SCRS/1975/094 Col.Vol.Sci.Pap. ICCAT, 5 (2): 297-301 (1976)

VARIATION IN SEX RATIO, SIZE DIFFERENCES BETWEEN SEXES, AND CHANGE IN SIZE AND AGE COMPOSITION IN WESTERN NORTH ATLANTIC GIANT BLUEFIN TUNA (THUNNUS THYNNUS)

by

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INTRODUCTION

The sex ratio of large adult bluefin tuna (Thunnus thynnus) varies with season and locality in the western Atlantic. According to data obtained from various sources, males and females occur together during the spring in the Gulf of Mexico, the Straits of Florida, the Yucatan Channel, the Windward Passage, and the northern Caribbean Sea (Fig. 1). At that time (April through early June), the fish are spawning and females are about two or three times as numerous as the males. Evidence of occurrence and spawning in the above areas and season has been summarized by Richards (MS.). After spawning, these fish, at least those occurring in the Straits of Florida, presumably migrate northward (Rivas, 1955; Wise and Davis, 1973) and spend the summer and early fall off the coasts of New England and Canada (Fig. 1). There is evidence, however, indicating that males greatly outnumber females among the giant fish occurring in northern waters during July through October.

Length, weight, and sex data on western Atlantic giant bluefin tuna indicate that males average 4 percent longer and 13 percent heavier than females. During the course of this study it was also discovered that, in recent years, both males and females have become increasingly larger and that, in the Bahamas, the larger males, once about as numerous as the larger females, are now less than half as numerous.

This study is based on a total of 296 giant bluefin from the Bahamas (May) and from the Gulf of Maine (July) as shown in Tables 1, 2, and 3. Sex was not adequately determined for the 29 specimens measured and weighed in the Bahamas in 1974 and these are, therefore, only included in Table 3.

VARIATION IN SEX RATIO

A total of 129 giant bluefin, 200 to 257 cm in fork length and 135 to 339 kg. in weight, was examined by me in the Straits of Florida (Bahamas: Bimini and Cat Cay) during May of 1952 through 1955 (Table 1). Of these 40 (31%) were males and 89 (69%) were females giving a male-female ratio of 1:2.2 for the four years combined. In 1952 the male-female ratio was 1:2.5 (10 males; 25 females), 1:2.8 (8 males; 22 females) in 1953, 1:1.6 (11 males; 18 females) in 1954, and 1:2.2 (11 males; 24 females) in 1955. In May 1966 Mather (pers. comm.) examined a total of 109 fish in the same area. Of these 29 (27%) were males and 80 (73%) were females giving a male-female ratio of 1:2.8.

In May of 1972 and 1973 additional sex determinations of giant bluefin tuna were made in Bimini and Cat Cay (Table 1). A total of 58 specimens, 213 to 286 cm and 148 to 379 kg., was examined of which 16 were males and 42 were females giving a male-female ratio of 1:2.6 for the two years combined. This ratio is not too different from the 1:2.2 ratio given above for the combined seasons of 1952 through 1955 and for 1966.

A combination of the Bahama seasons of 1952-1955, 1966, and 1972-1973, comprising 85 males and 211 females, gives a male-female ratio of 1:2.5 with a range of 1:1.6 to 1:3.5.

Bullis and Mather (1956) determined the sex of 13 giant bluefins taken in the Windward Passage in late April 1955 (Table 1). Of these, three were males and 10 were females giving a male-female ratio 1:3.3. This ratio is higher than the ratio of 1:2.2 obtained for the Bahamas in 1952-1955 but the difference may be due to the much smaller sample.

In the Gulf of Maine, and off Nova Scotia and Newfoundland, male giant bluefin tuna greatly outnumber females (Table 1). These large fish occur in this area only during July through October and, as already indicated, most or all of them apparently come from the Straits of Florida.

Every one of the 30 specimens examined by Crane (1936) during the latter part of July was a male. These fish were taken off Portland, Maine. All the nine giant bluefins from Wedgeport, Nova Scotia, examined by me in 1952 and 1953 (Rivas, 1955) were males. In July and August, 1974, 75 specimens from the Gulf of Maine were examined, 65 of which were males and 10 were females giving a sex ratio of 1:0.2. Butler (1971) examined 106 giant fish taken in Conception Bay, Newfoundland during July through September of 1966. Of these, 67 were males and 39 were females giving a male-female ratio of 1:0.6. A combination of all these data from northern waters yields a total of 220 specimens of which 171 (78%) were males and 49 (22%) were females giving a male-female ratio of 1:0.3.

As pointed out by Butler (1971) it would be premature, in the light of the present information, to speculate on the possible reason for sex ratio reversal between southern and northern waters. The data available, however, shows that few females occur in the Gulf of Maine (including southwestern Nova Scotia) and that females are more numerous farther north.

To summarize, the available data show that, in the Straits of Florida (May) females are more than twice as numerous as males but that in northern waters (July through October) males are almost seven times as numerous as females in the Gulf of Maine and nearly twice as numerous off southeastern Newfoundland (Fig. 1). This strongly indicates that perhaps all, or most of the males, migrate from southern to northern waters but that most of the females go elsewhere after leaving the Straits of Florida. Sex segregation into separate areas, outside of the spawning season, is known to occur in other large pelagic fishes such as the blue marlin (Makaira nigricans) (Rivas, 1975). There is also evidence of sexual segregation in the black marlin (M. indica) off the Pacific coast of Central and South America.

LENGTH AND WEIGHT DIFFERENCE

As shown in Table 2 the mean length of males from the Bahamas was 234 cm and that of females 227 cm for the four years 1952-1955 combined. For this period, therefore, males were three percent longer than females. For the combined two years 1972 and 1973 males were five percent longer with a mean length of 259 cm versus 247 cm for the females. In 1974, in the Gulf of Maine, males had a mean length of 261 cm and were six percent longer than the females whose mean length was 246 cm.

In the Bahamas the mean weight of males was 225 kg. and that of females 193 kg. for the four years 1952-1955 combined. For this period males were 14 percent heavier than females. For 1972 and 1973 males were 15 percent heavier with a mean weight of 283 kg. while that of females was 238 kg. In 1974, in the Gulf of Maine, males had a mean weight of 302 kg. and were 11 percent heavier than the females whose mean weight was 270 kg.

On the average, therefore, although males are only four percent longer than females, they are 13 percent heavier.

LENGTH AND WEIGHT INCREASE

The length and weight difference between males and females from the Bahamas has not changed appreciably during the past 22 years but the length and weight have significantly increased in both sexes. As shown in Table 2, during the intervening 16 years, between 1955 and 1972, the mean length of males has increased by 10 percent (25 cm) and that of females by eight percent (20 cm). The mean weight of males has increased by 20 percent (58 kg) and that of females by 19 percent (45 kg).

CHANGE IN AGE COMPOSITION

Because the length-weight ratio of giant bluefin is subject to wide seasonal variations (Rivas, 1955), length is a more reliable indicator of age than weight. According to age and growth studies by Mather and Schuck (1960) and by Mather et al. (MS.) the mean length of 234 cm. for males in 1952-1955 (Table 2) would correspond to the age of 12 years and that of 259 cm for 1972-1973 and 261 cm for 1974 to the age of well over 14. For females, the mean length of 227 cm in 1952-1955 would correspond to the age of 11 years and that of 247 cm for 1972-1973 and 246 cm for 1974 to the age of 14. In Mather and Schuck's paper the sexes were not separated but, as shown in the first section of this study, males are significantly longer than females. The intervals between mean lengths given by these authors for the ages 12 to 13 (9 cm) and 13 to 14 (5 cm) are about equal to, or less than, the difference between the mean lengths of males and females in 1952-1955 (7 cm), 1972-1973 (12 cm), and 1974 (15 cm).

It is obvious from the above discussion that males and females have to be aged separately but, by combining the lengths of both sexes, Mather and Schuck's findings may be applied as follows. For 1952-1955 the mean length for both sexes combined was 229 cm corresponding to the age of between 11 and 12, and for 1972-1974 it was 254 cm corresponding to the age of well over 14. Broken down by years, the mean length of both sexes combined was 227 cm in 1952, 229 cm in 1953, 232 cm in 1954, and 227 cm in 1955. These lengths correspond to the age of between 11 and 12 for each of the four years. The mean length of both sexes combined was 250 cm in 1972 and in 1973 corresponding to the age of 14 or 15, and 259 cm in 1974 corresponding to a much older age. Table 3 gives the frequency distribution of Bahamas fish, both sexes combined, by lengths corresponding to, or nearest to mean lengths given for ages 10 to 14 by Mather et al. (1974). Mean lengths and ages beyond 248 cm (14 years) are my own tentative extrapolations of Mather et al.'s data.

It is tentatively concluded from the above discussion and from Table 3 that 11 and 12 were the dominant age groups in the Bahamas during 1952-1955 and 17 and older in 1972-1974. Table 3 also shows that, in 1952-1955, there were not many fish older than 13, whereas in 1972-1974 most of the fish were older than 13. For the period 1972-1974 there is a distinct mode at 13 and another at 17 and older. Not so for the 1952-1955 period where there is only one distinct mode at 11.

The 1952-1955 frequency distribution is more indicative of a balanced population, in terms of age composition, than that for 1972-1974. This suggests that, either the 10 and 11 age groups are now nearly gone and/or that the rate of growth has accelerated considerably during the past 15 or 20 years.

CHANGE IN SIZE COMPOSITION OF LARGER MALES AND FEMALES

Rodriguez-Roda (1960) gave the length frequency of 145 giant bluefin, 200 to 255 cm in fork length, taken at Barbate, Spain during the combined years of 1956, 1957, and 1958. All the specimens 235 cm or larger were males with the exception fo a 240 cm female.

In trying to verify the above findings for the Bahamas it was found that, for the period 1952-1955, of 42 individuals 235 cm or longer 21 (50%) were males and 21 (50%) were females. For the period 1972-1973, however, of 53 individuals 235 cm or longer only 15 (28%) were males and 38 (72%) were females.

The above data show that, in 1952-1955, the larger males and females, 235 cm or longer, were equally numerous but that in 1972-1973 the larger males were less than half as numerous as the larger females. On the basis of this and the size and age composition changes discussed in the preceding sections it is tentatively concluded that giant bluefin tuna, especially the males, have been overfished during recent years. This

agrees with findings, as discussed in the first section of this study, that mostly males occur off New England and Canada where the heaviest fishing pressure takes place.

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TABLE 1. Sex ratios of western Atlantic giant bluefin tuna in the Straits of Florida, the Windward Passage, the Gulf of Maine, and Newfoundland.

YEAR	MONTH	N	MALES (M)	FEMALES (F)	M-F RATIO	SOURCE
STRAITS OF FLORIDA						
1952	May	35	10 (29%)	25 (71%)	1:2.5	Rivas (field data)
1953	May	30	8 (27%)	22 (73%)	1:2.8	Rivas (field data)
1954	May	29	11 (38%)	18 (62%)	1:1/6	Rivas (field data)
1955	May	35	11 (31%)	24 (69%)	1:2.2	Rivas (field data)
TOTALS (1952-55):		129	40 (31%)	89 (69%)	1:2.2	
1966	May	109	29 (27%)	80 (73%)	1:2.8	Mather (field data)
1972	May	9	2 (22%)	7 (78%)	1:3.5	NMFS (field data)
1973	May	49	14 (29%)	35 (71%)	1:2.5	NMFS (field data)
TOTALS (1972-73):		58	16 (28%)	42 (72%)	1:2.6	
TOTALS (STRAITS OF FLORIDA)		296	85 (29%)	211 (71%)	1:2.5	
WINDWARD PASSAGE						
1955	April	13	3 (23%)	10 (77%)	1:3.3	Bullis & Mather (1956)
GULF OF MAINE						
1936	July	30	30 (100%)	0 (0%)	1:0.0	Crane (1936)
1952-53	Aug/Oct.	9	9 (100%)	0 (0%)	1:0.0	Rivas (1955)
1974	Jul/Aug	75	65 (87%)	10 (13%)	1:0.2	NMFS (field data)
NEWFOUNDLAND						
1966	Jul/Sep.	106	67 (63%)	39 (37%)	1:0.6	Butler (1971)
TOTALS (GULF OF MAINE AND NEWFOUNDLAND)		220	171 (78%)	49 (22%)	1:0.3	

TABLE 2. Lengths (cm) and weights (kg) of male and female giant bluefin tuna from the Bahamas (Bimini and Cat Cay) and the Gulf of Maine (Bailey Island).

	BAHAMAS									
	LENGTH						WEIGHT			
	MALES			FEMALES			MALES		FEMALES	
YEAR	N	RANGE	$\bar{X}$	N	RANGE	$\bar{X}$	RANGE	$\bar{X}$	RANGE	$\bar{X}$
1952	10	222-251	236	25	211-249	224	184-259	229	135-253	187
1953	8	218-250	232	22	204-244	228	182-280	213	145-245	200
1954	11	200-255	233	18	213-249	232	155-339	227	152-269	203
1955	11	216-257	235	24	210-249	224	184-311	229	154-276	186
1952-55:	40	200-257	234	89	204-249	227	155-339	225	135-276	193
1972	2	262-274	268	7	238-252	245	283-379	331	209-260	226
1973	14	213-286	258	35	224-274	247	148-346	276	173-310	240
1972-73:	16	213-286	259	42	224-274	247	148-379	283	173-310	238
					GULF OF MAINE					
1974	20	246-274	261	9	221-269	246	256-357	302	231-337	270

Table 3. Frequency distribution of Bahamas giant bluefin tuna (both sexes combined) by lengths corresponding to, or nearest to mean lengths given for different ages by Mather et al. (1974). Mean lengths and ages beyond 248 cm (14 yr) are my own tentative extrapolations of Mather et al.'s data.

		AGE AND MEAN LENGTH (CM)							
YEAR	N	10 YR 203	11 YR 224	12 YR 234	13 YR 243	14 YR 248	15 YR 252	16 YR 255	17 YR AND PLUS 257 AND PLUS
1952	35	5	18	7	1	3	1		
1953	30	2	15	8	3	1	1		
1954	29	3	6	12	5	2		1	
1955	35	3	18	6	5	2	—	—	1
TOTALS:	129	13	57	33	14	8	2	1	1
1972	9			1	3	1	2		2
1973	49	1	1	7	10	6	5	4	15
1974	31	—	—	2	4	2	3	2	18
TOTALS:	89	1	1	10	17	9	10	6	35

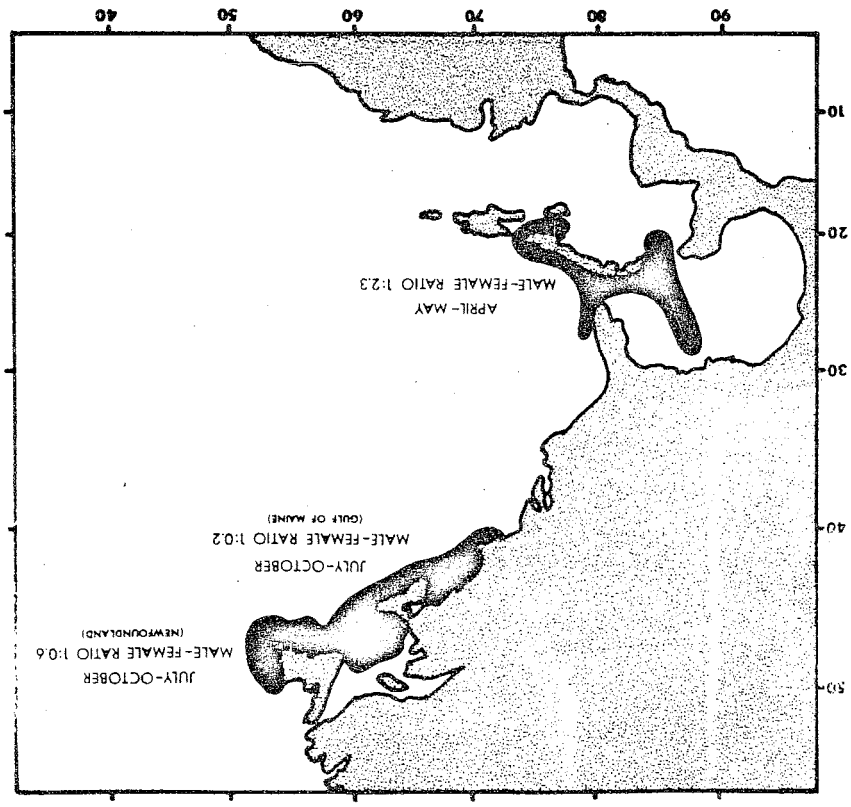

Figure 1. Geographic variation of sex ratio by season in western North Atlantic giant bluefin tuna.