Vertical distribution pattern of striped marlin estimated using pop-up tag data [1]

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1 Introduction

Vertical distribution patterns of billfishes, which are estimated with the data collected by fish tracking study, and pop-up and archival tag study, has been used for standardization of Japanese longline CPUE in the habitat model (Hinton and Nakano, 1996; Yokawa and Takeuchi, 2000, 2001, 2002).

In this study, we analysed archival pop-up tag data collected in the Eastern Pacific Ocean (EPO) by R/V *Shoyo-Maru* (2,494GRT) from September to November 2004 to evaluate the vertical distribution pattern of striped marlin.

2 Materials and Methods

In the period of 18 September to 7 November 2004, 30 longline operations were conducted by the R/V Shoyo-Maru (2,494GRT) in the EPO. Seven Pop-up Archival Transmitting tags (PAT tag, Wildlife Computers) were deployed on striped marlins through the Shoyo-Maru research cruise, and five PAT tags successfully reported data (Table 1). PAT tags were programmed to take and store discrete depth, water temperature, and light intensity every minute. The sensors have rather good resolution (0.5m for depth, 0.05°C for water temperature) and wide ranges (0 to 1000m, -40°C to 60°C for water temperature, and depth down to 300m in clear water conditions for light intensity). The data of depth, water temperature and light intensity (used to estimate geolocation) were aggregated into 12 ranks which decided arbitrary using sea surface temperature and converted into a histogram by every 1, 3, 6 or 24 hours. PAT tags also collect depth-temperature profile that contains the minimum and maximum temperatures recorded at each depth, and 6 further depths and their associated minimum and maximum temperatures that are dynamically chosen to be roughly equally spaced from the shallowest to the deepest depth.

Table 1 shows the summary of fish size, fish weight, tagging and pop-up location. Duration of data collection ranged from 3.0 to 19.5 days.

A titanium dart (70mm long) was connected to the tag by tether made by nylon, to attach the tag on the fish. An auto severing device called RD1800 was fastened on the nylon part of tether, and this device cut the nylon line and release the tag from the fish when it sense a pressure roughly corresponding to the depth of 1,800 m to prevent destruction by the water pressure. Majority part of the tether was covered the urethane pipe to prevent it from injuring the tagged fish. The dart was inserted by using harpoon aiming at the side of the body near the dorsal fin. Condition of hooked blue marlin was checked carefully by researchers, crews and observers to confirm whether it was good for tagging or not. Fish size was estimated by a veteran crew. The tagged fish were released by cutting the fishing line immediately after tag attachment. The tags detached from the fish, floated to the surface, and transmitted the data to the authors through the Argos satellite system.

We classified depth bins into 0 to 10 m, 10 to 25 m, every 25m at the depths from 25 to 200m, and every 50m afterwards, and temperature bins into every 2 ºC at the temperatures from 14 to 26 ºC and every 1 ºC from 26 to 30 ºC.

CTD operations were conducted before or after longline operations. In this study, we referred depth-temperature profiles collected by CTD.

3 Results

Fish A released southwest off Mexico moved to a northwest direction over 30 days (Figure 1). The fish spent 60 % of time at 0-10 m layer and dived mainly between 25 - 75 m (14 - 30< ºC, Figures 2, 3 and 4). With referring to CTD data, this fish dived into the thermocline (down to 80 m, 40 m below the bottom of the mixed layer, Figure 5), down to 13ºC below the bottom of mixed layer temperature.

Fish B moved in a westsouthwest direction over 11 days. This fish spent 68% of time at 0 - 10 m layer and dived mainly between 25 to 75 m. The tag recorded a broader range of temperatures (16 - 30< ºC) as well as Fish A. With referring to CTD data, this fish dived into the thermocline (down to 70m, 20m below the bottom of mixed layer), down to 11ºC below the bottom of mixed layer temperature.

Fish C moved in a south direction over 32 days. Depth distribution of this fish ranged 0 - 80m. Temperature distribution pattern of this fish (mainly in the 25 - 30 ºC layer) was different from fish A and B. With referring to CTD data, the fish spent mainly in the surface mixed layer.

Fish D did not take a long trip for 11 days. This fish spent vast majority (95%) of time at 0 - 10 m (29ºC), especially after four days from release. With referring to CTD data, this fish dived into the thermocline (down to 80 m, 40 m below the bottom of the mixed layer), down to 10 ºC below the bottom of mixed layer temperature.

Fish E was only individual which was able to obtain data released in the far southwest off Mexico. This fish moved in a north direction over 9 days. The fish spent 80 % of time at 0-10 m (26 - 27 ºC) and dived between 25 - 150 m. With referring to CTD data, this fish dived into the thermocline (down to 150 m, 90 m below the bottom of the mixed layer), down to 8ºC below the bottom of mixed layer temperature.

Figure 6 shows frequency histograms for depth layer relative to the sea surface temperature (Δtemp, ºC) calculated using nominal temperature histograms by pop-up tags. A Δtemp ranged 0 to -15 ºC. With exception of Fish C, Δtemp showed bimodal distribution pattern.

4 Discussion

In this study, striped marlin distributed mainly in a mixed layer and also dived down to 20 - 40 m below the bottom of mixed layer, down to 13ºC below the bottom of mixed layer temperature (Table 2).

The frequency of dive to the thermocline approximately ranged between 5 and 20 % except the Fish C. For Fish A, B and D which released almost the same depth-temperature profile showed the same depth distribution pattern (Figure 3). For Fish E released far southwest off Mexico dived deeper than the other fish. These results suggest that depth distribution pattern of striped marlin changes if depth-temperature profile is different.

With exception of Fish C which had no bimodal distribution pattern, all fishes seemed to regulate by the vertical change of water temperature (Figure 6). These results agree with hypnoses of Brill et al (1993).

Brill and Lutcavage (2001) reported that diving behavior of blue and striped marlin relates water temperature relative to the sea surface temperature (< 8 ºC), rather than absolute temperature. Our results suggest that striped marlin in the southwest off Mexico dived slightly deep layer (0 to -15 ºC in Δtemp). This result might caused by the characteristics of depth - temperature profiles in this area, where has high sea surface temperature and the rapid decline of the temperature. It would be better to examine the difference of vertical distribution pattern of marlins among areas where is the typical fishing ground of striped marlin, for the adequate estimation of fish stock.

Yokawa et. al. (2005) reported that vertical distribution pattern of CPUE for striped marlin calculated using time-depth recorders (TDR) had a peak in the -9 to -10 ºC in Δtemp. Our result keeps in accordance with the result of Yokawa and Kanaiwa (2005), because tagged striped marlin had the 2^{nd} peak of the vertical distribution pattern in -6 to -10 ºC in Δtemp. On the other hand, the largest peak of the vertical distribution which recorded in 0 ºC in Δtemp in this study was not seen in the results of Yokawa et. al. (2005). The difference might be occurred by that longline operations had few effects of hooks in the shallow water layer.

Acknowledgements

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References

Brill, R.W., D.B.Holts, R.K.C.Chang, S. Sullivan, H. Dewar & F.G. Carey (1993); Vertical and horizontal movements of striped marlin (*Tetrapturus audax*) near the Hawaiian Islands, determined by ultrasonic telemetry, with simultaneous measurement of oceanic currents. Marine Biology 117, 567-574.

Brill, R.W., and Lutcavage, M.E., 2001. Understanding environmental influences on movements and depth distribution of tunas and billfishes can significantly improve population assessments, American Fishery Society Symposium, vol 25, 179-198.

Hinton, M.G. and H. Nakano. 1996. Standardizing catch and effort statistics using physiological, ecological, or behavioral constrains and environmental data, with an application to blue marlin (*Makaira nigricans*) catch and effort data from Japanese longline fisheries in the Pacific. IATTC Bull., 21(4): 171-200.

Yokawa, K., Y. Takeuchi, M. Okazaki, and Y. Uozumi. 2001. Standardizations of CPUE of blue marlin and white marlin caught by Japanese longliners in the Atlantic Ocean. Col. Vol. Sci. Pap. ICCAT, 53:345-355.

Yokawa, K. ,M. Kanaiwa, Y. Takeuchi and H. Saito. 2005. Vertical distribution pattern of CPUE for striped marlin in the north Pacific estimated by the with data of the time, depth and temperature recorders collected through a longline research cruise of Shoyo-maru in 2004 in the north Pacific, preliminary results. ISC4(x), 13pp.

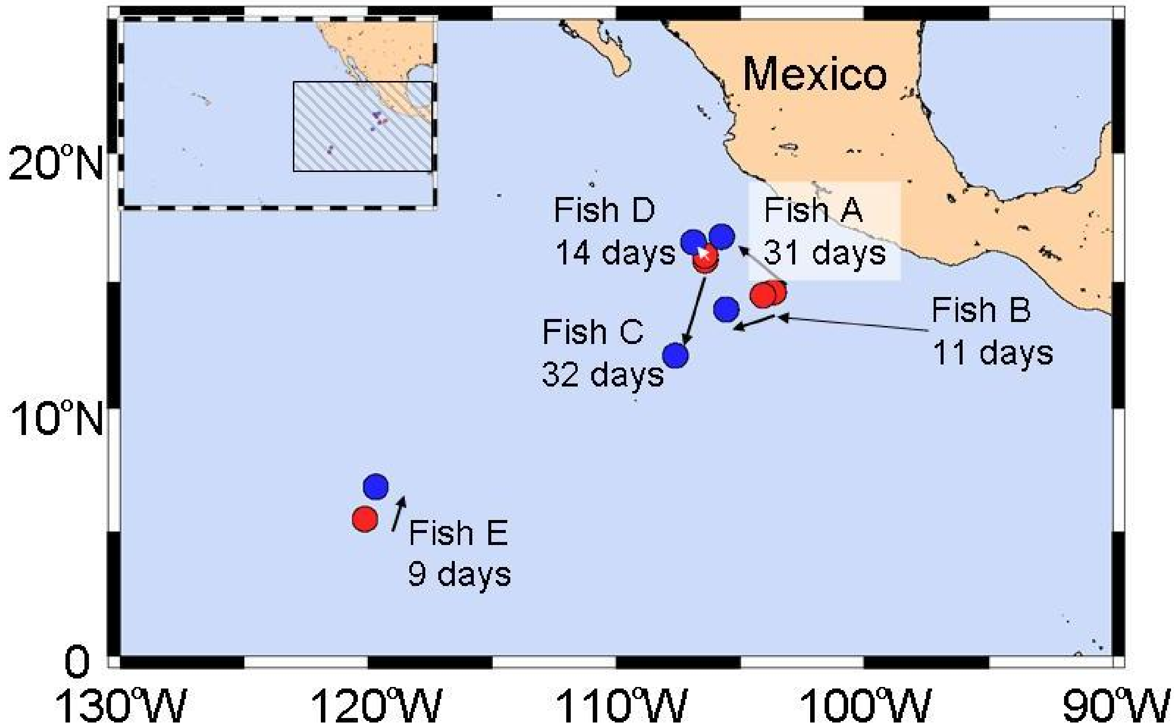

Figure 1. Released and popped up point of pop-up tags attached to striped marlins.

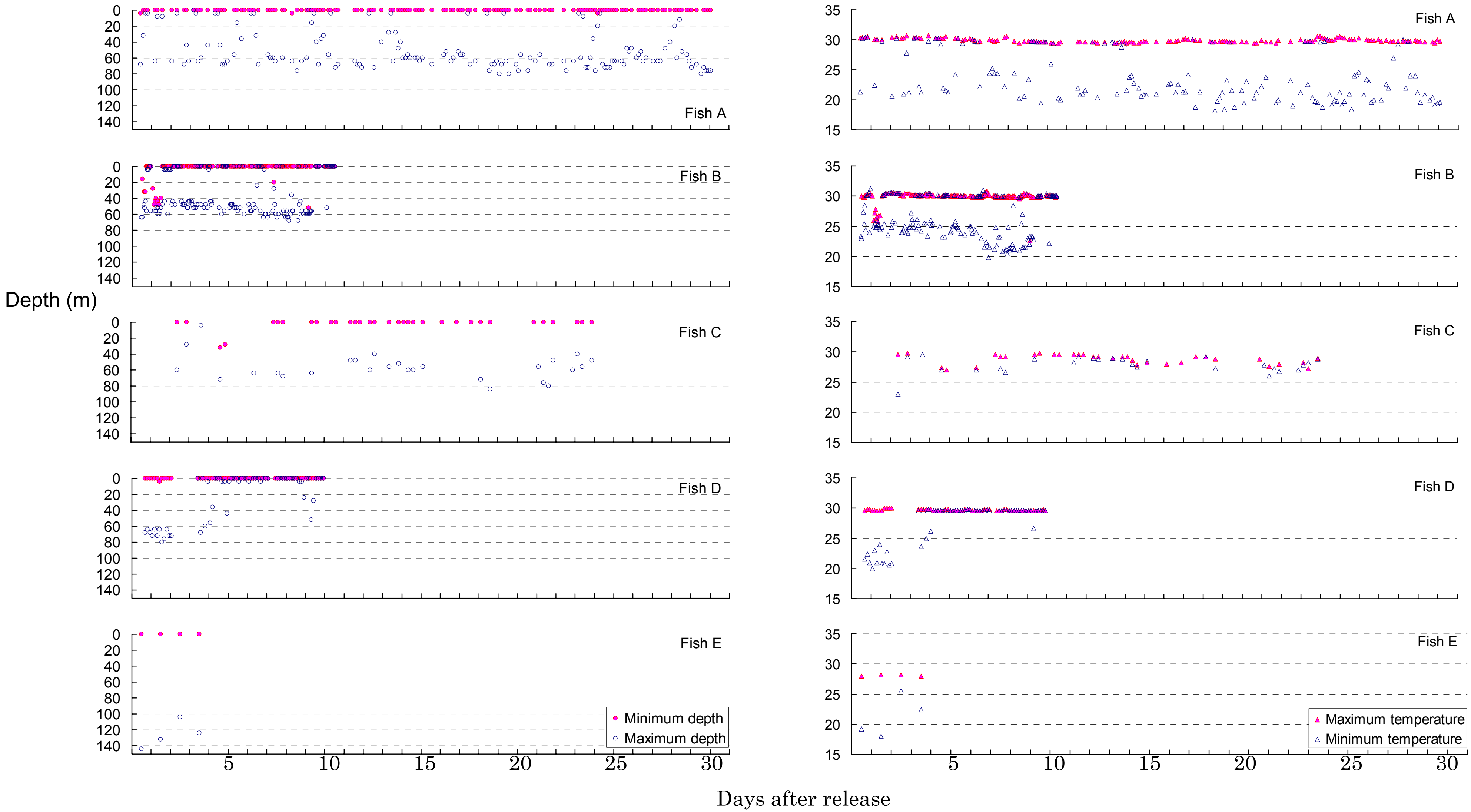

Figure 2. Profiles of diving depth (left) and temperature (right) recorded by pop-up tags attached to five striped marlins. For five PATs, the minimum and maximum temperatures recorded at each depth in each time bin were used in this figure.

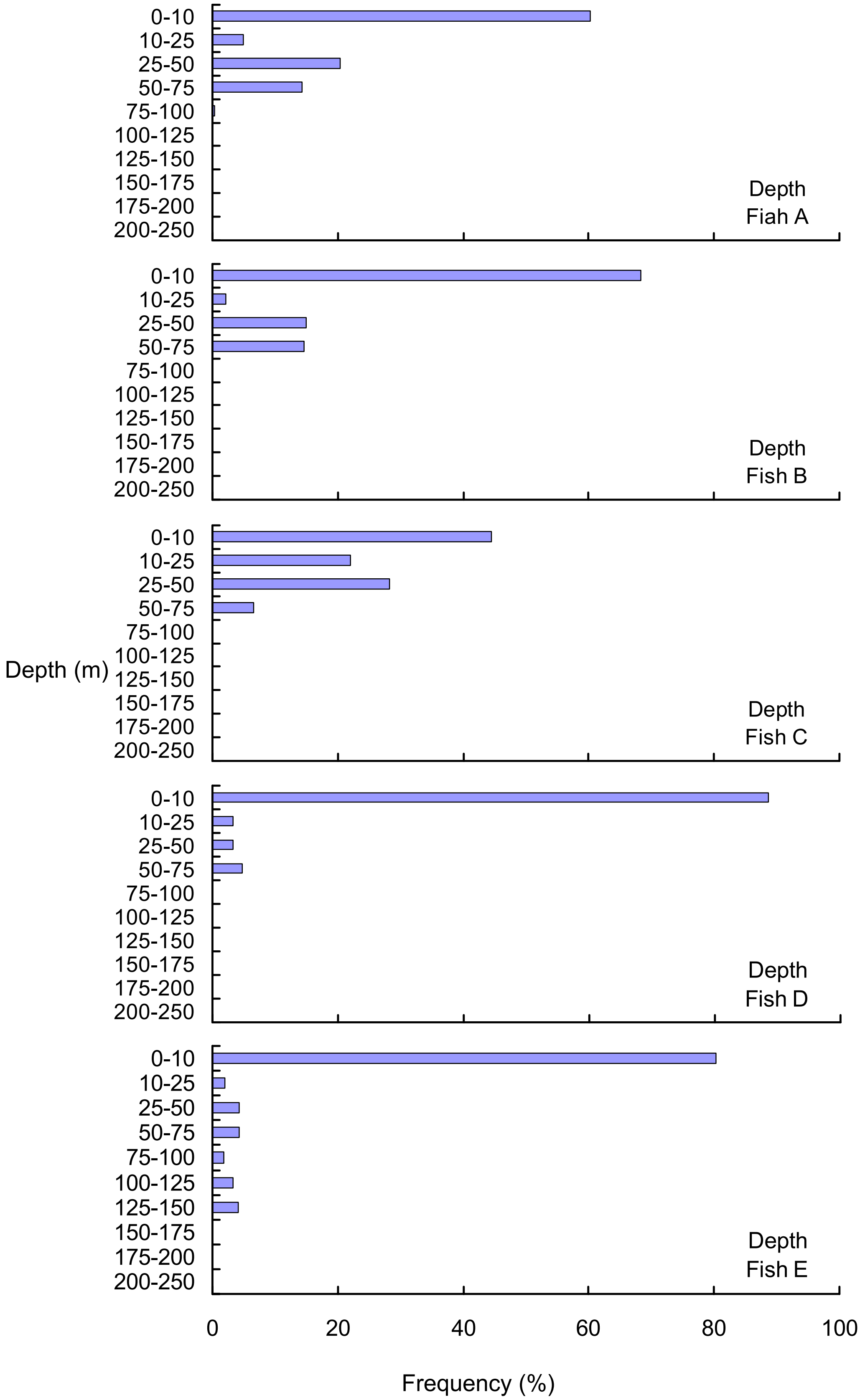

Figure 3. Frequency histograms for depth by pop-up tags attached to five striped marlins released in the Eastern Pacific Ocean.

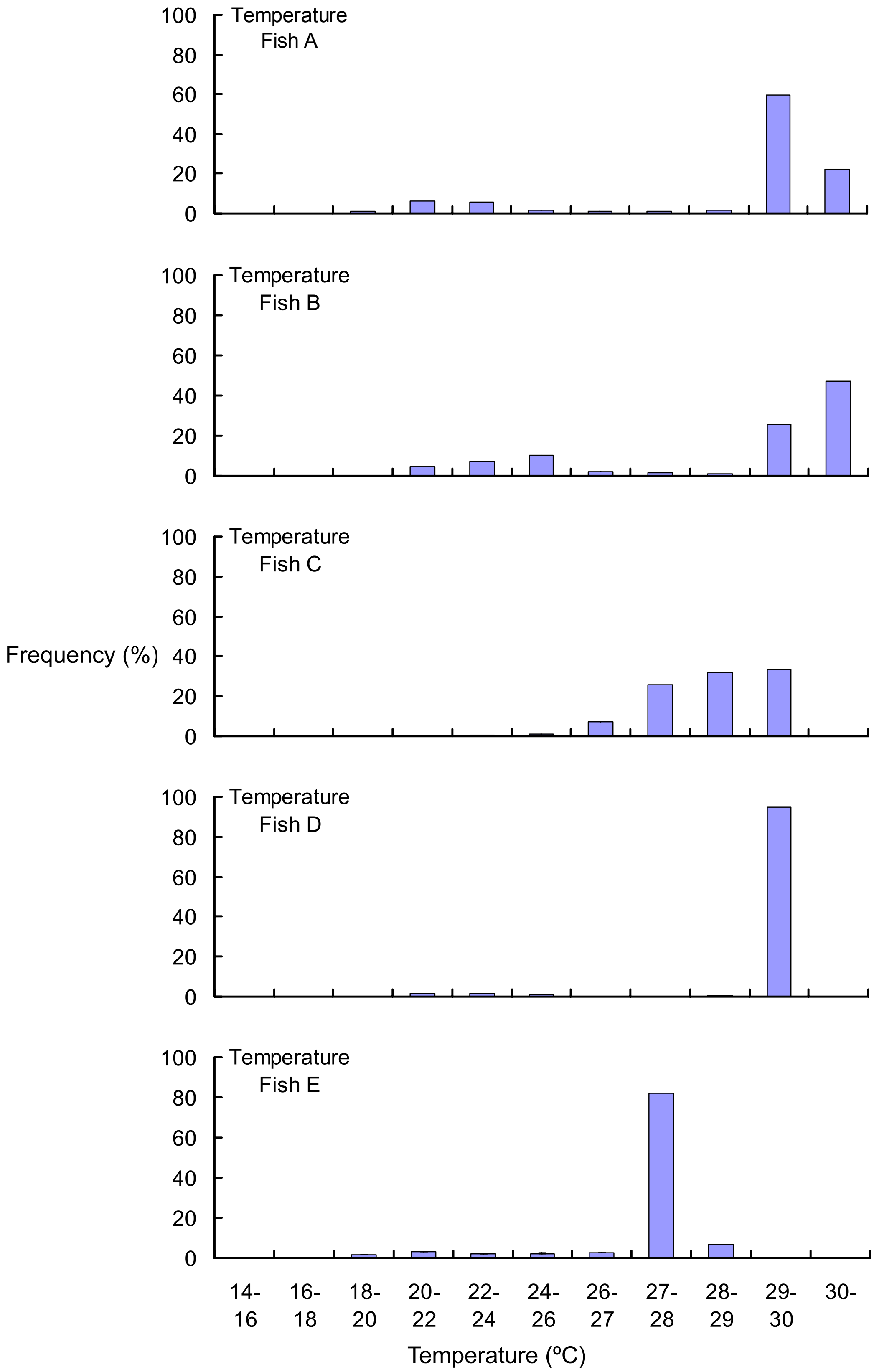

Figure 4. Frequency histograms for temperature by pop-up tags attached to five striped marlins released in the Eastern Pacific Ocean.

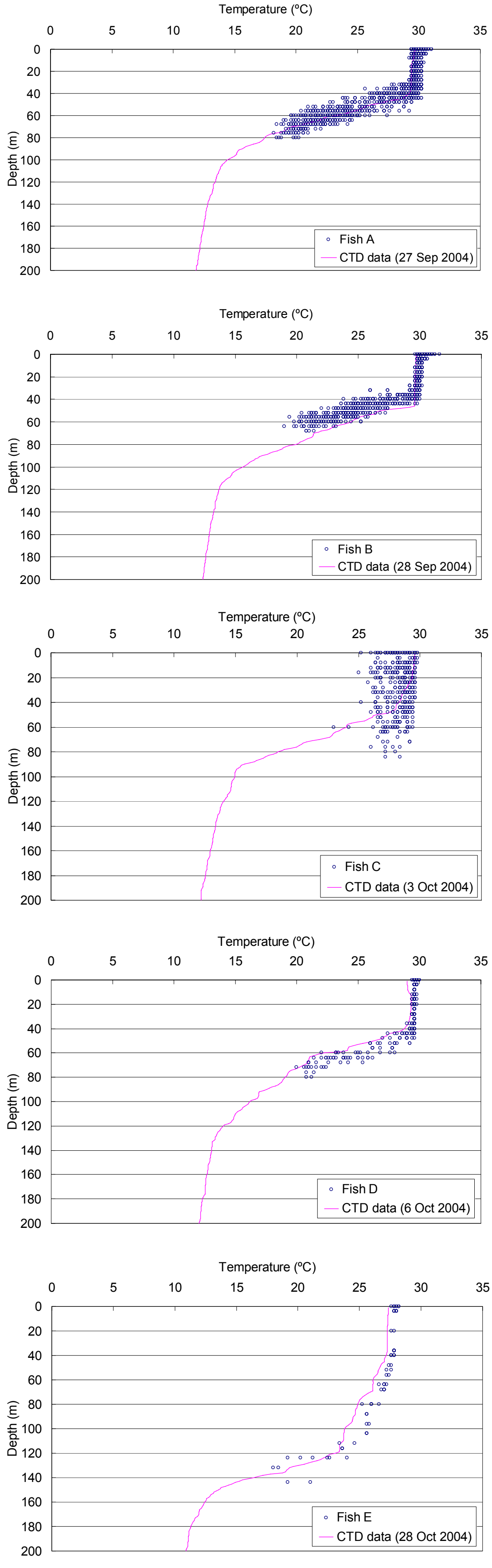

Figure 5. Depth-temperature plots by pop-up tags attached to five striped marlins and ones by CTD that measured before or after the longline operations.

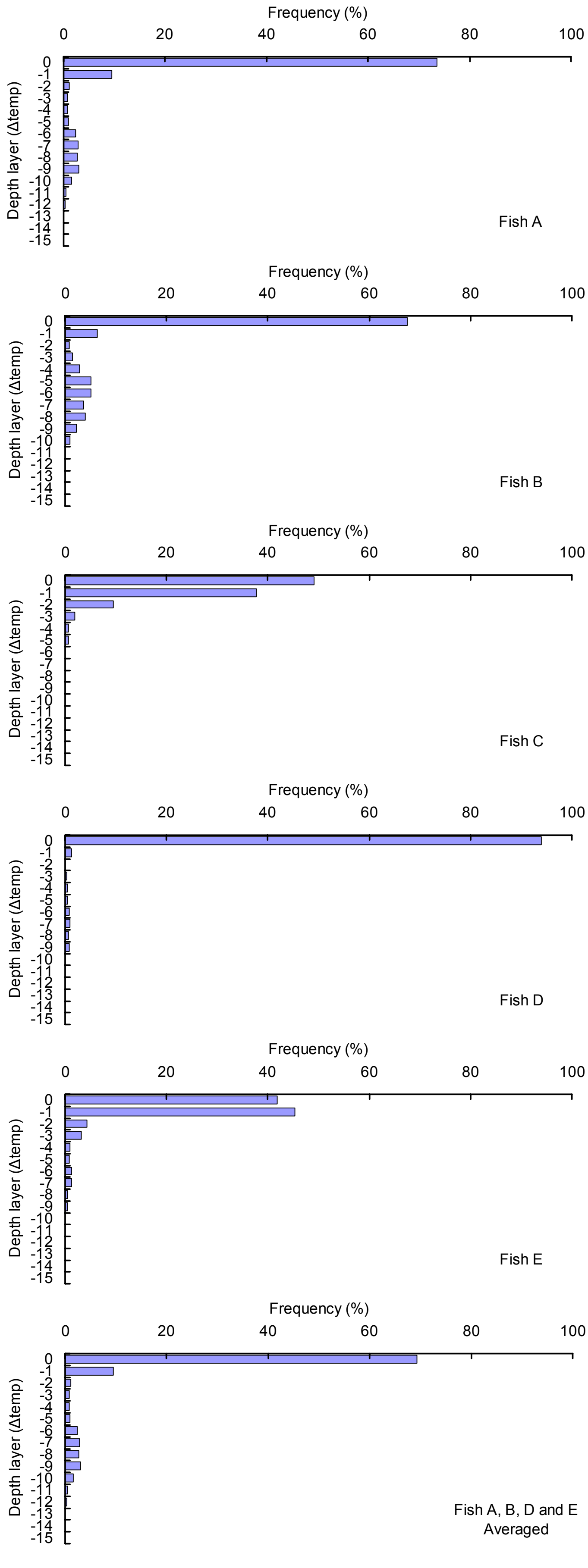

Figure 6. Frequency histograms for depth layer relative to the sea surface temperature (Δtemp, ºC) by pop-up tags attached to five striped marlins released in the Eastern Pacific Ocean

Table1. Fish ID, estimated body weight and summary of deployment and pop-up location for each individual.

Fish ID	Estimated body weight (kg)	Deployment					Pop-up date and location			Days of data available for analyses
		Date (Local)	Time (Local)	Time (UTC)	Latitude	Longitude	Date	Latitude	Longitude	
A	45	26-Sep-04	23:01	5:31	14.592N	103.671W	27-Oct-04	16.772N	105.765W	19.5
B	40	27-Sep-04	21:57	4:27	14.462N	104.093W	8-Oct-04	13.940N	105.579W	7.2
C	35	3-Oct-04	18:42	1:12	15.854N	106.431W	4-Nov-04	12.110N	107.620W	8.9
D	47	6-Oct-04	23:53	6:23	16.058N	106.415W	20-Oct-04	16.564N	106.879W	8.3
E	38	20-Oct-04	17:48	1:18	5.545N	120.138W	6-Nov-04	6.853N	119.696W	3.0

Table 2. Characteristics of vertical distribution pattern for each individual and the mixed layer in each released point.

Fish ID		A	B	C	D	E
Estimated body weight (kg)		45	40	35	47	38
Frequency in the 0 - 10 m layer (%)		60	68	44	89	80
Maximum diving depth (m)		75-100	75-100	200-250	75-100	125-150
Maximum temperature (ºC)		30<	30<	29-30	30<	28-29
Minimum temperature (ºC)		14-16	16-18	20-22	18-20	16-18
The bottom of the mixed layer by CTD	depth (m)	44	47	33	43	56
	temperature (ºC)	28.7	29.2	28.6	28.1	26.3