

THE DYNAMICS OF MATURATION AND SEX RATIO OF BIGEYE TUNA (THUNNUS OBESUS, LOWE) IN THE ATLANTIC OCEAN

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SUMMARY

Seasonal dynamics of maturation, sex ratio of bigeye tunas in different areas of the Atlantic Ocean and correlation between their populations in space and time are considered based on the materials for the 1966-1979 period.

RESUME

En se basant sur le matériel obtenu pour les années 1966-1979, on a étudié la dynamique saisonnière de maturité, le sex ratio du thon obèse dans diverses zones de l'océan Atlantique et la corrélation entre leurs populations dans l'espace et dans le temps.

RESUMEN

En base a la información disponible respecto al periodo 1966-1979, se estudia la dinámica estacional de la madurez y sex ratio del patudo en diferentes zonas del Atlántico y la correlación espacio-temporal entre sus poblaciones.

Introduction

The bigeye tuna is one of the least studied tuna species of the Atlantic Ocean. The annual bigeye tuna catches from the Atlantic amounted to 40-60 thous. tons during the recent decade (ICCAT, 1981). This catch size makes it possible to suggest that the exploitation level of the bigeye tuna stocks approached the maximum allowable level (Weber, Sacagawa, 1978, Kume, 1980). A discussion on isolation of stock units and population structure of this species is continued. The investigations of the oogenesis and sexual cycles of the bigeye tuna showed that sexual cycles of tuna groupings inhabiting the northern and southern hemispheres are in counterphase (Alekseev, Alekseeva, 1981), which may be considered as the evidence of existing of two bigeye tuna populations in the Atlantic. A number of questions, however, concerning the spacial and temporal correlations between the populations, and migration cycles of the species, are open. In the present paper some of these aspects are considered based on the analysis of sexual maturation of the bigeye tuna.

Materials and Methods

The analysis was based on the biological data collected during the long-lining expeditions conducted in the 1965-1975 period. During this period 31 804 tuna specimens were examined. For the analysis the material was separated into areas with regard for the break-down of the areas adopted in the ICCAT for the bigeye tuna fishing with long lines. In particular, the area 4 is isolated in the western part of the Gulf of Guinea north of the equator, and the western boundary of the areas 4 and 5 passes along 15°W (fig. 1). This is done to provide the convenience of the analysis and to maintain the integrity of the material.

Maturity stages were determined according to the following scale:

Stage 1 - juvenile specimens. Gonads undeveloped, ribbon-like. Sex cannot be identified even on thorough examination.

- Stage 1 - immature specimens. Ovaries elongated, thin. Testicles very thin, flat and ribbonlike. Sex can be identified on thorough examination.
- Stage 2 - early maturation stage. Ovaries enlarged, separate oocytes can be seen with the naked eye. Testicles enlarged, triangular on cross-section, sperm is not available in the central duct.
- Stage 3 - late maturation stage. Ovaries enlarged, oocytes can be seen with the naked eye. Sperm runs if the testicle is pierced or pressed.
- Stage 4 - mature or running. Ovary very enlarged, oocytes transparent, can be easily separated from follicles or are lost in the ovary cavity. Sperm freely runs from spermagonium.
- Stage 5 - spawned. Includes both recently spawned specimens and those spawned relatively long ago. Ovaries contain the residual ripe oocytes, and ripe oocytes at different resorption stages. Testides soft, bloodshot, their surface reddish or grey. Central duct contains little sperm or none.

Most difficulties are encountered ⁱⁿ differentiation between the gonads of the mature fish, which are sexually inactive and the gonads of the immature fish.

1. Change of the Sexual Maturity State During the Year

In areas 1 and 2 only sexually inactive, postspawning and immature specimens were recorded (fig. 2). These areas north of 15°N are feeding grounds for the bigeye tuna. A similar picture is also observed in the southern hemisphere south of 15°S in area 6 (fig. 3). Greater number of specimens with the gonads at maturation stage were recorded in November-December. The same situation both in these areas and off the Brazilian coast was observed by Kume, Morita (1976), who studied the sexual maturity using the gonad index.

In area 3, in May-August, the zone of high bigeye tuna abundance recorded at 03-10°N, 30-40°W. The dynamics of the state of sexual products of the bigeye tuna in this area is shown in fig. 4. The accumulation of pre-spawning specimens begins in April-May, the spawning reaches the peak in June-August, and comes to an end in September-October. In November-December the spawners are practically absent from the area.

In the southern hemisphere the massive spawning of the bigeye tuna is confined to 03-10°S, 05-15°W (area 5). The spawning there begins in December, reaches the peak in January-March and closes in April (fig. 5). There is a good agreement between the data on the dates of the massive spawning in areas 3 and 5 and seasonal distribution of the larvae (Richards, 1969; Richards, Simmons, 1971).

More than once it had been suggested that the northern and southern populations were likely to mix (Kume, Morita, 1977), that the reproductive areas of these groupings partly overlap in the south-eastern part of the tropical Atlantic, and even that a single group of the bigeye tuna might exist in that area (Alekseev, Alekseeva, 1981).

The analysis of the annual observations on the state of sexual products in area 4, which is likely to be the region where the populations mix, showed that in December-April the tunas with immature gonads were usually caught there, and in May-November the specimens at pre-spawning and spawning stages were mainly recorded (fig. 6). Since the massive spawning does not take place in this area, although the number of pre-spawners there exceeds 60%, it can be suggested that the maturity specimens migrate to the locations of massive spawning in area 3. Thus, the sexual cycle of the northern bigeye tuna population is on the whole characteristic of the group inhabiting area 4, which is indicative of belonging of this group to the northern population.

In some years, however, in particular, in January-April 1966 and in December 1970, the specimens at the spawning stage were caught in that area, which belong to the southern popula-

tion by the sexual cycle (fig. 7). In the same periods the tunas of the northern population were actually absent from the catches.

The collections of the larval bigeye tunas taken in February-April in the northern part of the Gulf of Guinea and off the West African coast can be attributed to the fact that the spawning specimens of the southern population penetrated into the northern hemisphere (Richards, 1969; Richards, Simmons, 1971).

In this case, the larvae can be regarded as a connecting link providing the exchange of the gene flow between the populations, which prevents from appearing too strong differences between these populations. Therefore, area 4 is not a zone, where the populations mix, but rather a boundary zone, where the exchange of the genetic information takes place between the populations at the larval level.

Since the spawning of the specimens from the southern population in the northern Gulf of Guinea is sporadic, it does not exert a serious influence on the self-dependence of the populations. The subsurface Lomonosov's Countercurrent flowing at the depth range between 30-50 m and 200-300 m (Khainachenko, 1979), where the bigeye tunas occur (Torin, 1969), is likely to be a natural border dividing the populations. Evidently, penetration of the specimens of the southern population into the boundary zone becomes possible only in definite years under favourable environmental conditions, and also in the years, when very strong year classes form spawning aggregations.

2. Sex Ratio

Sex ratio (the ratio of males to females) of the bigeye tunas differs by area and month. On the whole, the males outnumber the females in all the areas, except for area 2, and the number of males in the spawning grounds exceeds that in the feeding areas (Table 1). This can be attributed to the fact that the spawning of males is more prolonged, and they stay in the spawning grounds for longer time period than females.

Conclusion

Ripening of gonads of the bigeye tuna in the northern hemisphere begins in April, and the spawning takes place in May-August. The spawners concentrate in the area between 03-10°N and 30-40°W. In the southern hemisphere the massive spawning occurs in December-April in the zone between 03-10°S and 05-15°W. North of 15°N and south of 15°S only post-spawning, immature-sexually inactive specimens are found. The area between 0-10°N and 0-15°W is a boundary zone between the northern and southern populations, where in some years the exchange of the gene flows may happen between the populations at the larval level. Adult specimens of the populations are dissociated in space and time. Almost in all the areas of the Atlantic the males outnumber the females. This ratio is greater in the spawning grounds than in the spawning areas.

Reference

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Table 1

Sex Ratio of Bigeye Tunas

Area	1	2	3	4	5	6
Month						
January				2.07	1.33	
February		0.60		1.75	1.91	
March		0.88		1.84	1.30	
April			1.53	1.79	0.94	
May	1.13	1.15	1.97		6.63	
June	1.00		1.90		2.02	
July	2.86		1.64		2.02	1.14
August			1.50		1.76	1.02
September			1.58	1.23	2.62	1.46
October		1.06	1.46	2.53	2.07	1.80
November		1.13	1.37	1.43	2.17	1.83
December		0.71	2.15	2.03	1.23	1.12
Σ	1.67	0.89	1.72	1.75	1.88	1.35

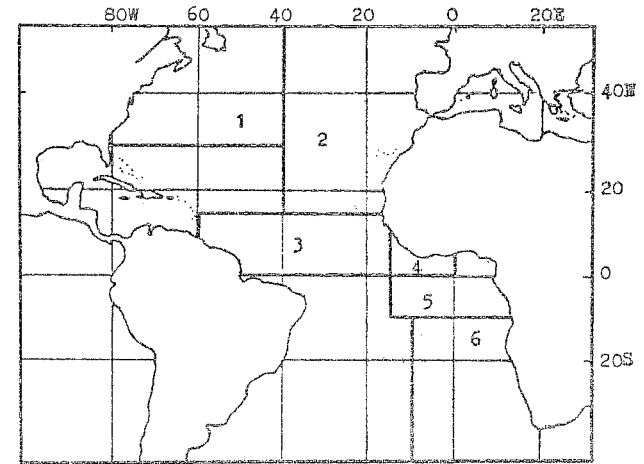


Fig. 1. A scheme of break-down by areas-

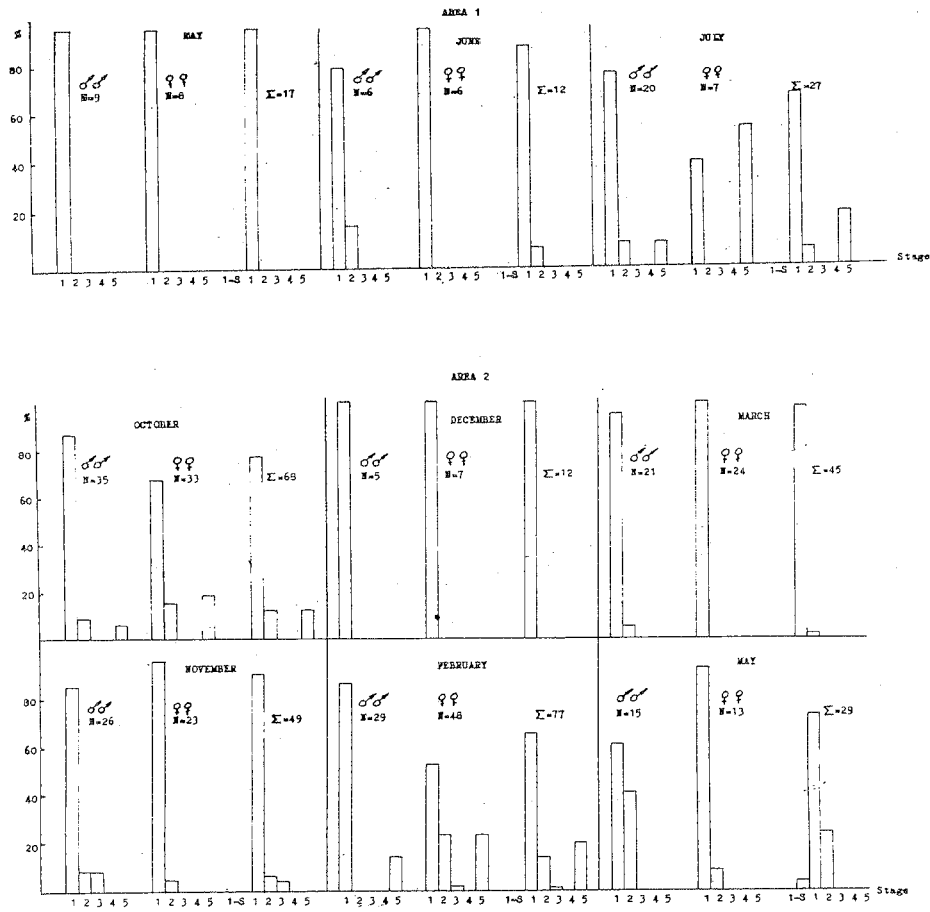


Fig. 2. Sexual maturity of bigeye tuna in areas 1 and 2.

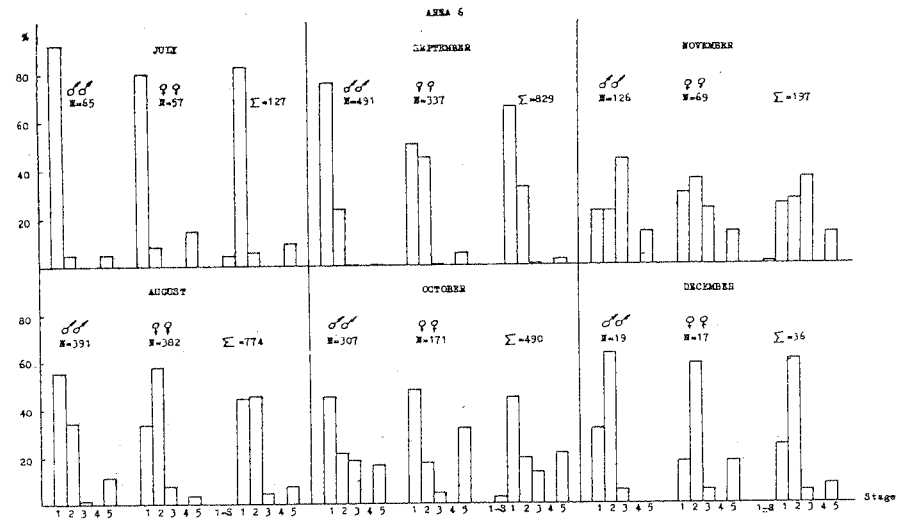


Fig. 3. Sexual maturity of bigeye tuna in the area 6.

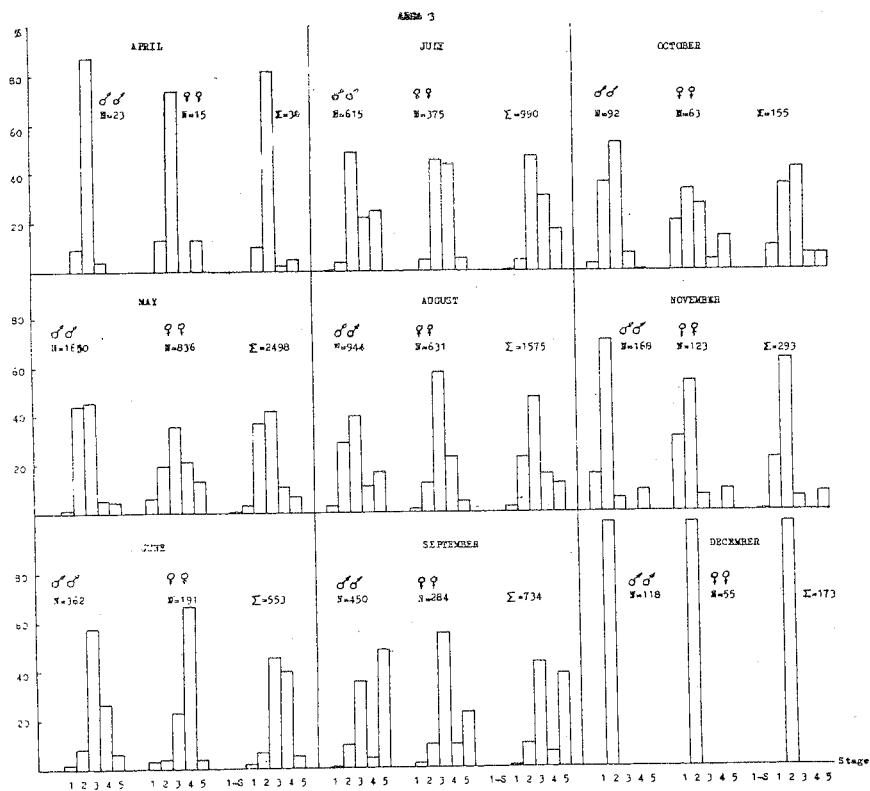


Fig. 4. Sexual maturity of bigeye tuna in the area 3.

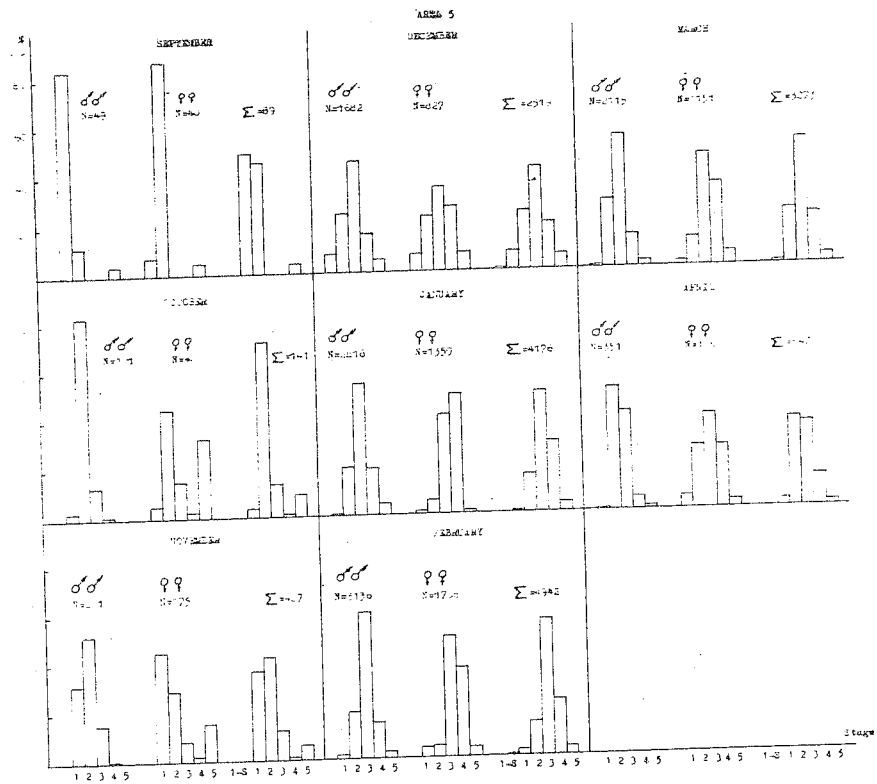


Fig. 5. Sexual maturity of bigeye tuna in the area 5.

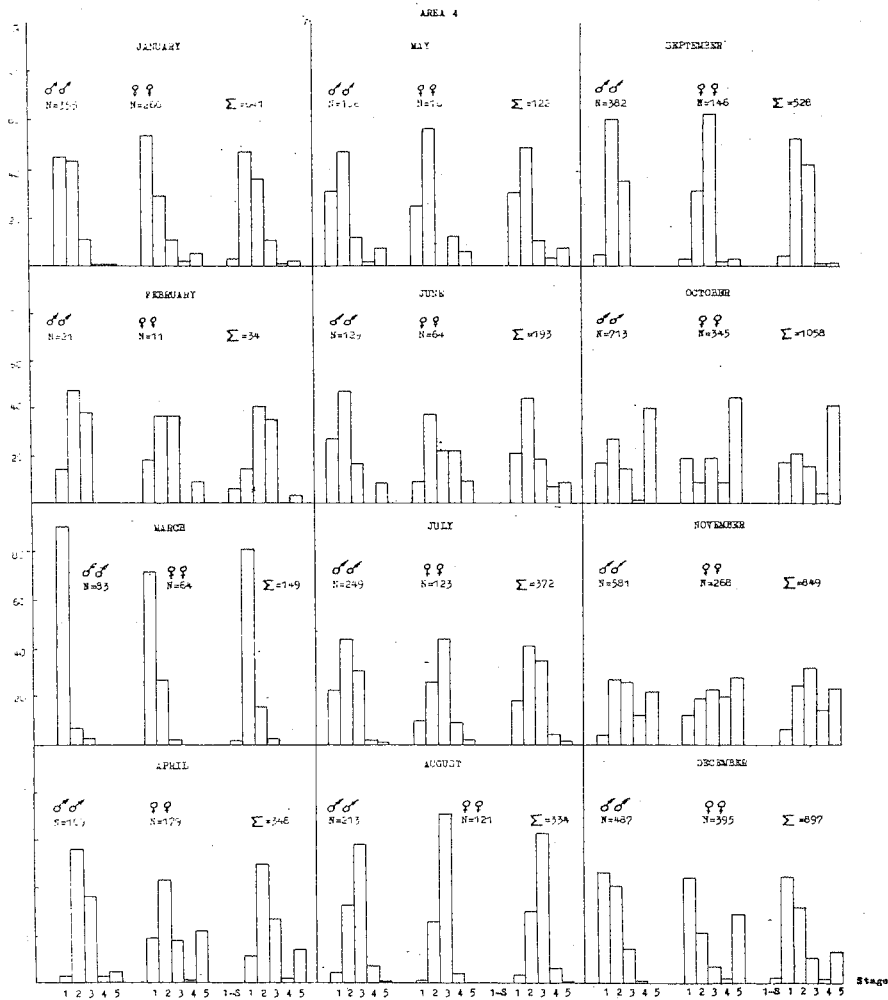


Fig. 6. Sexual maturity of bigeye tuna in the area 4.

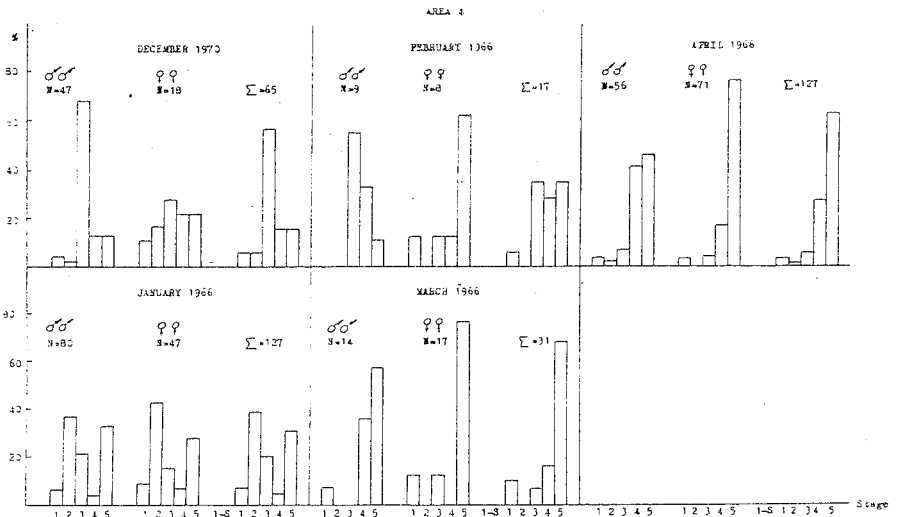


Fig. 7. Sexual maturity of bigeye tuna belonging to the southern population in the area 4.