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THE INFLUENCE OF TEMPERATURE AND BIOTIC FACTORS ON VERTICAL DISTRIBUTION OF BIGEYE TUNA (THUNNUS OBESUS) IN THE ATLANTIC OCEAN*

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SUMMARY

Temperature is the main factor determining the distribution of bigeye tuna (Thunnus obesus, Lowe). In the equatorial Gulf of Guinea the largest recorded catches were from 150 to 210 m depths with temperatures ranging from 11.1 to 14.2°C, and in the southeast Atlantic from 65 to 110 m depths with temperatures ranging from 13.9 to 15.7°C. Actually, there exists no correlation between the vertical distribution of tunas and their length, sex, maturity stage and the index of stomach fullness.

RESUME

La température est le facteur principale pour déterminer la distribution du thon obèse (Thunnus obesus, Lowe). Dans la partie équatoriale du golfe de Guinée, les prises les plus fortes enregistrées se trouvaient à une profondeur de 150 à 210 m avec des températures allant de 11.1 à 14,2°C, et dans l'Atlantique sud, de 65 à 110 m de profondeur et des températures allant de 13,9 à 15,7°C. Il n'y a actuellement aucune corrélation entre la distribution verticale des thonidés et leur longueur, sexe, stage de maturité et l'indice de l'estomac plein.

RESUMEN

La temperatura es el principal factor determinante de la distribución del patudo (Thunnus obesus, Lowe). En la zona ecuatorial del Golfo de Guinea, las mayores capturas se registraron a profundidades entre 150 a 210 m., con temperaturas que oscilaban entre 11.1 a 14.2°C, y en el Atlántico Sudoriental, a profundidades de 65 a 110 m. con temperaturas entre 13.9 a 15.7°. Actualmente, no existe correlación entre la distribución vertical de los túnidos y su talla, sexo, estado de madurez e índice de saciedad estomacal.

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Successful fishing for bigeye tuna Thunnus obesus (Lowe) varies in different parts of the World Ocean depending on depth. The investigations carried out in one of the areas west of Fiji Islands with the use of a special deepwater longline bearing a depth recorder attached near hooks, showed that the bigeye tuna were most numerous at depths below 300 m, and occured in catches taken to 380 m depth (Saito, 1975).

Suzuki, Varashina and Kishida (1977) compared catches taken with regular longlines to 130 m depths, and with deepwater longlines used at depths to 260 m. Average catches of the bigeye tuna taken with a deepwater longline appeared to be 1.79 times those taken with a regular longline. These observations show that the abundance of the tuna increases with depth.

The authors investigated the regularities of vertical distribution of the bigeye tuna with regard for the water temperature and biotic factors (size, gonad maturity stages, index of stomach fullness) in the equatorial part of the Gulf of Guinea and in the Southeast Atlantic.

Materials and methods

The materials were obtained during the scientific-research cruises to the equatorial part of the Gulf of Guinea during the January to March period, 1973, and to the Southeast Atlantic in 1978. The data from 36 longline sets were examined to study the biometrical distribution of the tunas. The bathometric and bathytermographic surveys conducted in the sites of longline sets yielded the temperature data. The depth of hook lowering was calculated theoretically using a longline model (Kuznetsov, 1969). The biological analyses involved measuring the body lengths from the tip of the snout to the end of the middle caudal fin ray, determinations of maturity stages of gonads (Gaikov, 1983) and indices of stomach fullness (Gaikov, 1984). A total of 262 sp. of tunas was analysed.

Results

As reported by some investigators, the temperature range slightly varies in the areas of tuna occurrence. According to Uda (1957), It is 11-29°C, Alverson and Peterson (1963) suggested 13-29°C, and Hanamoto (1975) reported 12-27°C. The higher temperature values are for regions of the surface fishery, and the lower values are for regions of the longline fishery. Squire (1963), who carried out investigations in the Northwest Atlantic in the Gulf Stream region, revealed a correlation between the vertical distribution of tunas and the temperature. The optimum temperature in the bigeye tuna habitat there was 13.3°C. The depth, where the temperature was measured, did not exceed 52.7 m. Similar investigations carried out by Torin (1968) above the Angola Shelf break between 10 and 13°S made it possible to establish the temperature range (14.2-15.8) that conditioned a tuna catch as high as 92.5%. The average temperature was 14.9°C, the depth studied ranged to 150 m. During our investigations carried out in the Southeast Atlantic to the south of 16°S, the range of optimum temperatures for the bigeye tuna was determined (13.9-15.7°C), at which 95.5% of tunas had been captured at 65-100 m depths.

According to Saito (1975), the optimum temperatures for the Pacific tunas is 11-15°C, which is typical of the lower boundary of the thermocline or somewhat deeper. Suda, Kume and Shiohama (1969) also admitted that the distribution of tunas depends on the position of the thermocline. Hanamoto (1975) reported on very high abundance of the bigeye tuna around the thermocline in the southern part of the eastern tropical Pacific.

The by-hook captures of the bigeye tuna from the Gulf of Guinea analysed by the authors showed vertical distribution of tunas in the region (table 1). The average depth of hook lowering given in the table, and the average temperature at the fishing depth makes it possible to trace a dependence of bathymetrical distribution of tunas on the temperature. The optimum temperature range for the bigeye tuna in the Gulf of Guinea is 11.1-14.2°C. It promotes formation of very large tuna aggregations despite varying depths (115-270 m).

Table 2 shows that the size composition of tunas captured at different depth levels varies insignificantly and is represented by 130.0 cm specimens on average. It is indicative of the fact that the vertical distribution of tunas does not depend on their size, at least at lengths exceeding 60 cm.

No correlation exists between the vertical distribution of adult specimens and the maturity stage of gonads (fig. 1). Mature and running specimens of both sexes can be found at all depths fished with longlines. The majority of specimens was captured with hooks 3-5, which corresponds to the depth of 150-210m. Presence of running females at those depth levels suggests that the massive spawning of tunas occurs at great depths, which is supposed to influence the vertical distribution of the larvae.

The larvae of the bigeye tuna are supposed to aggregate above the thermocline, through they are fished both within that layer and lower (Matsumoto, 1958; Strasburg, 1960). But it seems more probable that the larvae concentrate below the thermocline and perform diurnal vertical migrations, being caught in the surface layers in the dark.

The fluctuation of the indices of stomach fullness is insignificant by depth and amounts to 1.7-2.2 or 1.9 on average (fig. 2). The largest captures of the bigeye tuna from 150-210 m depths indicate that they feed in the mesopelagial most intensively.

Summary

The results of investigations into vertical distribution of the bigeye tuna suggest that the temperature is the major factor controlling their bathymetrical distribution. The optimum temperatures for the bigeye tuna are 11-16°C, which is usually observed below the thermocline and in different parts of the World Ocean they are recorded at different depths ranging to 380 m or deeper. In the equatorial part of the Gulf of Guinea the largest recorded catches were from the 150 to 210 m depths, and in the Southeast Atlantic from 65 to 110 m depths.

Actually, there exists no correlation between vertical distribution of tunas and their size, sex, maturity stage of gonads and the index of stomach fullness.

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Table 1

By-hook capture of bigeye tuna

No. of hook	1	2	3	4	5	6	7	8	9	lim	Σ
Mean depth of lowering hook, m	80	115	150	185	210	230	250	260	270	60-295	
Mean temperature of fishing depths, t°C	17.8	14.2	12.7	12.3	12.0	11.8	11.4	11.3	11.1	11.1-17.8	
Temperature fluctuations	17.6-18.0	13.6-17.5	11.6-14.5	10.6-14.0	10.6-14.5	10.6-13.5	10.6-12.5	10.3-12.5	10.5-13.0	10.3-18.0	
N	2	22	49	55	31	27	23	20	14		243
%	0.8	9.0	20.2	22.6	12.7	11.1	9.5	8.3	5.8		100.0

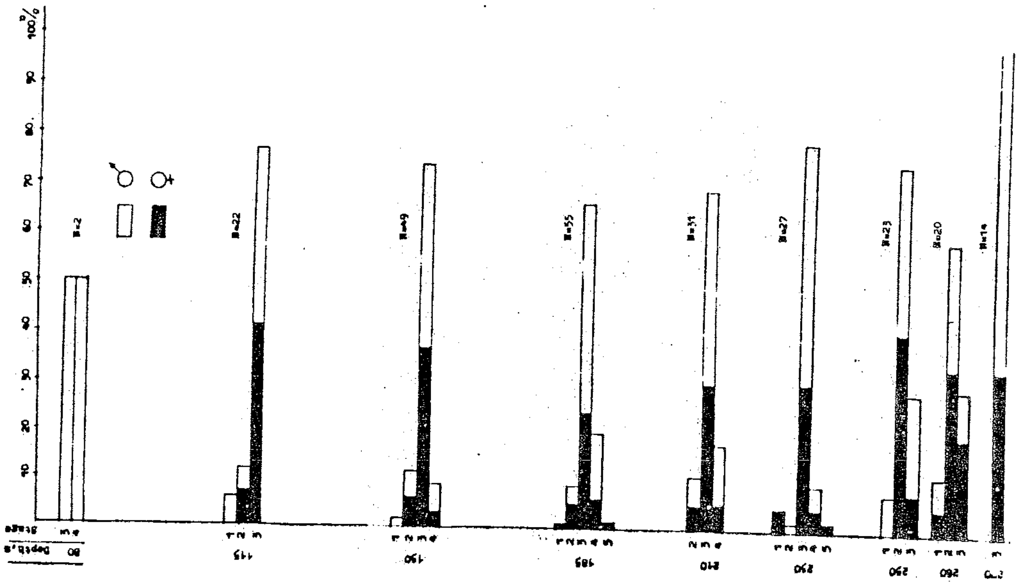

Fig. 1. Maturity stages of bigeye tunas at different depth levels.

Table 2

Size composition of bigeye tuna by depth

Depth, m	65	75	85	95	105	115	125	135	145	155	165	175	185	Σ	Mean length, cm
80									1	1				2	150.0
100				1		1								2	105.0
120		1		2			1							4	97.5
140			1	1	2	1	2	2		4	1	2		16	135.5
160		2	2	1	5	3	4		4	8	3	1		33	130.0
180		1		3	2	7	8	5	4	4	4	3		41	133.1
200			3		3	5	7		6	4	3	1		32	131.1
220			1	1	3	7	5	4	4	5			1	31	129.7
240	2		2	1	1	6	8	4	6	4	1			35	125.8
260			1	1	3	5	5	5	6	3	1	1	1	32	132.7
280				3	4	8	5	1	5	3			1	30	125.8
300							1		1		2			4	150.5
Σ	2	4	10	14	23	43	46	21	37	36	15	8	3	262	130.0
%	0.8	1.5	3.8	5.3	8.8	16.4	17.6	8.0	14.1	13.8	5.7	3.1	1.1	100	

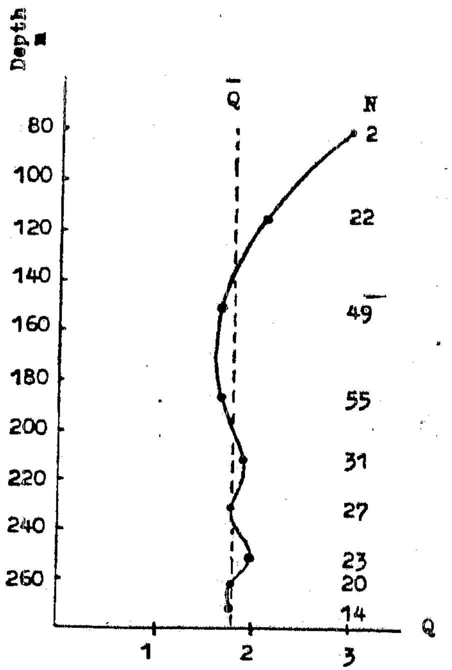

Fig. 2. Stomach fullness by depth.