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ON THE STUDY OF SPAWNING FREQUENCY FOR BIGEYE (Thunnus obesus) AND YELLOWFIN TUNA (Thunnus albacares), BASED ON THE ATLANTIC LONGLINE FISHERY DATA

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SUMMARY

The spawning frequency of yellowfin and bigeye tuna was studied in longline fishery samples. The version of the Hunter-Maçewicz method for "hydrated" females was used. Estimates are based on the analysis of 1,000 yellowfin and 3,000 bigeye females. The yellowfin tuna spawning frequency was 2.8 days during a spawning season in 1966, and 2.2 days during 1990. The estimates for bigeye tuna were 2.3, 3.1, 1.7 and 1.6 days during 1969-70, 1975, 1979 and 1990, respectively.

RESUME

La fréquence de ponte de l'albacore et du thon obèse est étudiée d'après des échantillons de la pêche palangrière. Une version de la méthode Hunter-Maçewicz pour les femelles "hydratées" a été utilisée. Les estimations se fondent sur l'analyse de 1.000 femelles d'albacore et 3.000 de thon obèse. La fréquence de ponte de l'albacore était de 2.8 jours pendant la saison de ponte de 1966, et de 2.2 jours en 1990. Pour le thon obèse, les estimations étaient de 2.3, 3.1, 1.7 et 1.6 jours respectivement en 1969-70, 1975, 1979 et 1990.

RESUMEN

Se estudia la frecuencia del desove del rabil y el patudo por medio de muestras de la pesquería palangrera. Se emplea la versión para hembras "hidratadas" del método Hunter-Maçewicz. Las estimaciones se basan en análisis de 1.000 rabiles y 3.000 patudos hembras. La frecuencia del desove del rabil era de 2.8 días en el curso de la temporada de desove en 1966 y de 2.2 días en 1990. Las estimaciones en el caso del patudo eran 2.3, 3.1, 1.7 y 1.6 días en los períodos 1969-70, 1975, 1979 y 1990, respectivamente.

Introduction

At present the method of spawning frequency estimation by Hunter-Maçewicz (1985) is the only possible for tuna species, characterized by multiple spawning (Bunag, 1956; Ref. in Schaefer, 1987; Batalyants, 1975; Alekseev, Alekseeva, 1981; Hunter, Maçewicz, Sibert, 1986; Cayre et Farrugio, 1986; Goldberg and Au, 1986; Schaefer, 1987). The authors of the method revealed the average spawning interval 1.18 day for skipjack females with postovulatory follicles from the eastern Pacific.At such spawning frequency a single female 4 kg weighted will spawn about 30 mln eggs over a 90-day spawning period (Hunter, Maçewicz, Sibert, 1986). Based on the analysis of females with hydrated oocytes, Schaefer (1987) estimated a spawning frequency for black skipjack (Euthynnus lineatus) from the area off California, off Central America and the Gulf of Panama as 2.1, 5.7 and 3.6 days, respectively, indicating that the average female could have spawned 43, 47 and 58 times a year. In IATTC reports the preliminary results are given in the number of yellowfin females with postovulatory follicles in the Clipperton Island area (the eastern Pacific). The average interval between spawnings was 1.3 days, indicating that spawning actually occured every day. (Ann. Rep. IATTC, 1988).

The results of the spawning frequency research by Hunter-Maçewicz method (1985) presented in our report are based on yellowfin and bigeye tuna sampled from the long-line fishery in the equatorial Atlantics. The estimates of spawning frequency of yellowfin tuna, based on the incidence of "hydrated" females are of interest to compare with those for rod-and-line fishery (Ann. Rep. IATTC, 1988).

Data on spawning frequencies for bigeye tuna are unknown.

Material and Methods

The study was based on the field identification of maturity stages for 1000 yellowfin and 3000 bigeye females sampled from long-line fishery in the Gulf of Quinea and offshore Atlantic areas. The analysis were performed over the spawning seasons (from December through May) of 1966, 1969-70, 1975, 1979 and 1990. The same area was studied during 1966-1979 (4°-7°S, 4°-9°W). In 1990 the both species were studied in different areas (Fig.1). The method of estimation "hydrated" females number was engaged in 1966-1979 (Hunter, Maçewicz, 1985). The percent ratio was determined by "hydrated" females (at maturity stage IV-V, according to 6-score scale) to the total number of mature females with ovaries in stages IV, IV-V, VI-IV. Females in stage V (running) were practically absent in samples.

The concept of "hydrated" females includes:

1. Females with oocytes hydrated over the whole ovary. This extremely short condition is observed in females just before spawning. It is accidentally recorded in trawl catches, some purse sets and rod-and-line catches, but practically absent in long-line samples.

2. Females with some transparent oocytes in ovaries, clearly distinquished among the bulk of opaque oocytes. As the histological study shows, most oocytes are characterized by such dispersion of germinal vesicles and hydration of yolk inclusions, which would not result in oocyte transparency. The females descibed are relatively often recorded in different gear catches.

3. Females with the advanced oocyte stage, followed by hydration process from the early coalescence of the lipoid vesicles through the definitive formation of lipoid droplet, migration of nucleus (the germinal vesicle) to the periphery and early hidration of yolk inclusions at the vegetative oocyte pole. This stage is determined histologically, by means of binocular microscope and visually. The females described occure most frequently during spawning periods.

In collection before 1990 the female ovaries, described in item 2, were designated as stage IV-V.

Our field observations in 1990 were supplemented with the data on prespawning females, described in the item 3. We describe this stage as IV V a, and the next one (item 2) as IV-V-b (Figs. 2-5).

Thus the concept "hydrated" females is to some extent conventional one, however, it is very useful to group females, which have to spawn over the nearest 24 hours.

The identification of ovaries in stages IV-V-a and IV-V-b revealed the consistent occurence of bigeye females in stage IV-V-b at long-line fishery depths. This confirms the bigeye tuna spawning occurence at the mentioned depths, since the hydration terminates at temperatures of spawning. The most yellowfin females, sampled from long-line fishery catches were in stage IV-V-a. We observed females in stage IV-V-b in purse sein samples from San-Tome are at sea-surface temperature 25.5°-27.0°C. Thus the long-line fishery samples provided information on ovary condition for prespawning yellowfin females, distributed within the mixed layer or in the thermocline during diurnal vertical migrations. The specific feature of long-line sampling is the possibility to analyse fish once every two days and only sometimes once a day at its delivery from a tuna-boat. In both cases the percentage of females with ovaries in stage IV-V was consistently high despite of the catch size. The percent occurence of such females is most evident at decade data arrangement. Unfortunately the tables for such data are too complicated, so we chose the data by months.

Results and Discussion

Consistently high percent occurence of bigeye "hydrated" females over four spawning seasons is indicative of the high spawning frequency for that species. (Table 1). It varied from 4.00 to 2.1 days (average 2.3 days) in 1969-70, from 5.6 to 2.5 days (average 3.1 days) in 1975 and from 2.6 to 1.2 days (average 1.7 days) in 1979. The data on 1990 provided the close values of spawning frequency (Table 2). The estimates varied by fishery areas and seasons within 2.2-1.4 days (average 1.6 days). The higher estimates of spawning frequency observed in 1990, as compared with those in 1969-70, 1979 may be the result of inclusion females with ovaries in stage IV-V-a.

The estimates of spawning frequency for the seasons investigated indicate that a single bigeye female is able to spawn 35 times over 3 months in 1969-70, 42 times over 4.3 months in 1975 and 59 times over 3.3 months in 1979. The values obtained are similar to those reported by Schaefer (1987) for black skipjack (*Euthunnus lineatus*).

Relatively low number of the yellowfin females sampled from catches in 1966 (399 specimens) is apparently caused by the deepening hooks far bigeyes tuna target fishery.

The spawning frequency estimates for February and March (2.8 and 1.8 days, respectively) (Table 3) were similar to those for yellowfin tuna from the Clipperton Island area (Ann. Rep. IATTC, 1988). The spawning frequency of females, sampled in February (14.4 days) is too high. We assume it to be the result of underestimating the number of females with ovaries in stage IV-V-a.

During 1990 the spawning frequency estimates varied by areas and seasons from 4.5 to 1.3 days (average 2.2 days) (Table 2).

Therefore we confirm actual identity of spawning frequency estimation based on 2 indices - the number of "hydrated" females in our study and the number of females with new postovulatory follicles (Ann. Rep. IATTC, 1988), which indicates the validity of Hunter-Maçewicz method.

Similarity of spawning frequency values for bigeye and yellowfin females confirms the previous conclusion on vitellogenesis and maturity process patterns similarity, which determines multiple spawning of different tuna species with short intervals between batches of eggs (Batalyants, 1975).

Conclusion

The bigeye tuna spawning frequency was estimated upon the materials of long-line fishery in the equatorial Atlantics. The method is based on the "hydrated" females number. During the seasons of 1969-70, 1975 and 1979 the spawning frequency values were 2.3, 3.1 and 1.7 days, respectively. During 1990 the estimate averaged by several areas was 1.6 days.

The estimate of yellowfin tuna spawning frequency from the same areas were 2.8 days in 1966 and 2.2 days in 1990. The estimates obtained are similar to those for yellowfin tuna from the Clipperton Island area (Ann. Rep. IATTC, 1988). We consider the results identity to confirm the Hunter-Maçewicz method validity.

The visual or microscopic possibility of identificating females with ovaries in stage IV-V-a provides the more representative data on prespawning females and improves the spawning frequency estimates by Hunter-Maçewicz method.

References

1. Alekseev F. E and E. I. Alekseeva. 1981. Some aspects of ocean and neretic tuna (Scombridae) reproductive biology in the tropical Atlantics. Problems of Ichthyology. Vol. 21. Issue 5: 853-866.

2. Annual Rep. of Inter. Am. Trop. Tuna Comm. 1988: 222.

3. Bataluants K. Ya. 1975. Reproductive peculiarities of some tropic Scombridae in the Atlantic Ocean. Trudy AtlantNIRO. No. 58: 193-196.

4. Batalyants K. Ya. 1989. On spawning of skipjack tuna (Katsuwonus pelamis L.). In Coll. Volume of Scient. Papers. Vol. XXX(1): 20-27.

5. Cayre P. et M. Farrugio. 1966. Biologie de la reproduction du listao (Katsuwonus pelamis L.) de l'ocean Atlantique. In Proceedings of the ICCAT Conference on the International Skipjack Year Program Int. Comm. Cons. Atl. Tunas. Madrid. Spain: 252-272.

6. Goldberg S. R. and D. W. An. 1986. The spawning of skipjack tuna from southeastern Brazil as determined from histological examination of ovaries. In Proceedings of the ICCAT Conference on the International Skipjack Year Program. Int. Comm. Conser. Atl. Tunas. Madrid. Spain: 277-284.

7. Hunter J. R. and B. J. Maçewicz. 1985. Measurement of spawning frequency in multiple spawning fishes. In Lasker, (editor). An egg production method for estimating biomass of pelagic fish. Application to the Northern anchovy (Engraulis mordax). US Nat. Mar. Fish. Serv., Nat. Oceanic Atmos. Adm. Tech. Rep. 36: 79-94.

8. Hunter J. R., B. J. Maçewicz and J.R. Sibert. 1987. The spawning frequency of skipjack tuna, Katsuwonus pelamis, from the South Pacific. U. S. Nat. Mar. Fish. Serv., Fish. Bull. 84 (4): 895-903.

9. Oven L. s. 1976. The oogenesis peculiarities and spawning pattern of marine fishes. Kiev. Naukova Dumka. p. 132.

10. Rokitsky P.F. 1974. Introduction into statistic genetics. Minsk. Vesheyshaya Shcola. p. 447.

11. Schaefer K. M. 1987. Reproductive biology of black skipjack, Euthynnus lineatus, an eastern Pacific tuna. Inter. Am. Trop. Tuna Comm. Bull. 19 (2): 169-260.

Table 1

Percent occurence of bigeye tuna ovaries at maturity stage IV-V in long-line samples from the area 4°-7°S, 4°-9°W during 1969-70, 1975 and 1979. 95% confidence intervals (Rokitsky, 1974) are presented in brackets for binomial distribution of stage IV-V female percentage

Month	Tuna-base "Solnechny Lutch" 1969-1970			Tuna-base "Solnechny Lutch" 1975			Tuna-base "Solnechny Lutch" 1979		
	Number of females in stages IV, IV-V, VI-IV	% of females in stage IV-V	Confidence interval	Number of females in stages IV, IV-V, VI-IV	% of females in stage IV-V	Confidence interval	Number of females in stages IV, IV-V, VI-IV	% of females in stage IV-V	Confidence interval
XII	36	25.00	(10.57, 39.43)						
I	96	35.41	(25.65, 45.17)	157	17.83	(11.72, 23.94)			
II	189	48.68	(41.41, 55.95)	483	29.39	(25.25, 33.53)	382	80.37	(76.31, 84.43)
III	80	47.50	(36.34, 58.66)	318	36.16	(30.77, 41.55)	443	42.89	(31.83, 53.95)
IV				142	32.39	(24.54, 40.24)	77	37.66	(26.62, 48.70)
V				318	39.39	(34.45, 45.43)	91	58.24	(47.91, 68.58)
	401	43.14	(38.20, 48.08)	1418	32.39	(29.81, 34.77)	993	58.31	(53.41, 63.21)

Table 2

Percent occurence of yellowfin and bigeye tuna ovaries at maturity stage IV-V in long-line samples of tuna-base "Solnechny Lutch" (January-June, 1990)

Area	Date	Yellowfin tuna			Bigeye tuna		
		Number of females in stages IV, IV-V, VI-IV	% of females in stage IV-V	Confidence interval	Number of females in stages IV, IV-V VI-IV	% of females in stage IV-V	Confidence interval
1	01.02-15.02	99	22.22	(13.87, 30.57)	74	60.81	(49.46, 72.16)
2	17.02-05.03	143	34.27	(26.34, 42.20)	60	70.00	(58.17, 81.83)
3	08.03-18.03	94	38.30	(28.28, 48.32)	18	44.44	(21.02, 67.86)
4	20.03-26.03	86	76.74	(67.63, 85.85)	7	71.43	(37.29, 00
5	27.03-09.05	255	53.33	(47.09, 59.57)	24	70.83	(52.28, 89.39)
		677	45.64	(41.81, 49.47)	183	63.40	(56.28, 70.52)

Table 3

Percent occurence of yellowfin tuna ovaries at maturity stage IV-V in long-line samples from the area 4°-7°S, 4°-9°W during 1966

Month	Number of females in stages IV, IV-V, VI-IV	% of females in stage IV-V	Confidence interval
II	44	6.82	(00, 14.42)
III	247	35.36	(29.27, 41.45)
IV	109	54.12	(44.58, 63.66)
	399	37.34	(32.50, 42.18)

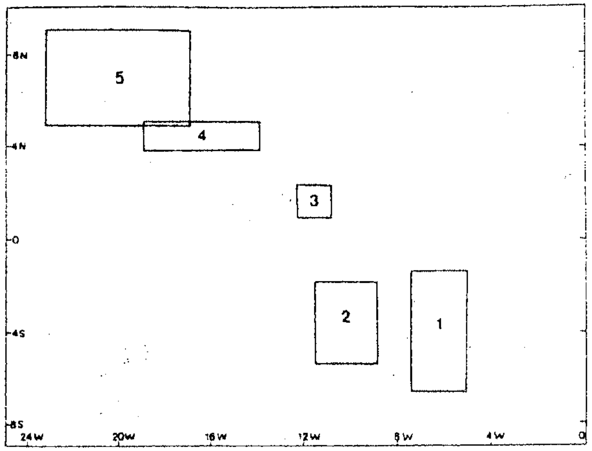


Fig. 1. The sampling locations for bigeye tuna ovaries from January through June 1990.

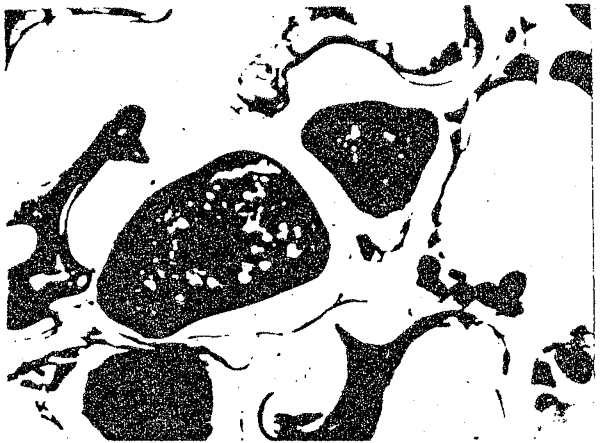


Fig. 2. Bigeye tuna. Ovaries in maturity stage V. Hydrated oocytes (of irregular form) just before ovulation and oocytes with completed vitellogenesis (with visually empty vesicles in ooplasma), represented the starting condition before preovulatory changes. This microphoto and the next one represent the histological ovarian preparation, stained with farrous hematoxilin by Heidengain and Mallory at magnification x80.

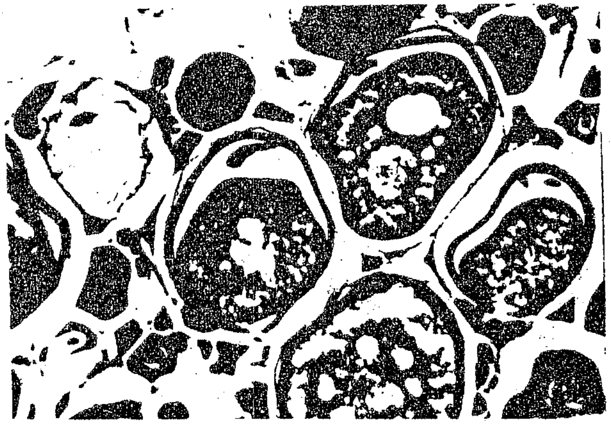
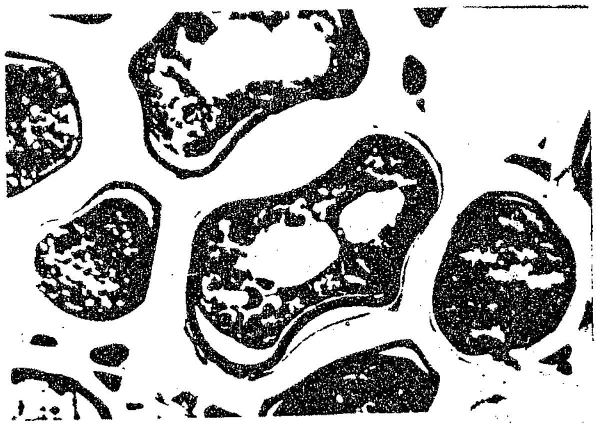


Fig. 3. Bigeye tuna. Ovaries in stage IV-V-a. The early preovulatory changes of oocytes.

3A. Fusion of small lipoid (visually empty) vesicles into the large one, followed by lipoid droplet formation.



3B. Terminal vesicle migration to the animal pole. The early hydration of yolk granules at the vegetative pole.

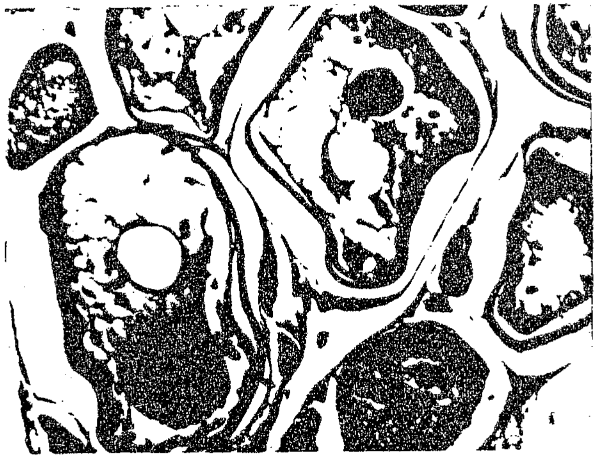


Fig. 4. Bigeye tuna. Ovaries in stage IV-V-b. Different phases of oocytes hydration.

4C. Early homogenization of hydrated yolk at the vegetative pole. The yolk granules are preserved at the animal pole.

4D. Homogenization of yolk at the vegetative pole. There are globules of hydrated yolk around the lipoid droplet at the animal pole.

4E. Yolk homogenization over the whole oocyte. The lipoid droplet is at the oocyte membrane.

Fig. 5. Bigeye tuna. Ovaries in stage V. Hydrated oocytes before ovulation and oocytes with completed vitellogenesis before early preovulatory changes.