PL44B-1880 : Deep Current Structure at the Main Gap of the Emperor Seamount Chain

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1. Introduction

In the North Pacific, **Emperor Seamount Chain** (ESC) extends with about 3000-km length in the north-south direction nearly along 170E between Aleutian Trench and Hawaiian Ridge. ESC plays a role of barrier for the deep ocean circulation between the west and east basins of the North Pacific (**Fig. 1**). Besides Aleutian Trench, only several gaps in ESC should be pathways for the deep water between the west and east. The widest, deepest gap called "**Main Gap**" has been thought as the most important pathway, where a fragment of the deep ocean circulation from the south passes to the eastern basin (**Fig. 2**).

However, observations done around Main Gap are very few and fragmentary:

- Hamann and Taft (1987) found a rather strong northeastward flow at the northeast flank of a tall guyot (Ojin Guyot) at the south of the gap by their mooring observation (**Fig. 3**).
- Komaki and Kawabe (2009) found an eastward velocity component near bottom at the center of the gap with LADCP observation (**Fig. 4**).

The former result should be affected by steep bottom topography, and the latter result is just a snapshot. We obtained great opportunity to extensively observe deep currents around Main Gap from 2016 to 2017.

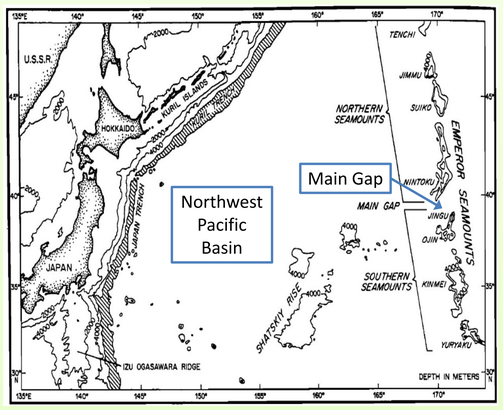

Fig. 1. Location of Emperor Seamount Chain (some topographic names were added to Roden and Taft, 1985)

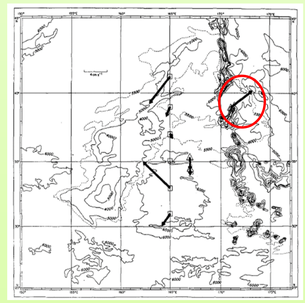

Fig. 3. Mean currents between Shatsky Rise and ESC (Schmitz, 1987). Northeastward current at the southern slope of Main Gap (shown in red circle) was observed by Hamann and Taft (1987).

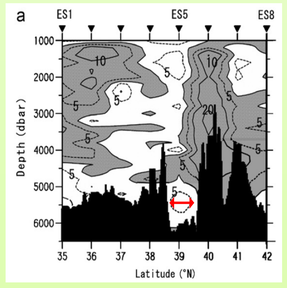

Fig. 4. Eastward velocity component (cm/s) section at 170E including Main Gap (shown by red arrow) by LADCP observation in R/V Hakuho Maru KH-03-1 Cruise (Komaki and Kawabe, 2009)

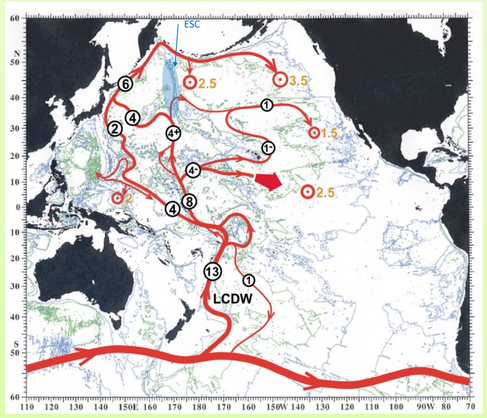

Fig. 2. The deep ocean circulation in the Pacific (Kawabe and Fujio, 2010). Numbers on the routes mean volume transports.

2. Observation and methods

R/V Hakuho Maru KH-16-3 Cruise was carried out in June 2016. The vessel departed from Tokyo on 31 May, arrived at ESC area on 9 June, left it on 13 June, and then returned to Tokyo on 29 June. Cruise track with observation points is shown in **Figure 4**.

We carried out the following observations in Main Gap shown in **Figure 5**.

- Five full-depth casts of CTD/LADCP, C014 – C018
- Deployment of two mooring systems, ME1 and ME2 (**Fig. 6**)

We succeeded in recovering ME1 in University Hokkaido's *T/V Oshoro Maru* C40 Cruise Leg 2, which was carried out from Tokyo to Dutch Harbor, Alaska, in June 2017. Unfortunately, our effort to recover ME2 in the cruise resulted in failure. Furthermore, we failed in accessing records in two upper instruments (FSI 3D-ACM) at ME1.

We used current profiles from LADCP within the range where bottom tracking was available (about 100-m above the bottom).

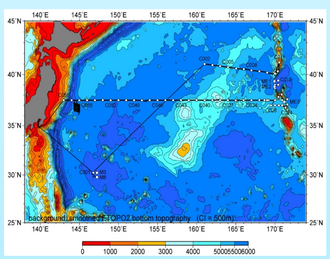

Fig. 4. Observation points and cruise track of KH-16-3 Cruise by R/V Hakuho Maru.

Photo. R/V Hakuho Maru at Tokyo.

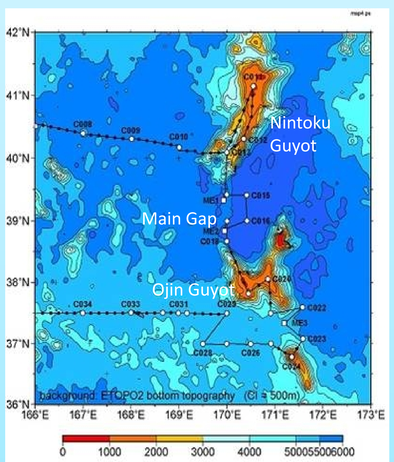

Fig. 5. Hydrographic observation with LADCP operation (C###) and mooring points (ME#) around ESC in KH-16-3 Cruise.

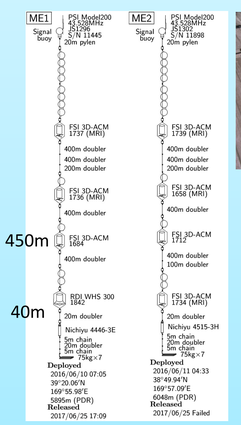

Fig. 6. Mooring systems deployed at Main Gap (ME1 and ME2). "450m" and "40m" are heights from the bottom, where current data were recovered and analyzed in this study.

Photo. Current meters FSI 3D-ACM, major instruments of the mooring systems.

3. Deep current through Main Gap

Current structure snapshot by LADCP

Strong eastward velocities are observed near the bottom at two southern stations (**Fig. 7**); 24.4 cm/s (137 °T) at 6265-m depth at C018, 12.8 cm/s (77 °T) at 5865-m depth at C017. Especially, the near-bottom water at C018 flows along the isobath on the flank of Ojin Guyot. This may be a part of flow surrounding the guyot, which we think was observed as a northeastward flow of 4.7 cm/s (56 °T) at the northeast flank of the same guyot by Hamann and Taft (1987) (**Fig. 3**).

The eastward near-bottom flow at C017 (**Fig. 7**) is consistent with LADCP results at 39N of Komaki and Kawabe (2009) (**Fig. 4**).

Near-bottom currents at C014 and C015 is eastward albeit weak (**Fig. 7**).

Currents observed by Moored Current Meters

Time-series data of current meters at ME1 also has dominant eastward velocity components. Though it has various time-scale variabilities from tides to several-month scales, eastward components occupy 61 to 65 % in hourly velocity data (**Fig. 8**).

Average speeds are very small (**Fig. 7**) as the followings:

- 1.3 cm/s toward 66 °T at 40-m height from the bottom
- 2.4 cm/s toward 60 °T at 450-m height from the bottom

Horizontal distribution of current velocity in Main Gap

Snapshot by LADCP implies that eastward deep flow occurs in the whole of Main Gap with a difference of current speed between the northern and southern parts. That is, the eastward flow is strong in the southern part while it is weak in the northern part. The weak, eastward flow in the northern part is supported by time-series measurements.

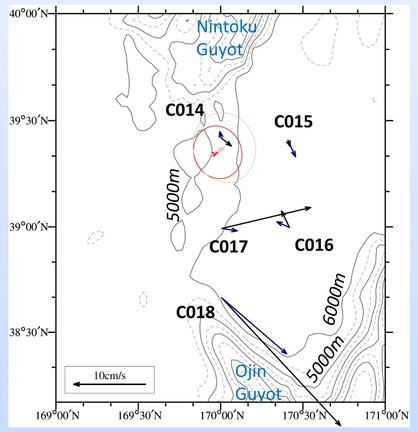

Fig. 7. LADCP bottom-tracked current vectors and Current Meter mean current vector in Main Gap. Black and blue arrows show near-bottom and 15-m height LADCP vectors, and red and pink arrow shows 40-m and 450-m height CM vector, respectively.

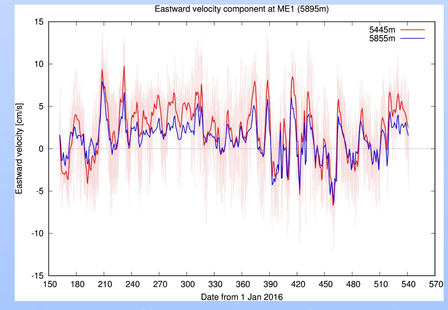

Fig. 8. Time-series of low-passed eastward current velocity at 40-m (blue) and 450-m (red) height from the bottom at ME1. Thin pink line shows hourly data including tides.

4. Where does the deep water come from?

We investigated the distribution of water property widely with using recent hydrographic dataset; P01, P02 and P10 of CLIVAR, the Japan Meteorological Agency's (JMA) *R/V Ryofu Maru* RF1106, RF1107, RF1203 and RF1206, and *R/V Hakuho Maru* KH-16-3.

Deep water in Main Gap has similar temperature to those to the west and east of Main Gap, and is different from the bottom water carried by the deep ocean circulation from the south (**Fig. 9**).

Deep dissolved oxygen in Main Gap is similar to those at 40N and not to those south of 36N where the deep ocean circulation flows (**Fig. 10**).

The deep water flowing eastward through Main Gap would come from the northern area in the basin east of Main Gap (pale blue arrow in **Fig. 9**).

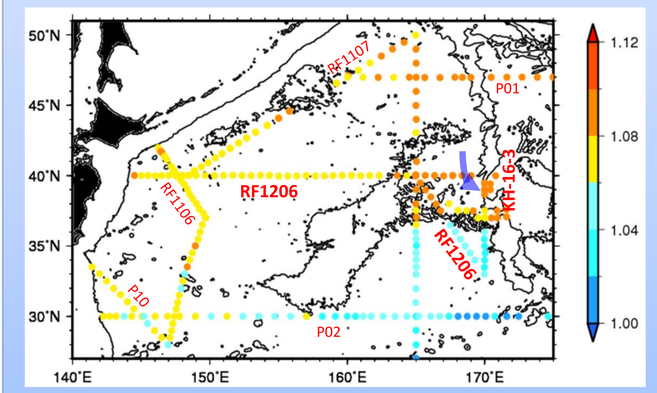

Fig. 9. Potential temperature distribution near the bottom over 5000 dbar.

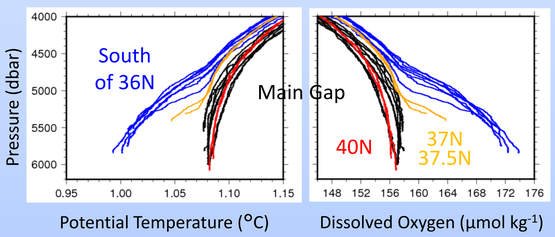

Fig. 10. Vertical profiles of potential temperature (left) and dissolved oxygen (right) obtained in RF1206 and KH-16-3 (see **Fig. 5**). Profiles south of 36N are colored by blue, ones at 37N and 37.5N are colored by yellow, and ones at 40N are colored by red. Profiles colored by black are those obtained at C014 to C018 in Main Gap.

5. Summary

Bottom current speeds observed by LADCP with bottom tracking indicate north-south difference among the gap; currents are very weak but eastward in the northern part while eastward currents are strong enough to exceed 20 cm/s in the southern part.

Weak eastward currents in the northern part are supported also by one-year time-series measurement with moored current meters. We did not detect any return flow of the strong eastward deep current in the southern half of Main Gap. Totally, the deep water is indicated to flows eastward through the Main Gap.

Hydrographic observations suggest that the deep water flowing eastward through the gap is not LCDW itself but the remnant water which LCDW may be modified to while it goes further north and spreads in the Northwest Pacific Basin.