

STATE OF YELLOWFIN TUNA FEMALES (*THUNNUS ALBACARES*) OVARIES AND OOCYTES  
IN LONGLINE AND PURSE CATCHES DURING SPAWNING PERIOD

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**SUMMARY**

The histological analysis of yellowfin tuna female ovaries and oocytes from the longline and purse seine catches was carried out, with special reference to the hypothesis of the relation between fish availability to various fishing gears and the state of the gonads during the spawning period. The identity of the gonad state was revealed in both the intervals between spawning and immediately before spawning. The total range of pre-ovulatory changes, excluding ovulation, is observed in females from the longline and purse seine catches. Females with ovulated eggs only occurred in the purse seine catches. The data obtained eliminate the connection of the availability of yellowfin tuna to various types of fishing methods and gonad maturity stages and confirm the role of the thermocline depth.

**RESUME**

L'analyse histologique des ovaires de l'albacore femelle et des oocytes des prises palangrières et de senneurs a été menée à bien en faisant surtout référence à l'hypothèse de la relation entre la disponibilité des poissons pour plusieurs types d'engins de pêche et l'état des gonades durant la période de frai. L'état des gonades a été révélé dans les deux intervalles entre la période de frai et la période juste avant le frai. Tous les changements préovulaires, mis à part l'ovulation, sont observés dans les femelles des prises palangrières et de senneurs. Les femelles avec des oeufs ovulés sont présentes uniquement dans les prises de senneurs. Les données obtenues éliminent la connexion de la disponibilité d'albacore avec plusieurs types de méthodes de pêche et les stades de maturité des gonades et confirment le rôle de la profondeur de la thermocline.

**RESUMEN**

Se llevaron a cabo análisis histológicos de ovarios y oocitos de hembras de rabil de las capturas de palangre y cerco, con especial referencia a la hipótesis de la relación entre la disponibilidad de los peces a los diversos artes de pesca y el estado de las gónadas durante el período de desove. En ambos, la identidad del estado de las gónadas se reveló en los intervalos entre la puesta e inmediatamente antes de la puesta. Se observó el rango total de los cambios preovulatorios, excluyendo la ovulación, en hembras procedentes de captura de palangre y cerco. Las hembras con huevos ovulados procedían sólo de las capturas de cerco. Los datos obtenidos eliminan la conexión entre la disponibilidad del rabil a varios tipos de métodos de pesca y las fases de madurez de las gónadas, y confirman el papel que desempeña la profundidad de la termocline.

## Introduction

Some scientists consider the yellowfin tuna availability to various fishery gears to be related with gonads maturity stage during spawning season. This point of view is based on the higher gonadosomatic indices (GI) recorded for females from purse catches as compared to that from long-line ones. (Hisada, 1973; Suzuki, 1988; Koido, Suzuki, 1989).

The above-mentioned point of view is questionable due to the following reasons. First, the both fisheries are carried out during particular periods in the spawning grounds of yellowfin tuna Zharov, 1969; Yanez, Barbieri, 1980; Koido, Suzuki, 1989). Second, the both fisheries differed as long-line fishery is nonselective one and purse fishery is a selective one. That is why averaged biological indices of fishes are inappropriate for comparison analysis. Third, Gonadosomatic index as a major tool of the above-mentioned observations could be considered as an accurate indicator of ovaries state only after histological analysis of ovaries and oocytes state (Cayre, 1986; author's observations).

In this paper the results of comparative histological analysis of female ovaries and oocytes state from long-line and purse catches are presented with special reference to the problem of relation tuna availability to various types of fisheries and gonad state.

## Material and methods

Background state of yellowfin tuna ovaries in long-line fishery during spawning season was studied based on the results of visual maturity stage evaluation in 875 females taken from 5 areas of the Atlantic Ocean in February-May 1990 (Fig. 1). From this amount females ( $LF \geq 115$  cm) with signs of oocytes maturation were analysed to estimate gonadosomatic index, to measure oocytes diameter and to analyse histologically ovaries and oocytes state. GI was estimated by the equation:

$$GI = GW \times 10^4 / LF^3$$

where GW - ovaries weight in grams

LF - fish length from the tip on mouth to the edge of median rays of the tail fin (in cm).

Oocytes diameter was measured in field on the fresh material and in the laboratory on the material, fixed in aldehyde-acetic solution,

where binocular was used (oc. 8, ob. 4). Histological preparations of ovaries of 5-6  $\mu$ m width were stained with ferrous hematoxiline according to Heidengyne and Mallory.

No special observations of long-line hooks sinking were carried out. The upper thermocline layer location was found by means of bathythermograph. Then tuna boats set long-lines, following the traditional Russian method of paired baskets. The observations by Paliy (1969) showed that paired baskets provide fishing through the depth over 50-60 m, i. e. through the total mixed layer. According to the data by Torin and Maksimov (1969) the most active yellowfin tuna biting was observed between 1100am & 1800pm with maximum at 1500-1600pm. In dark time the biting activity decreased actually to zero. Thus the long-line samples reflect the yellowfin tuna ovaries state in day and evening hours.

Purse samples were represented by fixed ovaries of 7 females from the Indian Ocean (3-4°S, 60-63°E) in April of 1988 and 2 fixed samples from the Sao-Tome and Principe area in August of 1988. The low sample number is related to the limited abilities to cut fish aboard the tuna catching seiners. GI values were estimated in all females, as well as oocytes diameters of the leading generation, and the oocyte histological samples were prepared. Samples were taken from the hauls in the range of 1400-1700 m.

A comparative analysis of gonad state requires to define clear criteria of successive changes in this organ during spawning. Definition of females as "ripe" commonly adopted in literature, disguises several states which reflects the degree of approaching the next spawning, and are identified both visually and histologically. Using 6-score scale those states may be defined as IV, IV-V and VI-IV maturity stages and V "running" stage.

Stage IV - ovaries are light-yellow or yellow, vascularisation is moderate, anterior and posterior parts are rounded elastic, ovarian cavity is weakly developed. Oocytes of the leading generation are visible by eye, with diameter of 0.45-0.50 mm. Microscopic study shows that oocytes are in stage of completed vitellogenesis (yolk inclusions over the total oocyte body, small fatty vacuole around nucleus, oocyte capsula is formed). The signs of the recent spawning in the form of atretic folliculae and resorbing oocytes are absent. This state is typical for females which have not spawned in the current year. Females with ovaries at stage IV

occured in small amount during the entire spawning season which suggests the continuous recruitment of spawning stock.

Stage IV-V - ovarian colour varied from dark-yellow to reddish-brown depending on the previous egg emissions number. It also determines the elasticity of anterior and posterior part of ovaries, cavity development and ovarian tissue friability. Oocytes of the leading generation are at various stages of preovulatory changes. Experienced researcher may early distinguish the latter visually from the oocytes with completed vitellogenesis based on diameter and whitish or opaque colour. In fresh material under binocular they differ from the latter as oocytes with various transparency degree from nontransparent ones. Diameter is of 0.50 mm and more. Sometimes the signs of completed spawning as atretic folliculae and resorbing eggs are recorded.

Stage VI-IV - the ovarian colour varied within the same extended limits as at the previous stage. During entire spawning period tuna ovaries are characterized by a strong vascularization. Evidently that phenomenon is related to the increased blood supply to the organ as a necessary condition of oocytes trophoplasmatic growth in younger generations and energetic supply of oocytes ripening in older one. By the late spawning period the lateral folding appeared in the caudal sector, the sector became much thinner and of violet-brown colour. At this stage ovarian cavity is well developed along the entire length of ovaries egg-carrying plates with signs of anatomical destructurization are observed. Oocytes of the leading generation are in the stage of completed vitellogenesis. The residue eggs may occur, and atretic folliculae and resorbing oocytes are observed in histological preparations. Nevertheless there are evidences that females will take part in the spawning.

The classification of the ripe females ovary state allows to identify mature stage in the field.

In comparative analysis IV-V stage is of particular interest, as the authors, quoted above, consider the difference in GI values in reference to female readiness to spawn. Preovulatory changes in oocytes of various tuna species are described by several authors (Schaefer, 1987, 1988; Nicaido, Miyabe, Ueyanagi, 1991; Bataliants,

1991), which enable to use the following histomorphological diagnostics of separate process stages as a whole (Table 1). Species peculiarities of yellowfin tuna are reflected in oocyte diameter during successive stages of ripening, started from oocytes in the stage of vitellogenesis completed. Oocyte diameter was measured in fixed material. Earlier we have used this diagnostics to study big-eyed tuna (Bataliants, 1991). Ovaries with oocytes at stages 2-5 were recorded as stages IV-Va, and at stages 6-8 as IV-Vb.

#### Results and discussion

The starting point comparative analysis of yellowfin tuna females state for samples from different fishery gear catches is the information on the background stages of adult fish maturity in both cases.

During long-line fishery in the Central-East Atlantic (April-August, 1965) we observed various maturity stages of adult yellowfin tuna within the same catches (Bataliants, 1975). Earlier Zharov (1969) reported on the wide range of ovarian state in yellowfin long-line catches within the same period.

The results of yellowfin females maturity stage estimation in long-line catches in February-May 1990 are presented in Table 2. Over entire area investigated from 8°N to 6°S and from 5°W to 24°W females of maturity stages IV, IV-V and VI-IV dominated in catches. Females of stages II and III constituted about 16% of the fishes analysed. Depending on the area this index varied from 1 to 27%. In general the majority of schools were apparently spawning ones.

Considering the above-mentioned reasons it appeared more difficult to illustrate background state of female gonads from purse catches. In our material random samples from the schools fished contained females at stages IV-V and V, but females at maturity stages IV and VI-IV were absent. Nevertheless, according to data by Koido and Suzuki (1989) the latter were observed in purse catches. Detailed information on the background maturity stages of yellowfin tuna in purse catches from the Pacific Ocean will be available in the next papers by Dr. K. Schaefer (San-Diego, California, USA).

Predomination of the maturity stage IV-V in both samples and ability of separate stages of preovulatory changes in oocytes determines this stage as a major subject of gonad state comparative

analysis for females from long-line and purse catches. The results of analysis are presented in Table 3.

The data presented show that in both cases female oocytes of the leading generation are at the same stage. This is evident in oocytes of 0.55-0.67 mm in diameter. Oocytes over 0.75 mm seldom occurred in ovaries of long-line females (about 4% of the total ovaries number). Besides females at that stage may be caught with the upper hooks of long-line. Starting from 0.75 mm the oocyte diameter is increased as a result of hydrated yolk homogenization. We suppose this process to progress at spawning temperature conditions, i.e. within epipelagical zone, where also maturity is completed and ovulation and spawning occur.

Oocyte occurrence in long-line and purse sample at the final stages of preovulatory changes is explained by the relation of feeding and mating behaviour of tunas. Occurrence of females with oocytes of 0.55-0.90 mm in diameter evidences that the feeding activity is the dominating one. Besides breeding games are theoretically excluded. The school as an object of directed haul in purse fishery should be a compact unit. This state is possible when the school is predominantly consists of fishes out of breeding games which is indirectly confirmed by histological analysis of ovaries. The occurrence of running females in purse catches may be explained by the fact that a mating group (or groups) occurs near the school fished.

Data on GI confirmed Cayre's opinion (1986) that it could not be taken as an accurate index of female approach to the spawning time. GI may vary considerably at the same oocyte state (Table 3). This is explained by the high variability of gonad weight, depending on the spawning cycle moment. Coming back to argument of Koido and Suzuki (cit op.) we should point that the data presented by them (ratio of female length and GI, group maturity), corrected to female size composition, evidence the gonad state identity rather than difference of the latter. The most correct would be the comparison of "mature" female up to 115 cm in length at differential account of ovaries with oocytes, which completed the vitellogenesis, in the process of maturation and before ovulation.

Exclusion of gonad maturity factor enables to consider hydrological conditions in spawning areas as the major factor of availability. We mean the traditional opinion on relation of yellowfin

tuna availability for long-line and purse fisheries and the upper thermocline depth (Sund, Blackburn, Williams, 1981). Observations at national long-line fishery confirm the conclusion that in the central part of the Gulf of Guinea the upper thermocline is located at 75-150 m and deeper (section along 10°W from 2° to 10°S. Reports of SRTM "Prognos", 1973; SRTM "Vyandra", 1975). Strongly developed homothermal and mixed layers extend the limits of adult yellowfin tuna diurnal activity depth range. The high warming of homothermal layer and its vertical development results in schools episodic occurrence at the surface. The continuous tuna tracking by sea-bird flocks is difficult in such conditions, so visual recording of schools occurred only accidentally. Thus in 1990 we observed twice surface schools of large yellowfin tuna which came from the depth and reaching the depth of 2-3 m from the surface sharply returned to the depth. This may be the element of heating-cooling cycle associated with vertical migrations into cooled water. The analysis of long-line tuna stomachs showed that mesopelagical species (small squid, mictophidae, gempylidae) were the major components of food ball.

Shallow location of the upper thermocline, typical for the grounds of adult yellowfin tuna purse fishery, is illustrated by the example of Sao-Tome and Principe area in July-October. Relatively stable fishery situation in July-August, 1988 is explained by the upper thermocline location at the depth of 30-50 m (Report of SRTM-8080 "Ekliptika", 1988). Considerable amount of surface schools, followed by sea-bird flocks, tuna aggregating at natural and artificial floatings, common "boiling" schools are considered as correlates of the shallow upper thermocline. We also consider it to be associated with forage species composition, differed from the ocean one, mainly the young shelf fish species with carangidae dominating. Spawning tuna occurrence in the area of deep and shallow thermocline does not confirm the suggestion by Yanez and Barbieri (1980), that thermocline depth should be of major importance for reproductive activity ("l'activite sexuelle...") of yellowfin tuna. Evidently that the absence of such relation may explain the broad spawning area for the species, with such necessary elements as temperature favourable for spawning in the epipelagical layer and high productivity.

### Conclusions

Hypothesis on adult yellowfin tuna availability for long-line and purse fisheries relation with gonad state was analysed by means comparative histological analysis of ovaries and oocytes in long-line and purse females. Comparison of oocyte state during preovulatory changes is of particular interest because the hypothesis suggests the differences occurrence in the moment of preparing for spawning. The comparative analysis is facilitated by the histomorphological diagnostics of maturity process separate stages. The investigation shows the occurrence of females with oocytes at the same maturity stage both in long-line and purse fisheries depth, including females with ovulated eggs, which were only in purse samples. The data obtained do not confirm the opinion that tuna availability for both fisheries is related with different stage of gonads. The practice of Soviet long-line and purse fisheries confirms the traditional points of view that tuna availability for both fisheries is determined by the upper thermocline location. Deep thermocline determines the wide depth range of vertical migrations in the first case and shallow one determines the narrow range in the second case. Prespawning female occurrence in both cases suggests that the depth of shift layer is not major feature of spawning areas. The determinative factor is represented by conditions favourable for spawning in epipelagical layer and sufficient forage basis.

### References

1. Batalyants K. Ya., 1975. Reproductive peculiarities of some tropical Scombridae in the Atlantic Ocean. Kaliningrad. Trudy AtlantNIRO. No. 58: 193-196.
2. Batalyants K. Ya., 1991. On study of spawning frequency for bigeye (*Thunnus obesus*) and yellowfin (*Thunnus albacares*), based on the Atlantic long-line fishery data. ICCAT, SCRS/91/60:12.
3. Cayre P., 1986. Review of the Gonad Index (GI) and introduction to the concept of its "critical value": application to the skipjack tuna *Katsuwonus pelamis* in the Atlantic Ocean, Mar. Biol., 90, No 3: 345-351.
4. Hisada K., 1973. Investigations on tuna hand-line fishing ground and some biological observations on yellowfin and bigeye tunas caught in the northwestern Coral Sea. Bull. Far Seas Fish. Res. Lab., No.8: 35-69.
5. Koido T., Suzuki Z., 1989. Main spawning season of yellowfin tuna, *Thunnus albacares*, in the western tropical Pacific Ocean, based on the gonad index. Bull. Far Seas Fish. Res. Lab., No.26: 153-163.
6. Paliy N. F., 1969. On the problem of optimal depths and temperatures for yellowfin tuna fishery (*Thunnus albacares*). Kaliningrad. Trudy AtlantNIRO. Issue XXV, pp. 120-125.
7. Sund P. W., Blackburn M. and Williams Fr., 1981. Tunas and their environment in the Pacific Ocean: A Review. Oceanogr. Mar. Biol. Ann. Rev., 19: 443-512.
8. Suzuki Z., 1988. Study of interaction between long-line and purse seine fisheries on yellowfin tuna, *Thunnus albacares*, (Bonmat.). Bull. Far Seas Fish. Res. Lab., No. 25: 73-139.
9. Torin Yu. A., Maksimov V. P., 1969. Selection of optimal drift period for a long-line in tuna fishery. Kaliningrad. Trudy AtlantNIRO. Issue XXV, pp. 130-134.
10. Yanez R. E., M. A. Barbieri B., 1980. Analyse de la prise par unite d'effort "saisoniere" et de l'evolution de l'indice gonado-somatique de la peche palangriere (1956 à 1977) et de surface (1969 à 1978) du yellowfin (*Thunnus albacares*) de l'Atlantique. ICCAT CVSP, 9/1/: 76-91.
11. Zharov V. L., 1969. Yellowfin tuna reproduction (*Thunnus albacares* Bonnat) in the Atlantic Ocean. Kaliningrad. Trudy AtlantNIRO. Issue XXV, pp. 41-62.

Table 1

Hystomorphological characteristics and diameter of yellowfin tuna oocytes at successive stages of prevulatory changes

Stage	Oocyte hystomorphological characteristics	Oocyte diameter (mm)
1	Oocyte filled with yolk inclusions, small fatty vacuolies in nuclear zone	0.45-0.50
2	Small fatty vacuoles of nuclear zone joint into large ones	0.50-0.60
3	Large fatty vacuoles joint into fatty droplet, nuclear begins to migrate towards animal pole	0.60-0.62
4	Yolk inclusion hydration at vegetative pole	0.62-0.70
5	Hydrated yolk homogenization in the vegetative half of oocyte, yolk hydration in nuclear zone	0.70-0.80
6	Yolk homogenization over entire oocyte volume	0.80-0.87
7	Nuclear dissolved, fatty droplet moves under oocyte membrane. In preparation oocytes remain rounded	0.87-0.90
8	Homogenization yolk transfers into more liquid aggregative condition. In preparations oocytes are of irregular polygonal form	0.90 and over
9	Ovulation	

Table 2

Maturity stages of yellowfin tuna females in long-line catches from various fishing areas in the Atlantic Ocean (February-May 1990)

Area	Date	Maturity stage of ovaries						%
		II	III	IV	IV-V	V	VI-IV	
1	01.02-	-	1	13	22	-	64	100
	15.02	-	1.0	13.0	22.0	-	64.0	100
2	17.02-	-	1	10	49	-	84	145
	05.03	-	0.7	6.9	33.8	-	57.9	0.7 100
3	08.03-	15	22	13	36	-	45	3 134
	18.03	11.2	16.4	9.7	26.9	-	33.6	2.2 100
4	20.03-	4	2	3	66	-	17	- 92
	26.03	4.3	2.2	3.3	71.7	-	18.5	- 100
5	27.03-	46	49	31	136	-	88	54 404
	09.05	11.4	12.1	7.7	33.7	-	21.8	15.3 100
	%	7.4	8.6	8.0	35.3	-	34.1	6.6 100

Table 3

Oocyte occurrence at various stages of prevulatory changes in ovaries of yellowfin tuna females from long-line and purse catches. Average GI are given in brackets

Stages	Females from long-line catches			Females from purse catches		
	Index	%	GI	Index	%	GI
2	128	67.7	3.07	1	11.1	4.7
3	51	27.0	3.36	4	44.5	4.7
4	1	0.53	2.60	-	-	-
5	2	1.1	2.80	1	11.1	4.5
6	5	2.63	4.07	1	11.1	4.4
7	1	0.53	1.67	-	-	-
8	1	0.53	7.87	1	11.1	4.01
9	-	-	-	1	11.1	7.87
	189	100.0		9	100.0	

Fig. 1. Areas of yellowfin tuna ovaries sampling at long-line fishery in the Atlantic Ocean in January-May, 1990.

