown by saline envelope shown in Fig. 6, there is a possibility that almost less saline water in the Shikoku Basin comes from south of the Izu Ridge going around south of the Izu Ridge.

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