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A Comparison between Giant Bluefin Tuna (*Thunnus thynnus*) from the Straits of Florida and the Gulf of Maine, with Reference to Migration and Population Identity¹

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Introduction

Ever since giant bluefin tuna (*Thunnus thynnus*) were discovered in the Straits of Florida, migrating northward during late spring along the edge of the Bahama Bank, speculations as to their destination after leaving the Bahamas have included various conjectures. Some have believed the fish followed the "Gulf Stream" all the way to Europe and others were of the opinion that they continue migrating towards the north, and are the same fish that arrive off the coasts of New England and Nova Scotia during the early summer. Few of these ideas, entertained mostly by anglers and fish guides, have ever been printed, and comments on the subject are mostly confined to the angling literature (Farrington, 1949; Mowbray, 1949). The possibility that the Bahama fish migrate to the north and may be the same as those occurring there later in the season has been recently suggested by Bigelow and Schroeder (1953) and by the writer (Rivas, 1954).

The destination of the bluefin tuna passing through the Straits of Florida constitutes an important element of their life history, both from the point of view of migration and population identity. If the Bahama fish are the same as those arriving in northern waters during early summer, two conclusions can then be formulated. First, that there is a seasonal migration from the south (Straits of Florida) to the north (Gulf of Maine). Second, that the Bahama fish form part of the population occurring in northern waters during the summer and fall. As a logical corollary, it could also be concluded that the fish return to the south after their sojourn in the north, to resume their yearly cycle. In addition, it is of interest to discover the reasons for such migrations and the manner in which they are effected.

The present study is a contribution towards the solution of the above problems. It represents the result of investigations conducted through a research fellowship made available to the University of Miami Marine Laboratory by the Charles F. Johnson Foundation, Inc. In addition to the Johnson

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Material and methods

Morphometric and meristic comparisons are based on 26 fresh-caught specimens, 1997—2493 mm in fork length, captured by anglers in the vicinity of Cat Cay, Bahamas, in May 16—29, 1952—1954, and 9 fresh-caught specimens 2059—2534 mm. in fork length, captured by anglers in the vicinity of Wedgeport, Nova Scotia, on October 3, 1952 and August 7—10, 1953. Of the 26 Bahama specimens, only 19 were fully measured and only counts were made on the remaining seven. All of the nine Wedgeport specimens were fully measured. The original measurements are given in Tables 8 and 9.

The methods used for measuring and counting are essentially those proposed by Godsil and Byers (1944) and Marr and Schaefer (1949), with the exception of certain modifications and additions introduced by the writer. The measurements made are listed below. The name of the measurements as designated by Marr and Schaefer (1949) is indicated in parenthesis.

First predorsal length (snout to insertion first dorsal). Second predorsal length (snout to insertion second dorsal). Prepectoral length: from tip of snout to insertion of erect, pectoral fin. Prepelvic length (snout to insertion ventral). Preanal length (snout to insertion anal). Origin of first dorsal to origin (insertion) of pectoral (pectoral insertion to insertion first dorsal). Origin of pelvic to vent: from the insertion of the erect pelvic (usually the left) to the anterior margin of the vent. Snout length: from its tip to the anteriormost point on the fleshy margin of the orbit. Mandible length: from its tip to the end of mandibular slit. Width of caudal peduncle at keels (greatest width caudal peduncle at keels). Height of first dorsal fin: from the origin of the erect first dorsal fin to its highest point. Height of second dorsal fin (length second dorsal). Height of anal fin (length anal). Length of pectoral fin (length pectoral). Length of pelvic fin: measured like the pectoral. Length of upper or lower caudal lobe: from posterior end of caudal keel to tip of lobe. Other measurements are self-explanatory or identical in name and method with those proposed by Godsil and Byers (l.c.) and Marr and Schaefer (l.c.)

Proportions are expressed in thousandths of the fork length (tip of snout to tip of middle caudal ray) and measurements (in millimeters) were taken with slide calipers, according to the procedure described by Godsil and Byers and Marr and Schaefer. The lateral measurements were usually taken on the left side of the fish.

Occurrence of giant bluefin tuna in the Straits of Florida and in northern waters

The periodical occurrence of spawning bluefin tuna in the Straits of Florida has been recently described by the writer (Rivas, 1954). In that study it was established that the migrating fish move along the Bahama side of the Straits of Florida in a northerly direction and that the migration lasts from

about the middle of May to the middle of June. It was also established that only large adult individuals weighing not less than about 300 pounds are involved in this migration (Table 2). It is obvious therefore, that only fish of equivalent size in northern waters will be considered as presumably arriving from the Straits of Florida. Bluefin tuna of this large size are usually referred to as "giant tuna" and occur in northern waters during the summer and fall along with smaller individuals (Crane, 1936; Westman and Gilbert, 1941; Westman and Neville, 1942; Bigelow and Schroeder, 1953). The whereabouts of these smaller fish during the period from about November through June are still unknown.

The periodical occurrence of giant tuna in northern waters from late spring through early fall has been common knowledge for many years (Crane, 1936; Heilner, 1937; Westman and Neville, 1942; Farrington, 1949; Bigelow and Schroeder, 1953). The species was first recognized by the herring fishermen as a giant mackerel-like fish "as big as a horse" (thence the name, "horse mackerel"), and later scientifically described by Storer (1867) as *Thunnus secundo-dorsalis*=*T. thynnus*, from specimens obtained at Cape Ann and Provincetown. In northern waters giant tuna occur from off New Jersey to the Gulf of Saint Lawrence, but they are much more abundant in the Gulf of Maine from Cape Cod to Nova Scotia (Bigelow and Schroeder, 1953). As to season, a survey of the literature and of records kept by angling clubs and commercial fishermen indicates that the fish usually arrive in northern waters during June and early July. They remain in these waters through early fall, and appear to be absent throughout the winter and early spring. Crane (1936) has pointed out that the first bluefin tuna appear off Portland, Maine in the latter part of June, are common in July and August and become scarce in September. They vanish altogether early in October.

Giant tuna congregate in the north to feed (Crane, 1936; Bigelow and Schroeder, 1953; Rivas, 1954), and the main feeding grounds extend from the Cape Cod area northward throughout the Gulf of Maine. Crane (1936) states that the bluefin tuna season off Portland, Maine, corresponds exactly to that of the herring and mackerel.

Correlation of migratory rate and direction with time and distance traveled

The chronological sequence involving the time of occurrence of the migration through the Straits of Florida (late spring) and the time of arrival of the fish in northern waters (early summer), correlated with the direction of the migration in the Straits of Florida (north) would seem to indicate that the fish travel from one point to the other. To add support to this assumption, however, it would be necessary to establish that distance and time are in reasonable agreement with migratory rate (in terms of distance traveled per unit of time) and that the possible cause for such a migration is in accordance with its effect.

The average migratory speed of tuna while moving through the Straits of Florida has been estimated by the writer at about 3.5 knots, on the basis of observations conducted in Bahama waters from surface vessels and from low-flying planes, during the seasons of 1951, 1952 and 1953.

The procedure followed from surface vessels was to keep a school in sight from as far away as possible, and follow it for the longest possible distance. The ground speed was obtained by comparison with the known ground speed

of the vessel. It should be pointed out that tuna schools in Bahama waters can be approached to within a very short distance without disturbing the direction or speed of the fish, provided the approach is effected slowly and without sudden changes of the engine's speed. Usually a distance of not less than about 50 yards was maintained, with the vessel to the side or ahead of the school and never behind. Observations were conducted during different times of the day and under various weather and ocean conditions, in the area between Riding Rocks and Bimini.

Time of day did not seem to have any effect on the fish movements, but fairly strong southerly winds caused them to move faster, and strong northerly winds to move slower. This effect of wind direction and force on the tuna has been well-known to anglers and guides in Bahama waters for many years.

The numerous observations conducted according to the procedure discussed above indicate that the traveling speed of bluefin tuna in the Straits of Florida varies from about three to five knots, with an average of about four knots.

The procedure followed from airplanes was to locate a school and follow it for the longest possible distance between two points of reference. The speed was obtained by dividing the distance travelled by the time taken by the fish to travel from one point to the other. For example, on April 24, 1952, a school of four fish was sighted directly west of Orange Cay at 1409 and followed to a point five nautical miles directly north of the island, where the fish were lost at 1539. It took the school one hour and 30 minutes to travel a distance of five miles, and the speed attained was therefore 3.3 knots.

The results obtained from aerial and surface observations are in agreement, but it must be pointed out that these observations have also shown that any given school of tuna may stop traveling for short periods of time and remain "milling around" in a given area, presumably engaged in the act of spawning. These stops do not appear to occur frequently and usually do not last for periods of much more than about two hours. On May 23, 1951, a milling school of about 100 individuals was sighted from a Coast Guard plane in shallow water about five miles southwest of Great Isaac lighthouse. It took the school two hours and 15 minutes to resume travel in the usual northward direction. Of all the observations conducted on stationary schools, this has been the longest.

Taking all the above factors in consideration, it is reasonable to assume that although a speed of about four knots was observed when the fish were actually traveling, an average rate somewhat less than this would be obtained in their migration through the entire northern part of the Straits of Florida. The distance between Riding Rocks and Manzanilla Shoals (Figure 1) is 135 nautical miles, and if the fish were constantly traveling at a speed of four knots, it would have taken them 34 hours to cover that distance. If it is assumed that the school stops for at least one period of about two hours during that time, the average speed for that distance would then be of 3.5 knots, corresponding to an average migratory rate of 84 nautical miles per day.

Obviously, the migratory speed of bluefin tuna is not known for the area between the Straits of Florida and northern waters, which these fish are assumed to traverse. If, as assumed, spawning is completed when the fish leave the Straits of Florida (Rivas, 1954), there is no reason to believe that they may stop again for that purpose on their way north. There is also no reason to believe that the hunger drive may increase migratory speed. It has been

recently shown (Rivas, 1954) that giant tuna feed little or not at all during their occurrence in the Straits of Florida. It would seem, therefore, that the fish, after a period of fasting and exhaustion resulting from spawning, would be eager to proceed to the feeding grounds in the north. The traveling speeds observed in the Straits of Florida, however, appear to be the same for schools assumed to be composed of spent fish (Rivas, 1954) and those assumed to be composed of ripe fish. In addition, it is reasonable to assume that the weakened condition of the fish would not be compatible with the expenditure of energy that would be required for sustained increased velocity in traveling the long distance (more than 1000 miles) to the north.

In order to correlate migratory rate with time and distance traveled, it is necessary to establish the time of arrival of the fish at a given point in the Florida Straits and in the north, and to establish the distance between these points. The choice of these points depends, of course, on the availability and reliability of records, and according to this criterion the most suitable points appear to be Cat Cay, on the Bahama side of the Straits of Florida and the Cape Cod area. In addition, the Cape Cod area represents, as already indicated, the beginning of the feeding grounds of the tuna. It would seem, therefore, that the fish do not stop or reduce their speed for feeding purposes before reaching the Cape Cod area. The distance between Cat Cay and Cape Cod is 1,150 nautical miles.

The time of arrival of giant tuna in the waters adjacent to Cat Cay has been recently discussed in detail by the writer (Rivas, 1954). In that study it was established, on the basis of surface and aerial observations, that although a few individuals arrive during late April, the bulk of the migration does not arrive in the area until about the middle of May. Examination of the records kept by Mr. John Mahony for Cat Key Club shows that the run began about May 18 in 1951, about May 12 in 1952, and about May 17 in 1953.

Dates of the first trap net catches of giant tuna in the Cape Cod area from 1947 through 1954 have been obtained by Frank J. Mather of the Woods Hole Oceanographic Institution and Howard Schuck, formerly of the U. S. Fish and Wildlife Service. These records have been made available to the writer (*in litt.*) and show that the earliest catches have occurred between May 25 (1953) and June 21 (1947). In six out of the eight years recorded, the earliest catches have occurred between May 30 and June 11, which would seem to indicate that the bulk of the migration arrives in the Cape Cod area usually during the first week of June.

If the distance between Cat Cay and Cape Cod is 1,150 miles, and the estimated migratory rate of the tuna is 84 miles per day, it would take the fish about 14 days to travel that distance. This is in agreement with the time of arrival of the fish in the Cat Cay area (middle of May) and later in the Cape Cod area (early June).

As to the direction of the migration when the tuna leave the Straits of Florida, it would seem that if the fish continued to travel in a northerly direction, they would strike the American coast in the vicinity of Charleston, South Carolina (Figure 1). However, at about 120 miles south of Charleston, the Florida Current turns towards the northeast. Since the fish are traveling with the current, it is to be expected that the change of direction of the current would also deflect their direction towards the northeast.

No giant bluefin tuna have ever been captured or seen between the Straits

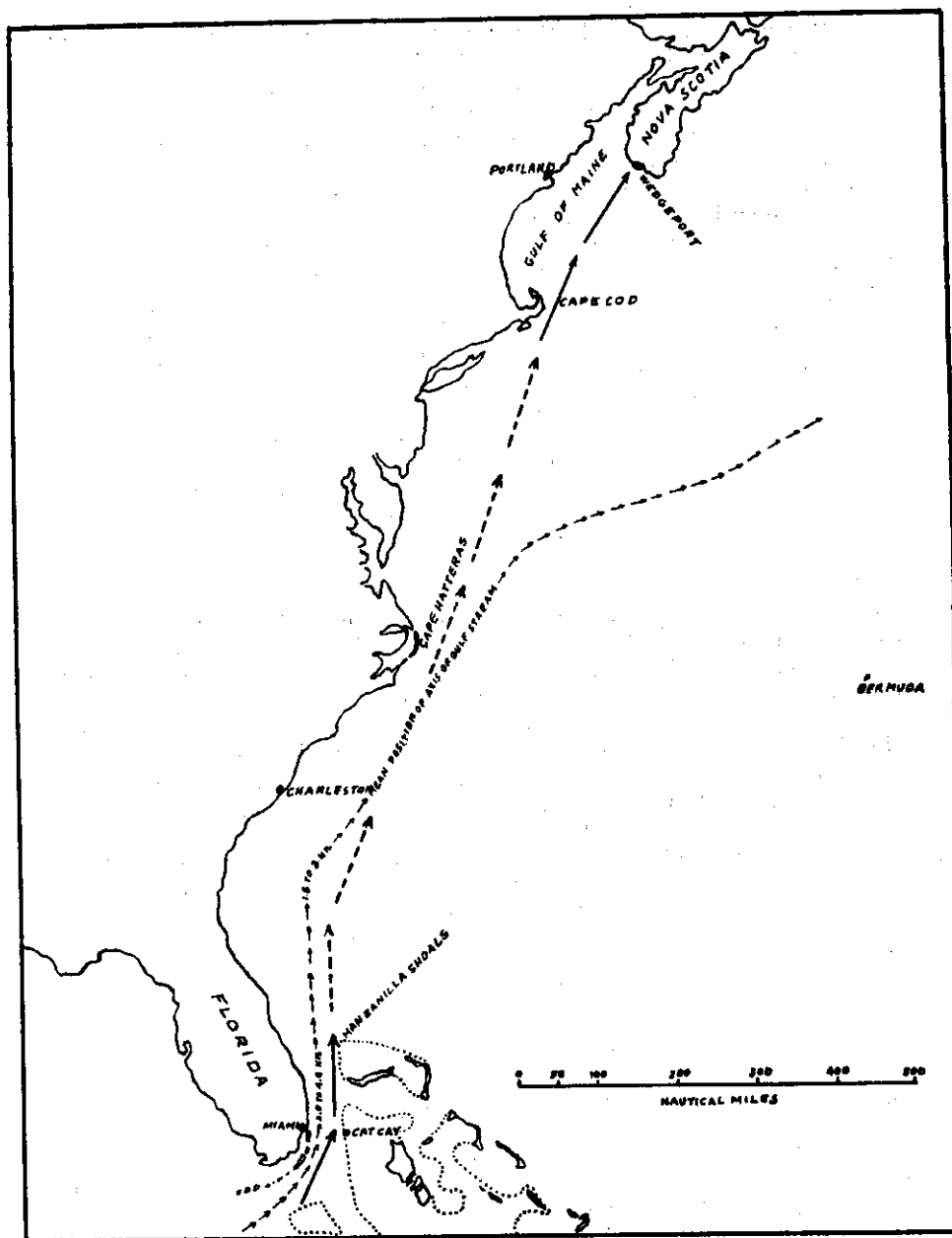


FIGURE 1.—East coast of North America from the Straits of Florida to Nova Scotia, showing the presumed migratory route (arrows) of giant tuna (*Thunnus thynnus*). Data on Gulf Stream from U. S. Navy Hydrographic chart No. 1411.

of Florida and northern waters, but this may be attributed to lack of exploration rather than to their absence there. Examination of a chart (Figure 1) would show that their assumed route would bring them relatively close to Cape Hatteras, at a distance of probably 30 to 150 miles east of the cape. It is possible that giant tuna have never been seen there because they may be traveling deep, as they and related species appear to do when occurring in deep water (Rivas, 1953).

As to the possible reasons for a northward migration immediately following spawning, it is obvious that its logical cause is in accordance with its effect. As already indicated, giant tuna appear to cease feeding during their spawning period in the Straits of Florida and it has been established in the present study that the feeding grounds are located in the north and that the fish are engaged in that activity during their occurrence in that area. In addition to the data already published on feeding habits (Crane, 1936; Bigelow and Schroeder, 1953; Rivas, 1954) and based almost entirely on stomach contents and size of the stomach, the chronological sequence of body condition is also in agreement with the time, cause and effect of the assumed migration, as discussed in the next section.

Correlation of body condition with time and place of occurrence

The giant tuna captured in the Straits of Florida are leaner in appearance and weigh less on the average than the fish from the northern feeding grounds (Tables 1 and 2). These conditions have been known for many years to anglers fishing both the Bahamas and northern waters, and appear to be correlated with decrease or cessation of feeding during spawning (Rivas, 1954) followed by intense feeding. Mowbray (1949) has already pointed out that the lean condition of bluefin tuna in the Bahamas might be due to spawning, and Bigelow and Schroeder (1953) state that "... they are much thinner in the spring in their more southern habitat than they are in summer to the northward."

If the giant tuna passing through the Straits of Florida are the same as those occurring later in the north, then the northern fish should be leaner upon arrival during the early part of the season and heavier towards the end. This change of body condition has been observed by anglers and commercial fishermen for years, and Crane (1936) states that when bluefin tuna appear off Portland, Maine, in the early summer (late June, early July), they are "always much thinner than later on." Table 1 shows the increase in weight of giant tuna from Wedgeport, Nova Scotia, for every season during the years 1947-1952. The weight records on which Table 1 is based were furnished by Mr. Elson Boudreau of the Wedgeport Tuna Guides Association. Every fish taken in the area from the smallest "school tuna" to the largest giant tuna is listed, with the date, weight and name of the angler throughout the season.

Although the Wedgeport fish are leaner during the early part of the season (July) than later on, they are already about 7.5 percent heavier than the Bahama fish, as shown in Table 2. This may be explained by their sojourn in the feeding grounds for a period of about a month, while moving from the Cape Cod area to Wedgeport. As already discussed, the tuna arrive in the Cape Cod area, presumably from the Bahamas, during early June, and according to the Wedgeport records they arrive in the latter area during early

TABLE 1.—Weight frequency distribution (pounds) of 1060 giant tuna (*Thunnus thynnus*) from Wedgeport, Nova Scotia, for July and September, 1947-1952, showing increase in weight during the season. The smallest fish weighed 298 pounds, the largest 932. Data from records kept for the Wedgeport Tuna Guides Association and furnished by Mr. Elson Boudreau.

Year	Mean Weight	250-299	300-349	350-399	400-449	450-499	500-549	550-599	600-649	650-699	700-749	750-799	800-849	850-899	900-949
JULY															
1947	522			1	5	4	9	4	3	1	1				
1948	501	1	2	5	11	14	20	13	6	4	1				
1949	499			5	8	12	12	14	3	1					
1950	517		1	5	6	10	11	3	9	5	2				
1951	503		5	8	8	14	23	10	5	6					
1952	492		1	7	7	8	18	4	3	2					
Totals	506	1	9	31	45	62	93	38	29	19	4				
SEPTEMBER															
1947	611			3	6	7	20	49	46	36	21	5	2	3	
1948	578			10	8	5	20	30	38	26	8	1		1	
1949	535			11	29	21	27	20	26	14	6	4		2	
1950	560			6	4	8	14	12	13	12	2				
1951	611			2	2	10	11	13	15	15	8	4	2		1
1952	579			3	3	10	12	12	13	7	6	3	1		
Totals	579			35	52	61	104	136	151	110	51	17	5	6	1

TABLE 2.—Weight frequency distribution (pounds) of 381 giant tuna (*Thunnus thynnus*) from Cat Cay, Bahamas (May and early June, 1947-1942), and 331 from Wedgeport, Nova Scotia (July, 1947-1952). The smallest Bahama fish weighed 292 pounds, the largest 719. The smallest Wedgeport fish weighed 298 pounds, the largest 741. Bahama data from records kept for Cat Key Club and furnished by Mr. John Mahony. Nova Scotia data from records kept for the Wedgeport Tuna Guides Association and furnished by Mr. Elson Boudreau.

Year	Mean Weight	250-299	300-349	350-399	400-449	450-499	500-549	550-599	600-649	650-699	700-749
BAHAMAS											
1947	466		2	5	15	15	8	4	3	1	
1948	482		2	9	20	19	13	10	6	1	1
1949	482	1		3	8	12	10	3	4		
1950	479		2	6	18	17	14	5	4		
1951	456		1	5	7	10	3	2	1		
1952	440	2	5	20	41	25	9	8	1		
Totals	467	3	12	48	109	98	57	32	19	2	1
NOVA SCOTIA											
1947	522			1	5	4	9	4	3	1	1
1948	501	1	2	5	11	14	20	13	6	4	1
1949	499			5	8	12	12	14	3	1	
1950	517		1	5	6	10	11	3	9	5	
1951	503		5	8	8	14	23	10	5	6	2
1952	492		1	7	7	8	18	4	3	2	
Totals	506	1	9	31	45	62	93	38	29	19	4

July. This increase in weight of about 7.5 percent per month is further confirmed by a similar increase observed in Wedgeport between July and September, as shown in Table 1.

According to the Bahama weight records, only three fish out of 381 weighed during the period 1947-1952, weighed less than 300 pounds, and the smallest weighed 292 pounds (Table 2). If the Bahama run includes only giant tuna of not less than about 300 pounds and if these fish increase their weight through feeding by about 7.5 percent per month, it is obvious that Wedgeport fish weighing not less than about 370 pounds in September should be considered as having come from the Straits of Florida.

In addition to mean weights, the observed lean and robust condition of Bahama and Wedgeport individuals respectively, can be expressed by length-weight relationships and by certain morphometric characters that reflect leanness or robustness of the body, as shown in Table 3. The samples compared in Table 3 are of similar length and therefore directly comparable. The lean

TABLE 3.—Comparison of giant tuna (*Thunnus thynnus*) of similar length, from Cat Cay, Bahamas, and Wedgeport, Nova Scotia, on the basis of morphometric characters reflecting leanness or robustness of the body. Proportions are expressed in thousandths of the fork length.

	BAHAMAS		NOVA SCOTIA	
	Range	Mean	Range	Mean
Number of individuals	19		9	
Time of year	May 16-28		Aug. 7-Oct. 3	
Length in millimeters	1997-2493	2269	2059-2534	2286
Weight in pounds	297-593	433	376-701	522
Girth	630-752 ¹	689	716-765	733
Origin first dorsal to origin pectoral	138-163	150	152-166	159
Origin first dorsal to origin pelvic	233-267	247	248-268	257
Greatest depth of body	242-282	257	256-284	269
Origin second dorsal to origin anal	204-227	217	226-242	234
Depth of body at 6th finlet ²	93-111 ³	102	105-119	113
Least depth of caudal peduncle	24-30	27	25-28	27
Width of body at origin of pectoral	169-196 ⁴	183	181-198	190
Greatest width of body	172-200 ⁵	185	188-209	199
Width of body at origin of anal	108-142 ⁶	126	132-167	148
Width of body at 6th finlet ²	75-88 ³	81	80-106	91
Width of caudal peduncle at keels	73-81 ⁷	76	74-86 ⁸	81

¹Only 17 specimens measured (see Table 8)

²Counting from last finlet

³Only 8 specimens measured (see Table 8)

⁴Only 15 specimens measured (see Table 8)

⁵Only 18 specimens measured (see Table 8)

⁶Only 17 specimens measured (see Table 8)

⁷Only 13 specimens measured (see Table 8)

⁸Only 7 specimens measured (see Table 9)

condition of the Bahama fish as compared with the northern fish is more apparent to visual inspection in the anterior region of the caudal peduncle. This is shown in Table 3 by the progressively increasing difference in depth and width from the region of greatest cross-section of the body (behind pelvic fins) towards the second dorsal and anal fins. The difference between the means of greatest depth of body, greatest width of body, origin of second dorsal to origin of anal and width of body at origin of anal, correspond to 12, 14, 17 and 22 respectively and represents 5, 8 and 17 percent of the mean of the shorter character. The characters relating to depth and width of caudal peduncle are identical, or nearly so. This is to be expected, since the muscle and adipose tissue surrounding the vertebral column becomes very thin at the narrowest part of the caudal peduncle.

Morphometric and Meristic Comparisons

The two different approaches discussed in the preceding sections are mutually confirmative and indicate that the Bahama giant tuna migrate to the north in the late spring. It would seem, therefore, that the Bahama and the Gulf of Maine fish are the same, or that at least they form part of the same population, and that biometric comparison would show that they are identical. It is reasonable to assume that if a large number of significant, reliable characters is used without detecting differences, the samples may be considered to be identical.

Godsil (1948), on the basis of five characters, concluded that the yellowfin tuna (*Neothunnus macropterus*) ranging from Lower California to the Equator, form part of a single, intermingling population. This conclusion was arrived at despite the fact that statistical analysis showed significant differences between the 13 samples used, but he attributed these anomalous conditions to fundamental differences in the concepts of statistical and biological homogeneity. He concluded that the differences observed were phenotypic rather than geographical, since differences were observed even between samples collected in the same locality. Most of the specimens used by Godsil were young, less than a meter in length, collected over a period of four years (1936-1940), and as he points out, "Varying environmental conditions during the developmental period undoubtedly result in slight variations in the characteristics of individuals." These conditions would not produce statistical homogeneity despite the fact that the samples come from a population assumed to be biologically homogeneous and composed of freely intermingling individuals. As a corollary to the above discussion, it may be assumed that if the samples really represent a single, homogeneous population, statistical homogeneity will be dependent on the age (size) of the individuals composing the sample. In other words, the older and larger the individuals, the higher the probability of attaining statistical homogeneity.

In the present study the problem is greatly simplified, since the samples compared are composed of large, adult individuals of similar size, already assumed to form part of the same population on the basis of the evidence discussed in the preceding sections.

The morphometric comparison between giant bluefin tuna from the Bahamas and Nova Scotia is given in Table 4 on the basis of 19 characters, including those customarily employed by racial workers. As already indicated, the samples are composed of individuals of similar length and therefore di-

TABLE 4.—Morphometric comparison between giant tuna (*Thunnus thynnus*) of similar size, from Cat Cay, Bahamas, and Wedgeport, Nova Scotia. Proportions are expressed in thousandths of the fork length.

	BAHAMAS		NOVA SCOTIA	
	Range	Mean	Range	Mean
Number of individuals	19		9	
Time of year	May 16-28		Aug. 7-Oct. 3	
Length in millimeters	1997-2493	2269	2059-2534	2286
First predorsal length	273-292	282	276-291	283
Second predorsal length	509-537	522	514-534	521
Prepectoral length	274-296	281	272-282	276
Prepelvic length	296-326	311	296-321	310
Preal length	581-618	600	582-608	595
Origin of pelvic to vent	280-305 ¹	295	280-309	298
Head length	265-286	272	267-280	273
Snout length	95-102	98	97-102	99
Orbit diameter	24-30 ²	26	24-30	26
Maxillary length	97-105	101	100-106	103
Mandible length	102-114 ³	107	105-113 ⁴	108
Interorbital width	103-116 ⁵	108	108-118	112
Height of first dorsal fin	86-124	111	102-120	108
Height of second dorsal fin	142-190	158	147-173	156
Height of anal fin	140-170	152	137-153	148
Length of pectoral fin	173-203 ⁶	188	184-194	188
Length of pelvic fin	110-120 ⁷	115	108-125	113
Length of upper caudal lobe	191-216	204	197-216	207
Length of lower caudal lobe	193-216	206	197-218	209

¹Only 10 specimens measured (see Table 8)

⁵Only 18 specimens measured (see Table 8)

²Only 18 specimens measured (see Table 8)

⁶Only 17 specimens measured (see Table 8)

³Only 12 specimens measured (see Table 8)

⁷Only 18 specimens measured (see Table 8)

⁴Only 8 specimens measured (see Table 9)

rectly comparable. Examination of the means show that their difference in all characters is five or less and that no statistical computations are needed to show that the two samples are identical on the basis of all characters. Attention is called to the fact that the shorter the characters, the smaller the difference between their means, and in characters resulting in about 100 thousandths of the length or less, the difference between the means is always 0, 1, or 2. In all characters, the difference between the means represents less than four percent of the mean of the shorter character, and in most characters the difference represents less than two percent. In all characters the range of variation of one sample either coincides with the range of the other or is included in it. For obvious reasons discussed in the preceding section, morphometric characters correlated with leanness or robustness of the body (Table 3) have not been included in Table 4.

It is interesting to note that characters such as head length, first and second predorsal lengths, prepelvic and preanal lengths, length of pectoral fin and heights of first dorsal, second dorsal and anal fins, in which populations of other species of tunas have usually been found to differ (Godsil, 1948; Schaefer and Walford, 1950; Godsil and Greenwood, 1951,) are identical in the samples compared in the present study. In addition, these racial studies show that the larger (older) the fish compared, the greater the difference between most of these characters.

Meristic comparisons are given in Tables 5 to 7 in which six characters are considered. The difference between the means was tested for each character and no significant difference was found to occur. In all cases the standard error of the difference was found to be less than 0.5.

The evidence presented above indicates that it is highly probable that the samples compared in the present study were drawn from the same population. This is in accordance with the indications discussed in the two preceding sections.

Conclusions

The evidence presented in this study strongly indicates, but does not prove conclusively, that the giant bluefin tuna occurring in the Straits of Florida in the late spring migrate to the north and constitute part of the same population occurring there during the summer and early fall. Definite proof will depend, of course, on tagging information, and until one or more fish tagged in the Straits of Florida are recovered in the north, the conclusions suggested by the present study must remain tentative. Farrington (1949) states that giant tuna "... have been caught at Wedgeport with Bimini (Bahamas) hooks in them" but he offers no proof to support his statement. The brands and sizes of hook used in Wedgeport are the same as those used in the Bahamas, and unless marked it would be difficult to identify a hook recovered in Wedgeport as having come from the Bahamas. Marked hooks were tried in the Bahamas (Bimini and Cat Cay) by Frank Mather and the writer in 1952 and 1953, and a dart-tag was used by Mather in 1954. So far no recoveries have been obtained from these efforts. A more extensive tagging program is planned for future seasons.

The three lines of approach discussed are in accordance and mutually confirmative. If the degree of morphological dissimilarity is an index of the degree of spacial separation between two populations, then the Bahama and

TABLE 5.—Frequency distribution of dorsal spines, rays and finlets in giant tuna (*Thunnus thynnus*) from Cat Cay, Bahamas, and Wedgeport, Nova Scotia.

	Spines		Rays			Finlets			Rays plus finlets					Mean
	13	14	13	14	15	8	9	10	21	22	23	24		
BAHAMAS	11	15	13.6	5	19	2	22	2	9.0	1	3	20	2	22.9
NOVA SCOTIA	5	4	13.4	2	5	2	14.0	1	6	2	9.1	8	1	23.1

TABLE 6.—Frequency distribution of anal rays and finlets in giant tuna (*Thunnus thynnus*) from Cat Cay, Bahamas, and Wedgeport, Nova Scotia.

	Rays			Mean	Finlets	Mean	Rays plus finlets			Mean	
	13	14	15	8		9	21	22	23		
BAHAMAS	7	17	2	13.8	23	3	8.1	4	20	2	21.9
NOVA SCOTIA	1	7	1	14.0	6	3	8.3		6	3	22.3

TABLE 7.—Frequency distribution of gill rakers in giant tuna (*Thunnus thynnus*) from Cat Cay, Bahamas, and Wedgeport, Nova Scotia.

	Lower limb					Mean	Upper limb					Mean	Lower limb plus upper limb										Mean
	24	25	26	27	28		10	11	12	13	14	15		35	36	37	38	39	40	41	42	43	
BAHAMAS			7	11	5	3	26.2	1	2	9	11	2	1	12.5	1	1	4	3	11	4	1	1	38.7
NOVA SCOTIA	1	2	4	2		25.8				1	5	3	13.2		2	1	2	3	1			39.0	

TABLE 8.—Original measurements (millimeters) of 19 fresh-caught specimens of giant tuna (*Thunnus thynnus*) from Cat Cay, Bahamas, May 16-29, 1952-1954.

	1997	2043	2112	2130	2150	2178	2190	2245	2260	2265	2274	2298	2302	2377	2420	2421	2470	2485	2493
Length.	341	316	297	346	362	353	389	420	401	378	437	407	416	525	593	540	569	556	592
Weight (pounds)	1500	1400	1328	1430	1520	1430	—	1600	1540	1470	1530	1500	—	1680	1740	1700	1730	1760	1770
Girth	584	560	603	617	600	609	598	626	645	631	655	649	628	668	695	696	685	698	711
First predorsal length	1073	1070	1096	1128	1098	1133	1113	1172	1182	1171	1190	1196	1204	1249	1263	1268	1263	1306	1293
Second predorsal length	590	574	585	628	604	598	603	627	640	638	631	635	653	685	665	682	692	696	696
Prepectoral length	646	647	624	696	677	668	684	691	683	694	715	685	729	754	756	775	778	763	765
Prepelvic length	1212	1223	1256	1307	1255	1302	1299	1344	1362	1325	1387	1333	1383	1425	1448	1465	1526	1507	1490
Precanal length	325	304	311	317	325	300	334	338	337	323	323	337	337	373	374	373	378	364	380
Origin 1st D. to orig. pect.	533	496	492	515	538	516	542	561	548	530	551	545	560	615	623	628	610	610	638
Origin 1st D. to orig. pelv.	264	275	227	253	275	245	288	297	257	260	—	280	282	297	345	337	344	308	—
Origin 2nd D. to orig. anal	451	443	433	455	443	458	494	503	484	471	506	470	479	517	550	534	548	544	548
Origin of pelvic to vent	609	600	—	—	603	—	653	650	661	—	—	660	689	708	732	—	—	—	—
Greatest depth of body	565	517	512	547	550	547	572	605	576	542	577	560	573	633	639	637	642	633	671
Greatest width of body	395	380	363	400	392	387	408	420	425	390	420	403	407	452	484	457	485	464	—
Width body at orig. pect.	393	374	358	393	385	383	—	415	415	389	406	—	—	453	462	457	473	455	—
Width body at orig. anal	264	275	227	253	275	245	288	297	257	260	—	280	282	297	345	337	344	308	—
Depth body at 6th finlet ¹	220	195	—	—	224	—	222	—	—	—	—	214	221	248	269	—	—	—	—
Width body at 6th finlet ¹	167	162	—	—	180	—	171	—	—	—	—	172	179	195	214	—	—	—	—
Least depth caudal peduncle	52	53	56	57	60	61	57	61	57	60	63	57	55	64	63	67	75	70	63
Width caud. ped. at keels	—	—	158	157	—	162	175	169	166	178	165	—	170	180	—	195	197	182	—
Head length	571	554	561	602	582	583	594	596	607	605	613	622	628	660	671	664	679	669	682
Snout length	203	195	201	214	213	213	210	220	220	219	224	222	225	239	247	241	240	248	250
Orbit diameter	61	55	58	58	57	56	55	61	60	60	60	60	60	65	58	65	69	63	60
Maxillary length	211	202	207	220	219	221	214	226	233	228	230	231	226	249	246	244	254	237	243
Mandible length	228	220	—	—	233	—	236	235	234	250	—	242	242	260	261	—	—	—	255
Interorbital width	226	217	218	230	232	229	232	244	242	237	247	250	247	277	270	263	268	268	—
Height of 1st dorsal fin	249	237	180	250	251	276	227	251	254	237	272	272	262	234	240	240	296	282	267
Height of 2nd dorsal fin	288	311	306	335	336	332	335	404	357	363	328	400	328	364	358	460	404	383	450
Height of anal fin	282	286	305	325	334	320	352	367	385	370	326	327	326	354	345	397	395	367	422
Length of pectoral fin	—	404	415	424	420	428	420	456	415	429	404	398	—	421	435	452	455	462	460
Length of pelvic fin	225	243	233	247	244	259	271	—	255	250	272	259	272	281	282	292	276	281	—
Length upper caudal lobe	409	431	402	452	465	442	425	458	465	454	440	470	463	506	470	515	530	490	531
Length lower caudal lobe	413	419	413	448	447	452	427	458	465	466	455	480	468	510	466	520	533	511	537
Sex	M	F	F	F	F	F	M	M	F	F	F	F	F	F	M	M	M	F	F

¹Counting from last finlet

TABLE 9.—Original measurements (millimeters) of 9 fresh-caught specimens of giant tuna (*Thunnus thynnus*) from Wedgeport, Nova Scotia, October 3, 1952 and August 7-10, 1953.

Length	2059	2113	2138	2197	2293	2393	2397	2450	2534
Weight (pounds)	380	385	376	467	504	573	640	701	675
Girth	1506	1510	1520	1650	1660	1720	1830	1870	1830
First predorsal length	586	607	614	639	660	661	667	689	717
Second predorsal length	1077	1092	1108	1171	1209	1230	1252	1275	1302
Prepectoral length	573	592	582	597	638	651	675	689	691
Prepelvic length	643	671	653	683	702	709	763	787	765
Preanal length	1226	1229	1256	1333	1369	1395	1457	1472	1483
Origin 1st D. to orig. pect.	333	334	326	353	360	373	399	406	402
Origin 1st D. to orig. pelv.	522	538	530	572	589	594	641	657	653
Origin 2nd D. to orig. anal	479	480	484	524	543	557	578	592	587
Origin of pelvic to vent	611	592	620	674	696	716	742	738	756
Greatest depth of body	546	565	557	608	614	612	667	695	688
Greatest width of body	409	397	405	448	455	475	501	511	497
Width body at orig. pect.	389	388	388	424	440	451	476	490	483
Width body at orig. anal	297	280	295	347	329	358	365	410	372
Depth body at 6th finlet ¹	219	222	231	254	258	276	282	288	302
Width body at 6th finlet ¹	170	170	179	213	211	223	219	259	235
Least depth caudal peduncle	56	58	54	58	62	61	64	68	69
Width caud. ped. at keels	—	175	158	179	188	—	194	210	202
Head length	567	589	573	597	620	645	656	688	676
Snout length	211	217	209	218	223	235	238	242	250
Orbit diameter	61	58	57	56	59	60	64	65	60
Maxillary length	214	216	215	227	233	244	249	256	263
Mandible length	228	229	227	—	246	251	255	277	272
Interorbital width	243	240	242	240	249	259	270	284	281
Height of 1st dorsal fin	248	224	223	234	260	253	260	254	284
Height of 2nd dorsal fin	303	330	360	330	337	381	367	380	437
Height of anal fin	314	290	327	318	345	357	365	374	353
Length of pectoral fin	400	400	409	411	430	443	442	475	472
Length of pelvic fin	223	230	236	249	276	266	299	283	278
Length upper caudal lobe	429	447	436	434	471	498	487	522	546
Length lower caudal lobe	429	452	433	434	466	498	504	533	549
Sex	M	M	M	—	M	M	M	M	—

¹Counting from last finlet

Nova Scotia samples cannot be assumed to represent separate units. Therefore, since these samples come from widely separated localities and the fish are absent in one place when present in the other, it must be also assumed that a migratory movement takes place between the two areas.

According to Heldt (1930, 1931) all the European giant bluefin tuna seem to constitute a single race or population, and to migrate to the northward after spawning. These conclusions were also tentative and based on a study of the recovery of hooks whose origin appeared to be well established. A Spanish hook recovered off Oslo, Norway, indicated that the fish had traveled more than 1000 nautical miles in less than a month.

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Comparación del Atún de Aleta Azul (*Thunnus thynnus*) de los Estrechos de la Florida y el Golfo de Maine, con Referencia a la Migración é Identidad de la Población

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Abstracto

Se presenta evidencia, indicando que los atunes gigantes de aleta azul que ocurren in los estrechos de la Florida durante mayo y junio, migran al Norte y forman parte de la población que se encuentra en New England y Nova Scotia a través del verano y principios del otoño. Dicha evidencia incluye comparaciones morfométricas, dirección y velocidad de la migración y condiciones del cuerpo.

Growth of Sub-Population of Mullet (*Mugil cephalus*) On the West Coast of Florida* (Abstract)

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Extensive market samples taken in 1950, 1951, 1952 and 1953 leave no doubt that mullet landed in the commercial fishery on the west coast of Florida became progressively smaller toward the north and west sections of the state. Subsequent studies of the juvenile mullet, market samples from the commercial fishery, tag returns, and scale analysis revealed the following information about the growth of the fish in west Florida.

1. The young mullet reach a mean size of 110 mm. at Pensacola, 115 mm. at Apalachicola, and 148 mm. at Cedar Keys during September of their first year of life. Peak spawning is during October, November and December.
2. The period of maximum growth of tagged fish was during May, June, July and August. There were indications that the tagging had a detrimental effect on the growth of the fish.
3. Scales proved to be successful in obtaining the age and growth of the fish. Fin ray sections, opercular bones, and vertebrae proved inferior, although they did display annual marks.
4. Scale analysis indicated that mullet from Pensacola and Apalachicola grew considerably slower than the fish from Cedar Keys and Homosassa.

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