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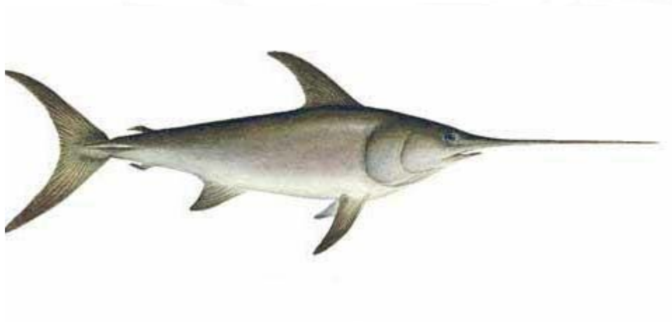
Relationships between the hydrographic structure of the warm core ring and the longline catch of tuna and marlins, inferred from Fall 2009 Shoyo-maru

Kotaro Yokawa
National Research Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan 424-8633

Akiko Takano
National Research Inst. of Far Seas Fisheries
5-7-1 Orido, Shimizu, Shizuoka, Japan 424-8633



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Relationships between the hydrographic structure of the warm core ring and the longline catch of tuna and marlines, inferred from fall 2009 Shoyo-maru

Kotaro Yokawa and Akiko Takano

National Research Institute of Far Seas Fisheries
5-7-1 Orido, Shimizu-ku, Shizuoka 424-8633, JAPAN

Introduction

The trials to introduce oceanographic information into the model to standardize CPUE of tunas and billfishes have been conducted by variety of scientists, but so far there seems no widely agreed method being developed. One the contrary, many Japanese longline fishermen apparently refers the oceanographic information, such as map of surface water temperature and sea surface height to decide their operation point. The distribution pattern of fishing efforts or CPUEs of Japanese longliners also shows strong tendency that they gather to the area having particular oceanographic condition. In the case of fishing ground of Kuroshio frontal area in the northwest Pacific, skippers of longliners pay attention to the Kuroshio extension fronts or the edge of warm-core rings (WCR) that were pinched off from the meanders of Kuroshio extension.

To investigate the relationship between the oceanographic characters of the warm-core rings and the catch of marlins and tunas by longline, one longline research cruise was conducted in September, 2009 in the Kuroshio extension area in the northwest Pacific. This document briefly reports the results of the analysis of data obtained by this cruise.

Method

1) Hydrographic observation

To explore the relationship between the oceanic environmental structure and spatial distribution of tuna and marlines, hydrographic surveys and Longline surveys was conducted, focusing on the species composition in warm-core rings in the Kuroshio Extension (KE) region (30° −40° N、160° −180° E) from 25th of August to 21th of September in 2009 (Fig. 1). Satellite altimetry images (Map of Absolute Dynamic Topography; MADT) distributed by AVISO were used to find the locations of warm-core rings (We could only get the image 7 days before). Transect observations of hydrographic variables are planed across a warm-core ring (WCR) to figure out the structure of WCR (Fig.2). The expendable Bathythermograph probes (XBT) and the expendable conductivity - temperature

- depth probes (XCTD) were deployed along the line transects to infer properties of the water mass. The vertical current structure was observed by ship-mounted Acoustic Doppler Current Profiler (ADCP) and the horizontal distribution of geostrophic current were calculated from the MADT. The Echo amplitude of ADCP indicates the deep scattering layer (DSL).

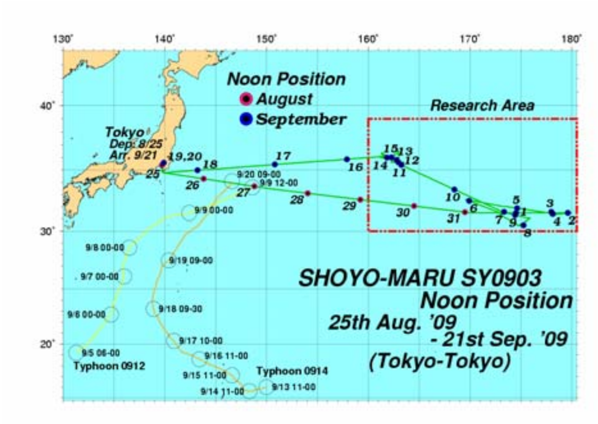

Fig. 1　Map of the ship track and the research area.

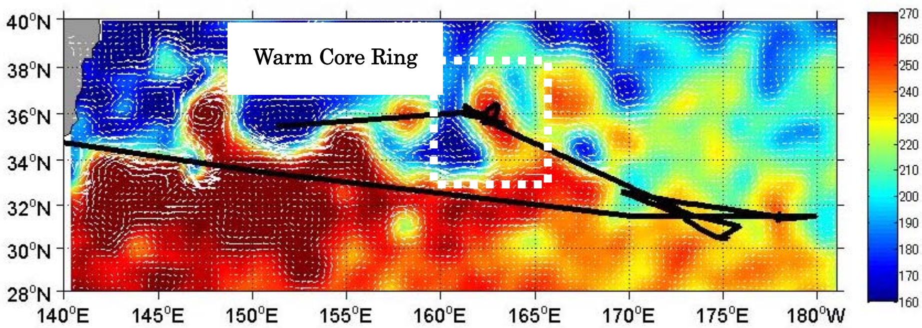

Fig. 2　Map of absolute dynamic topography (MADT) and geostrophic currents. The center of a warm-core ring located at the point (36° N, 163° E). The contour map indicates ADT, the white line indicates geostrophic currents and the black line indicates the ship track.

1) Longline operation

Four longline sets were conducted in the WCR whose oceanographic characters were investigated. The number of hooks deployed in a set was 975, and the number of hooks between float was 15. Length of branch line was 31 m and float line was 20 m. The shortening ratio was fixed at 75 % to attain wider vertical coverage of the gear. The gear setting was started in 8:00 AM and the retrieving was started in 3:00 PM. All fishes caught were brought on board to identify species, measure length to the nearest centimeter, weighted and sexed.

Results and discussion

1) Hydrographic observation

We observed the vertical structure of the WCR. The water properties of the WCR was characterized as high temperature (about 10 – 20 ℃) and high salinity (about 34.6 psu) (Fig. 3). The deep-thermocline located at the bottom of WCR, and the depth of the deep-thermocline at the center of the WCR (Stn. S26) was about 50m deeper than the edge (Stn. S29). The surface mixed layer characterized as high temperature and low salinity water covered over the WCR.

The location of the WCR inferred from MADT corresponds to that of the hydrographic observations. The ADT (230m) indicates the edge of WCR, and the ADT (higher than 250cm) indicates 15℃ isothermal depth is deeper than 300m. These relationships between ADT and WCR structure would be almost the same as the other areas in this WCR.

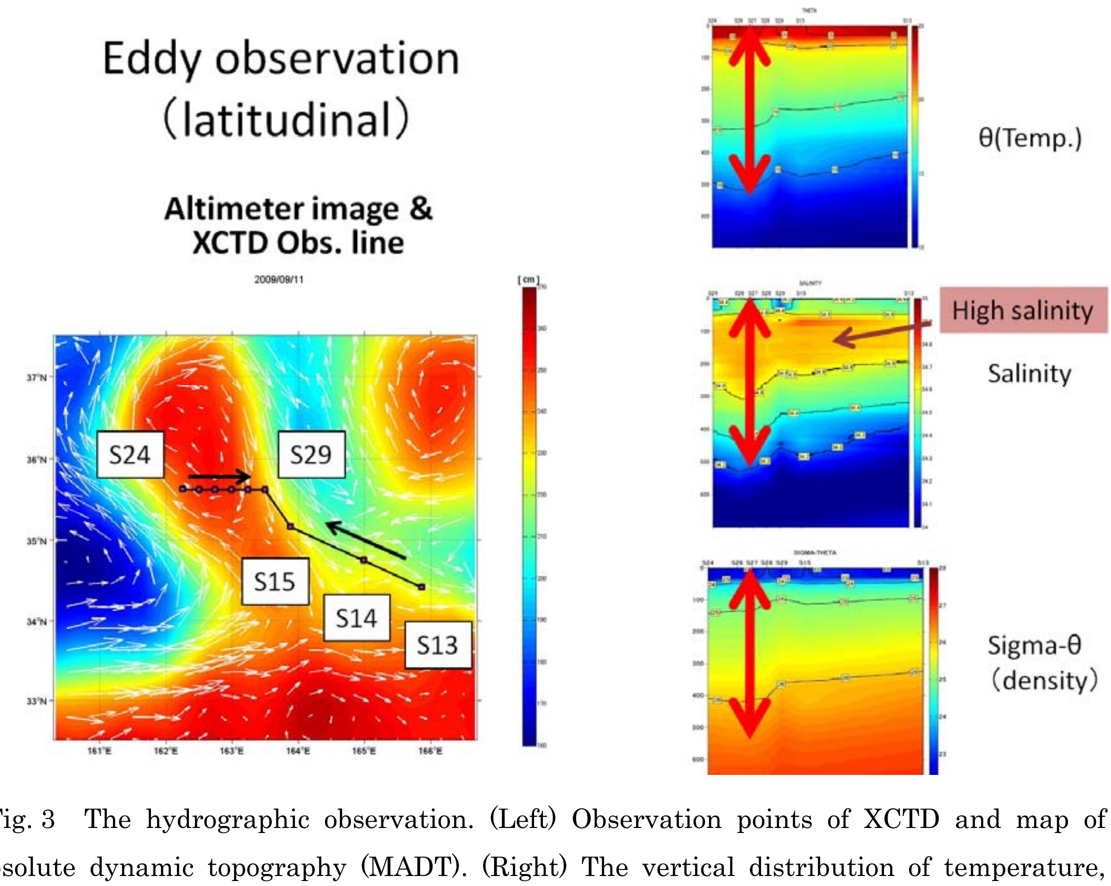

Fig. 3 The hydrographic observation. (Left) Observation points of XCTD and map of absolute dynamic topography (MADT). (Right) The vertical distribution of temperature, salinity and density.

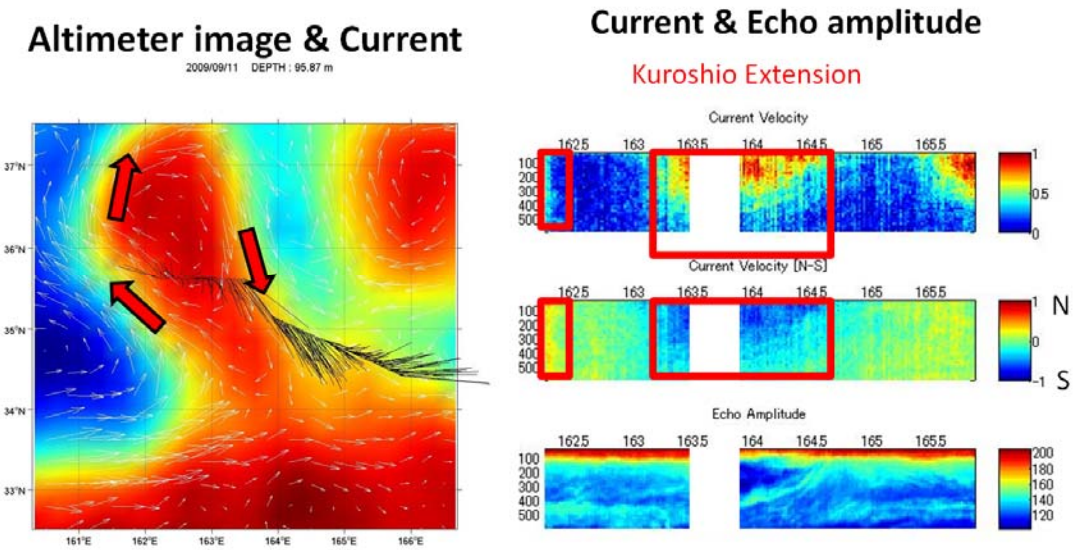

Fig. 4 The distribution of current and echo amplitude. (Left) The black line indicates the horizontal distribution of currents observed by ADCP. The white line indicates geostrophic currents calculated from the absolute dynamic topography. (Right) The vertical distribution of currents velocity, currents velocity in the direction of the north – the south and the echo amplitude describing deep scattering layer (DSL).

Vertical current structure was observed by ADCP. There was strong current at the edge of WCR, and the strong current reached down to about 400m depth (Fig. 4).

Map of geostrophic currents estimated from satellite altimetry is a very useful to decide a direction of setting a longline. As the accuracy of satellite altimetry is uncertain, the estimated geostrophic currents were compared with *in-situ* currents observed by ADCP (Fig. 4). The geostrophic currents correspond to the *in-situ* currents at 100m depths in the edge of the WCR where currents speed was high, however the current at the center of the WCR was not clearly identified. The Map of currents estimated from satellite altimetry is very useful information in the setting of longlines, especially in the edge of WCR.

Dial vertical migration of DSL in the WCR was observed by ADCP (Fig. 4). In the daytime, the depth of the DSL reached to about 300 - 500m depths and there was no DSL in the mid-layer (200 – 300m depth), while the DSL was found in the mid-layer in the nighttime. The depth of DSL inside the WCR was deeper than the outside. This suggests that production of organisms inside the WCR is higher than the outside.

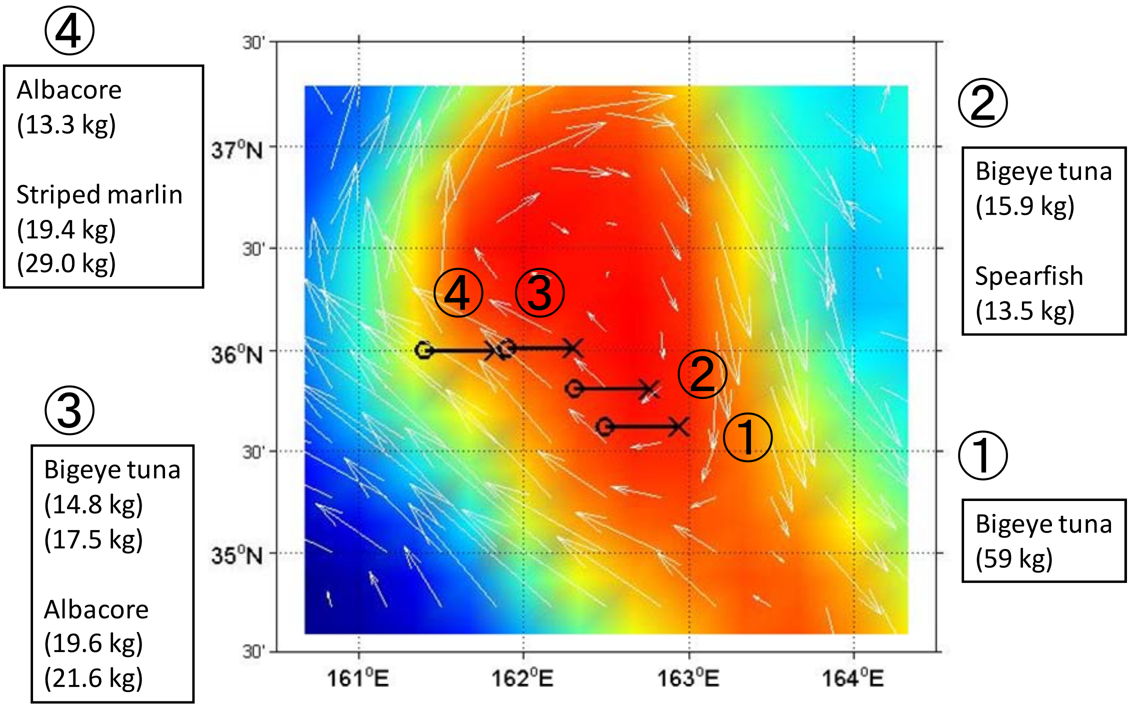

Fig. 5. The positions of the longline sets in the warm-core ring (WCR), and the tuna and billfish catches obtained in each set.

The positions of the four longline sets were decided to cover the radius of WCR from the center to the western edge (Fig. 5). The larger bigeye tuna (59 kg) was caught in the vicinity of the center of the WCR where 15 degree isothermal depth could be about 320m and the current speed was lower, while marlins were caught in the edge of the WCR where strong currents occurred. In the area between the center and the edge of the WCR, albacore, smaller bigeye tuna and spearfish were caught. The result shows that each species could inhabit the different part in the WCR.

Though the numbers of tunas and billfishes caught were not many primary due to the fact that September is still earlier for the main fishing season in the survey area, the order of the tunas and billfishes caught from the center of WCR to the edge is roughly coincide with the order of the depth that these fishes distribute during the day time. Large bigeye tuna is usually caught deeper strata than the small one. Striped marlin stay most of its time at surface, and swimming depth of albacore is usually deeper than the surface mixed layer but it is apparently shallower than bigeye tuna. Within WCR, the warm water originated from Kuroshio attains deepest depth at the vicinity of the center, and it becomes shallower as the position get closer to the edge. So, the result of this research should indicate that the distribution of tunas and marlins within WCR has high relationship with the swimming depth of fish during daytime and the depth of warm water.

In the research cruise we analyzed its data in this study, only four longline sets were conducted, and the number of fishes caught by these sets was limited. Further information should be necessary to confirm the working hypothesis addressed in this study. Additional information such as the stomach contents of fishes as well as distribution pattern of prey organisms within WCR would be helpful for the better understanding of the mechanism of habitat segregation of tunas and billfishes within WCR. The amount of information which we can obtain from the longline research is limited in compare with the one from the fishery. Nevertheless, the result of this study shows that the information we can obtain from the well designed research cruise could give us good insights for the strategy about how to analyze the fishery data with the oceanographic information.