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Possible Anomalies of Giant Bluefin Tuna

HOWARD A. SCHUCK

INTRODUCTION

Recently, observers collecting Atlantic bluefin tuna, *Thunnus thynnus thynnus*,[1] data have contended that they have seen some bluefin tuna that differ markedly in form and bodily proportions from the bulk of the fish observed.

These fish were first reported by Raimondo Sara who noted that some of the fish landed in Italy in the 1974 season appeared "strange" (Frank J. Mather, pers. commun., 10 June 1974, see Appendix). He believed that such fish possessed unusually long second dorsal, anal, and pectoral fins, and were heavier in relation to their length. They were all extremely large fish: From 250 to 260 cm in length, and weighing from 362 to 485 kg (796-1,067 pounds).

Sara posed possible theories as to the identity of these strange tunas. He wondered if they could be: 1) Another species—yellowfin (*Thunnus albacares*), bigeye (*Thunnus obesus*), etc.?; 2) A modification of *Thunnus thynnus thynnus* (a subpopulation not heretofore present in the Mediterranean?); 3) or perhaps merely a function of size (and thus not noticed earlier because fish of these large sizes were not often taken).

Without knowing of the Mediterranean June 1974 observations, Linda Despres of the Northeast Fisheries Center (NEFC), while measuring bluefin tuna at Bailey Island, Me., in July 1974, noticed that some of these fish seemed to differ in appearance from normal fish in that they had distinctly longer second dorsal and anal fins. She was not impressed that pectorals were also longer, or that these fish were fatter than normal. She reported that some fishermen believed that there were two different "types," and that the longer-finned type first appeared a couple of years ago. They were also of the opinion that this type was more often taken by harpoon than by hook and line. There was another theory—that the "long-fin" were of one sex, the "normal" fish of the other.

THE PROBLEM STATED

In response to the interest generated by these observations, it was decided that answers to the following questions should be sought.

1) Is there a group of large bluefin tuna in the North Atlantic or Mediterranean that differs significantly with respect to fins or other characteristics (such as relative heaviness) from "normal" fish? Or, are these observations of an "abnormal" type spurious? For instance, could they represent merely the longest of a graduated spectrum of fin lengths ranging from relatively short to relatively long—i.e., the result of normal biological variation, that is found to some degree in all species and for all parameters?

2) Do bluefin tuna at present (1974) have significantly longer fins, or other characteristics (like relative weight) significantly different from fish measured in earlier years?

3) If the answer to either 1 or 2 is "Yes," then what hypothesis seems reasonable to explain these differences?

THE DATA

The data available to the author for resolving the above questions are described in the following paragraphs.

Western Atlantic

1. Bailey Island, Me., 23-27 July 1974

Linda Despres of the Northeast Fisheries Center (NEFC) measured most of the tuna landed during the Bailey Island Tournament held 23-27 July 1974. After noticing an unusual "type," characterized mostly by relatively long second dorsal and anal fins, she classified 40 fish into 2 categories. Twenty-three were classified as appearing to possess a "regular" fin and 17 as appearing to possess a "long (or sickle) fin." No fins were measured, but two second dorsals (one long, one regular) were cut off and brought to Woods Hole where they were subsequently measured by Schuck and F. J. Mather, III.

Howard A. Schuck is with the Northeast Fisheries Center, National Marine Fisheries Service, NOAA, Woods Hole, MA 02543.

[1]For a description of the species and its characteristics, see Gibbs and Collette, 1967 and Mather, 1964.

She also photographed another long fin (Fig. 1) and another regular fin (Fig. 2) and provided these to the author. However, no photointerpretation technique has been found to validly estimate the actual (or relative) lengths of these two fins. Thus, the only "long fin" second dorsal for which we have a measurement (of fish landed at Bailey Island during the Tournament) is the preserved one which measures 50 cm. The fork length of this fish was 246 cm. The single "regular" second dorsal measures 36 cm, and is from a fish of 239 cm. These two samples were from a total landing of 73 fish during the 5-day period.

A great deal of other information was also collected on some of the 73 fish landed, i.e. sex, how caught, weight and length (thus lg-wt)—much of it subjectively divisible into "long fin" vs "regular fin" groups. Table 1 provides a summary of the Bailey Island Tournament data.

Table 1.—Data from Bailey Island Tournament, July 1974.

Length (inches)	Wt. (lb)	Sex	Gear
"Regular fin"			
103.25	720	M	B[1]
105.50	673	M	B
97.00	603	F	B
101.50	586	M	HP[2]
100.25	603	M	B
96.50	587	—	HP
100.25	594	—	HP
107.00	740	—	HP
101.00	673	M	HP
107.75	696	M	HP
100.50	643	M	B
97.00	563	M	B
104.25	672	M	HP
102.50	620	M	HP
103.25	712	M	HP
103.00	650	M	HP
101.25	664	F	HP
96.75	527	F	HP
104.00	786	M	HP
94.00	525	—	B
99.50	634	—	B
107.75	733	—	HP
94.00	508	—	HP
"Long fin"			
91.25	561	F	B
101.25	625	F	B
106.25	684	M	HP
96.25	671	—	HP
100.25	627	—	HP
102.00	718	M	HP
105.75	741	F	HP
110.50	711	F	B
99.00	572	M	HP
106.50	713	M	HP
103.75	723	M	HP
101.25	677	—	HP
101.75	781	—	HP
102.00	672	M	HP
103.00	670	—	HP
97.00	610	—	HP
96.75	532	—	B

[1]Bait
[2]Harpoon

2. Gloucester, Mass., 23 Sept.-1 Oct. 1974

A presumably "random" sample of 33 fish landed at Gloucester for the fishing season up to 1 Oct. 1974, was provided by Peter Wilson on 7 October (Table 2).

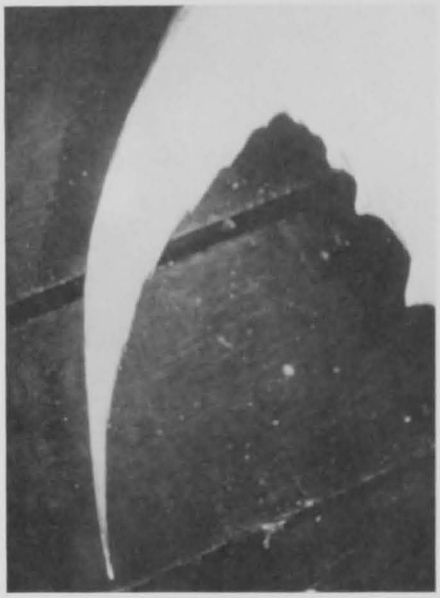

Figure 1.—"Long-finned" second dorsal selected by Despres.

Figure 2.—"Regular" length second dorsal selected by Despres.

3. Gloucester, Mass., 2-11 Oct. 1974

A second "random" sample of Gloucester-landed fish (30 fish for the period 2 Oct. through 11 Oct. 1974) was provided by Peter Wilson at the end of the season (Table 3).

Table 2.—Data[1] from Gloucester, Mass., 23 Sept.-1 Oct. 1974.

Spec. no.	Date	Fork L. (curved lg.)	P. Dor. L. (tape)	2nd dorsal	Anal	Wt-Rnd (lb)	Sex
1	9/23	245	183	37	33	—	F
2	9/26	274.5	192	34	39	710	F
3	9/26	255.3	189	44.8	[2]32.3	755	F
4	9/26	259.5	193.5	39	40.3	810	M
5	9/26	266	191	39.7	42.5	725	M
6	9/26	245.5	177	41.5	41	655	F
8	9/27	255	187	42.5	44.5	655	F
9	9/27	264	195	44	39	830	M
10	9/27	259	191	43	41	670	F
11	9/27	270	200	50.5	43.5	770	M
12	9/27	225.5	163.5	36.5	38.5	470	F
13	9/27	253	182	41	38	630	F
14	9/27	273	196	38.5	44	760	F
15	9/27	270	197.5	40.5	41	785	M
16	9/27	268	198	41.5	41.5	785	F
17	9/27	281	201.5	49	45	845	M
18	9/27	219	165.5	34	33	425	M
19	9/27	270.5	196.5	44	43	695	M
20	9/27	277.5	204	41.5	41.5	820	M
22	9/28	248	—	41.5	39	645	F
23	9/28	254	—	40.5	41.5	650	M
24	9/28	274.5	—	37	35.5	770	F
25	9/28	282	—	42.5	40	790	M
26	9/28	257	184.5	38.5	36	675	F
27	9/28	226.5	162.5	35	35	560	M
28	9/28	276.5	198	45	43.5	830	F
29	9/29	263	187.5	42	[2]30.5	760	M
30	9/29	274	196	[3]56	36	795	M
31	9/29	272	199	41	43.5	810	M
32	10/1	261.5	190.5	41	39	755	M
35	10/1	228	162.5	37.5	31	450	M
36	10/1	251.5	—	38.5	38.5	625	F
37	10/1	277	195.5	46.5	41.5	780	M

[1]All lengths are in centimeters.
[2]Damaged
[3]Preserved

Table 3.—Data[1] from Gloucester, Mass., 2-11 Oct. 1974.

Date	Fork length (curved lg.)	2nd dorsal	Anal	Round wt. (lb)	Sex
10/2	277	43.0	41.5	880	M
10/2	269	[2]57.0	[2]47.5	705	M
10/2	251	35.5	35.0	685	F
10/3	254	35.5	37.0	610	F
10/3	270	42.0	46.0	800	M
10/3	247	40.0	42.0	695	F
10/3	267	[3]39.0	41.0	775	F
10/3	274	49.5	43.0	825	M
10/3	275	39.0	39.0	875	M
10/4	244.5	35.5	33.0	635	F
10/5	274	39.5	38.0	815	F
10/5	260	39.0	42.0	700	F
10/5	267	38.0	37.5	735	F
10/5	275	41.5	42.5	785	M
10/6	260.5	[2]49.0	[2]46.0	735	F
10/6	269	49.5	46.5	775	F
10/6	275.5	[2]51.5	[2]50.5	845	M
10/7	270	42.0	43.5	780	M
10/7	264	36.5	35.5	—	M
10/8	257.5	44.5	38.5	670	M
10/8	276	36.0	37.5	715	M
10/8	261.5	42.0	[3]36.0	835	M
10/8	290.5	44.5	38.0	840	M
10/10	273.5	47.0	46.5	900	M
10/10	290	39.5	39.0	885	M
10/10	201	26.0	25.5	280	F
10/11	221	34.5	29.5	410	F
10/11	256.5	40.5	38.5	—	M
10/11	272	53.0	49.5	—	M
10/11	265.5	35.0	36.0	790	M

[1]All lengths are in centimeters.
[2]Preserved frozen
[3]Damaged

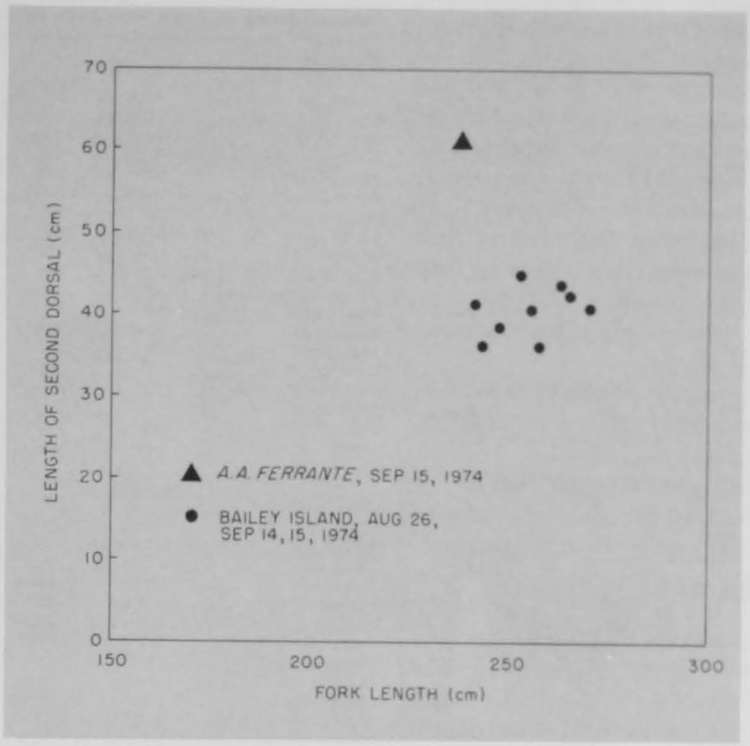

Figure 3.—Data of 10 fish provided by SEFC.

4. Prince Edward Island, 2-4 Oct. 1974

From 2-4 Oct. 1974, Fred Nichy of NEFC was stationed at Prince Edward Island at the request of Southeast Fisheries Center (SEFC) to obtain measurements of 31 tuna landed there during that period. Second dorsals were measured along with many other parameters. These data, which can also be considered as a "random" sample, are shown in Table 4.

5. Bailey Island, Me., August, September; *A. A. Ferrante*

From SEFC, graphical data were received representing total length and length of second dorsal of 10 tuna, 9 of which were measured at Bailey Island, Me., 26 August and 14 and 15 September. Presumably these can be considered as a random sample. The tenth plotted point was for a single fish out of the total catch of 60 tons taken by the U.S. purse seiner *A. A. Ferrante* in September. Reportedly no other fish of this large catch was measured. It must therefore be considered as a selected sample. This one "measurement" indicates a very long second dorsal fin (61 cm is our interpretation of the graphed point, from a fish of about 238 cm total length). These original data are shown in Figure 3.

European Waters

From Frank Mather's translation of Sara's 10 June 1974 letter (Appendix) and subsequent telephone calls and notes to Sara by Frank Mather, it appears that:

1) While the total number of fish in the 1974 Italian trap catch was extremely small[2], the fish taken were exceptionally heavy (with "averages peaking at 880 pounds").

2) Not only were the fish extremely large, but they included individuals of unusual body proportions (very heavy in relation to their length, and with noticeably longer pectoral, second dorsal, and anal fins).

3) At Favignana five of these "strange" fish were measured. They ranged from 250-260 cm in total (fork) length, and had weights of 485, 479, 406, 362, 461 kg (1,067, 1,053, 893, 796, and 1,014 pounds). Their second dorsals ranged from 53 to 55 cm, anals from 52 to 54, and pectorals from 48 to 50.

4) Apparently, only the 5 "strange" fish were measured—out of 2,080 fish landed. They were seemingly picked as examples of the "strange-looking" fish, and must be considered as a non-random sample.

5) Supplementing Sara's earlier transmissions, Frank Mather received a 29 Jan 1975 communication from Sara. He stated that the "strange" tunas perhaps amounted to 12-15 percent of the total landed. He provided photographs of two of these fish, which I have reproduced with Frank Mather and Sara's permission as Figure 4.

6) Finally, Frank Mather received in December 1974 a report by a Canary Island fisherman of a tuna of 497 kilos (1,094 pounds) that was apparently so heavy for its length that it was classified by its captors as a "bigeye" tuna (*Thunnus obesus*).

[2]Revised 1974 totals for the Italian traps were given by telephone on 9 Oct. 1974, to be: Favignana, 2,080 fish; Formica, 580 fish; Bonagia, 290 fish; Sardinia, none.

DEFINITIONS

1) The fin used to represent the "longfin" phenomenon was the second dorsal fin, inasmuch as it had been measured most often by 1974 observers.

2) The measure of "relative"

fin-length used was the length of the fin in relation to the length of the fish.

3) The lengths of both fish and fins utilized in this analysis were straight-line (rather than curved) distances, as shown in Figure 5 (from Mather, 1964), and are expressed in centimeters.

4) The length of fish used is fork length. It is referred to either as fork length or total length.

5) The weights utilized were round weights, in pounds.

6) The measure of relative heaviness was the weight in relation to length of fish.

7) The subjective terms "larger" or "smaller" sized fish generally refer to length of fish, rather than weights.

PROCEDURES

1) Conversions of the original data were made where necessary. The straight-line total (fork) length of each fish was estimated in centimeters in cases where original data were provided in inches or were curved lengths (measured by tape around the curvature of the body). As provided by Frank Mather, this formula was used: $0.958X = Y$, where X = curved fork length, Y = straight-line fork length[3].

2) The resultant standardized values of all available Western Atlantic 1974 fin data received for this analysis, is presented in Table 5. It is to be noted that these 106 fish contain 103 that can be considered as random samples: 33 from Gloucester in September, 30 from Gloucester in October, 31 from Prince Edward Island and 9 from Bailey Island in August and September. It also includes 3 that must be considered as selected and non-random (2 from Bailey Island in July—1 "long fin," 1 "regular fin;" 1 from the purse seiner *A. A. Ferrante*).

3) The European 1974 fin data were summarized as 5 fish of 250 to 260 cm fork length with second dorsals ranging from 53 to 55 cm.

4) Perusal of the literature turned up the fact that the relationship between length of second dorsal and length of fish is not a straight line, but is curvilinear, with larger fish having rela-

[3]Also, weights were converted, where necessary, from kilograms to pounds (kg = 2.2 pounds).

Table 4.—Bluefin tuna data, North Lake, Prince Edward Island.

Sample No.							
Vessel	*Aquarius*	*Bee Jay*	*Scott's Pride*	*Lucky Strike*	*Seawood*	*Bessie Keefer*	*Lucky Dawn*
Date	2 Oct. 74	2 Oct. 74	2 Oct. 74	2 Oct. 74	2 Oct. 74	2 Oct. 74	2 Oct. 74
Sex	Male	Male	Male	Male	Male	Male	Male
Weight	758 lb	901 lb	845 lb	769 lb	850 lb	900 lb	890 lb
Fork L.	8'5"	8'8"	8'10½"	8'4"	8'8¾"	8'8¾"	8'6"
Flank L.	104½"	109½"	112¼"	108¼"	108"		
Pectoral Fin L.	15"	18½"	17¼"	17"	17"	17⅞"	17⅞"
Dorsal Lobe	21"	18"	15³⁄₁₆"	18½"	18"	15¾"	15¾"
Head Length	27¾"	27½"	28⅝"	27¹¹⁄₁₆"	27¾"	28⅝"	28"
Max. Depth	27½"	29¾"	29¼"	28¾"	28½"	29⅜"	29"
Caudal Spread	36"	35½"	35⅞"	35"	34¼"	34⅞"	34⅜"
Max. Girth	82"	81"	77½"	77"	80"	79½"	79"
Anal Depth	20⅜"	22¾"	22⅛"	21"	22"	22⅛"	22"
Anal Girth	52"	61"	56"	55¼"	59"	60"	62"
D1 to 6th Finlet	51"	56¾"	59½"	56¼"	54½"	59½"	
D1 to Caudal Fork	6'3"	6'7¾"	6'7¾"	6'6¾"	6'5"	6'4¾"	
Max. Width							
Muscle Taken	yes	yes	yes	yes	yes	yes	yes
Vertebrae Taken	yes	yes	yes	yes	yes	yes	yes
Anal Width							

Sample No.							
Vessel	*Red Baron*	*Liz*	*Lynell Jane*	*Spray Boy*	*Wendy R.*	*Morag*	*Sheryll & Tammy*
Date	2 Oct. 74	2 Oct. 74	2 Oct. 74	2 Oct. 74	2 Oct. 74	3 Oct. 74	4 Oct. 74
Sex	Male	Male	Male	Male	Male	Male	Male
Weight	1,020 lb	867 lb	725 lb	899 lb	840 lb	914 lb	845 lb
Fork L.	9'4"	8'5¼"	7'10"	8'9"	9'1"	9'1"	8'4½"
Flank L.	117"	108"	101½"	114½"	113"	115½"	108½"
Pectoral Fin L.	21"	16"	16½"	17⅜"	17¼"	17⅛"	19"
Dorsal Lobe	18½"	14½"	14⅝"	19¾"	18½"	20"	18"
Head Length	28½"	27¼"	24¹¹⁄₁₆"	26⅝"	27"	29½"	27⅜"
Max. Depth	31"	29½"	28"	28⁹⁄₁₆"	27½"	29¹⁄₁₆"	29¼"
Caudal Spread	39"	39½"	31"	39¾"	36"	34"	36"
Max. Girth	84"	80"	75½"	79½"	77½"	82½"	79"
Anal Depth	24"	22½"	21³⁄₁₆"	21"	19½"	21¹³⁄₁₆"	22½"
Anal Girth	61"	62"	58"	56⅛"	51½"	57½"	60"
D1 to 6th Finlet	60"	54"	51⅞"	59½"	60¼"	60¾"	54½"
D1 to Caudal Fork	6'11"	6'2"	5'11"	6'9½"	6'11"	6'9¼"	6'2"
Max. Width							
Muscle Taken	yes	yes	yes	yes	yes	yes	no
Vertebrae Taken	yes	yes	yes	yes	yes	yes	no
Anal Width							

Sample No.					
Vessel	*Gulf Queen*	*Clayton D.*	*Steven K.*	*Bessie Keefer*	*Sheryll & Tammy*
Date	4 Oct. 74	4 Oct. 74	4 Oct. 74	4 Oct. 74	4 Oct. 74
Sex	Male	Male	Male	Male	Male
Weight	853 lb	985 lb	856 lb	840 lb	750 lb
Fork L.	8'5½"	9'1¾"	8'10½"	8'5½"	8'3"
Flank L.	106"	113¼"	112"	106"	103"
Pectoral L.	18½"	18⅜"	17½"	18¼"	16¾"
Dorsal Lobe	14½"	19½"	16½"	16½"	16"
Head Length	27⅝"	28½"	26¾"	27¾"	27⅛"
Max. Depth	28⅜"	30¾"	28¾"	28¾"	27¾"
Caudal Spread	33⅞"	37¼"	35"	36"	32"
Max. Girth	80"	84½"	78"	79"	76"
Anal Depth	22⅝"	24¼"	20¾"	21¾"	21½"
Anal Girth	61½"	62"	54½"	59"	56"
D1 to 6th Finlet	56½"	59¾"	53"	55¼"	54"
D1 to Caudal	6'4⅝"	6'9⅝"	6'7"	6'2½"	6'½"
Max. Width					
Muscle Taken	yes	no	yes	no	yes
Vertebrae Taken	yes	no	yes	no	yes
Anal Width	14¾"				

Sample No.					
Vessel	*Cape Light*	*Bay Lady*	*Clayton D.*	*Best O Luck*	*Aquarius*
Date	4 Oct. 74	4 Oct. 74	4 Oct. 74	Oct. 74	4 Oct. 74
Sex	Male	Male	Female	Male	Male
Weight	921 lb	859 lb	696 lb	865 lb	930 lb
Fork L.	8'6"	8'4¾"	8'1"	8'6½"	8'7⅝"
Flank L.	107"	103½"	98¼"	107½"	109¼"
Pectoral Fin L.	15½"	17½"	16"	18"	18¾"
Dorsal Lobe	17½"	16¾"	14"	16¼"	16½"
Head Length	26"	27⅛"	26½"	27"	27½"
Max. Depth	29¾"	28"	26⅛"	29⅝"	30¼"
Caudal Spread	34"	35½"	32½"	36"	35"
Max. Girth	80"	78"	76"	80"	83"
Anal Depth	23¾"	21⅝"	20¹⁄₁₆"	20⅝"	23"
Anal Girth	65"	63"	58"	60"	62"
D1 to 6th Finlet	56"	53½"	50¼"	51"	53⅝"
D1 to Caudal Fork	6'6"	6'2⅜"	5'10⅜"	6'3"	6'1"
Max. Width				21⅝"	
Muscle Taken	no	yes	yes	yes	yes
Vertebrae Taken	no	yes	yes	yes	yes
Anal Width					

Table 4.—Bluefin tuna data (cont'd).

Sample No.							
Vessel	*Aquarius*	*Morag*	*I'm Alone*	*Bee Jay*	*Morag*	*Patricia Irene*	*Troy B.*
Date	4 Oct. 74	4 Oct. 74	4 Oct. 74	4 Oct. 74	4 Oct. 74	4 Oct. 74	4 Oct. 74
Sex	Male	Female	Male	Female	Female	Male	Male
Weight	800 lb	790 lb	710 lb	640 lb	721 lb	901 lb	712 lb
Fork L.	8′6⅝″	8′3″	8′7⅝″	7′10½″	8′2¼″	8′10″	8′1″
Flank L.	109¼″	106⅞″	110⅜″	99⅝″	103⅝″	110½″	
Pectoral L.	16⅜″	16¼″	19½″	16¼″	19¾″		18″
Dorsal Lobe	17⅜″	19⅜″	22⅜″	16¼″	16¾″	16⅜″	16½″
Head Length	28⅛″	27″	28 1/16″	24″	25⅝″	29 5/16″	25¼″
Max. Depth	29⅜″	27½″	27⅛″	24⅝″	25¾″	29⅝″	27″
Caudal Spread	36¼″	32¾″	35⅜″	30⅜″	32″	33¾″	31″
Max. Girth	78½″	78″	73″	70″	72″	79″	74″
Anal Depth	21 9/16″	20 7/16″	18½″	20¾″	20″	22⅛″	21½″
Anal Girth	57½″	59¼″	48½″	55½″	55½″	58½″	59″
D1 to 6th Finlet	55⅝″	50″	55½″	35⅜″	54⅝″	58¼″	54⅞″
D1 to Caudal	6′4¾″	6′⅝″	6′5⅝″	5′11¾″	6′1⅝″	6′7¼″	6′1½″
Max. Width	20⅛″	21½″		19 11/16″	19⅝″	21 5/16″	19¼″
Muscle Taken	yes	yes	yes	yes	yes	yes	yes
Vertebrae Taken	yes	yes	yes	yes	yes	yes	yes
Anal Width	15¾″	17⅛″		13⅜″	17 5/16″	17″	15½″

tively longer second dorsals than smaller fish[4]. Thus, the simplifying use of relative size of second dorsal (i.e., relative to the length of the fish) by either percentage or ratio of one part to the other was generally ruled out. Any comparison of ratios or percentages for groups of fish that are not almost exactly of the same size will introduce an artificial error that could lead to unwarranted conclusions.

[4]See Figure 6, from "A Preliminary Report on Biometrical Studies of Tunas (Genus *Thunnus*) of the Western North Atlantic," by Frank J. Mather, III, WHOI, Woods Hole, Mass., June, 1959.

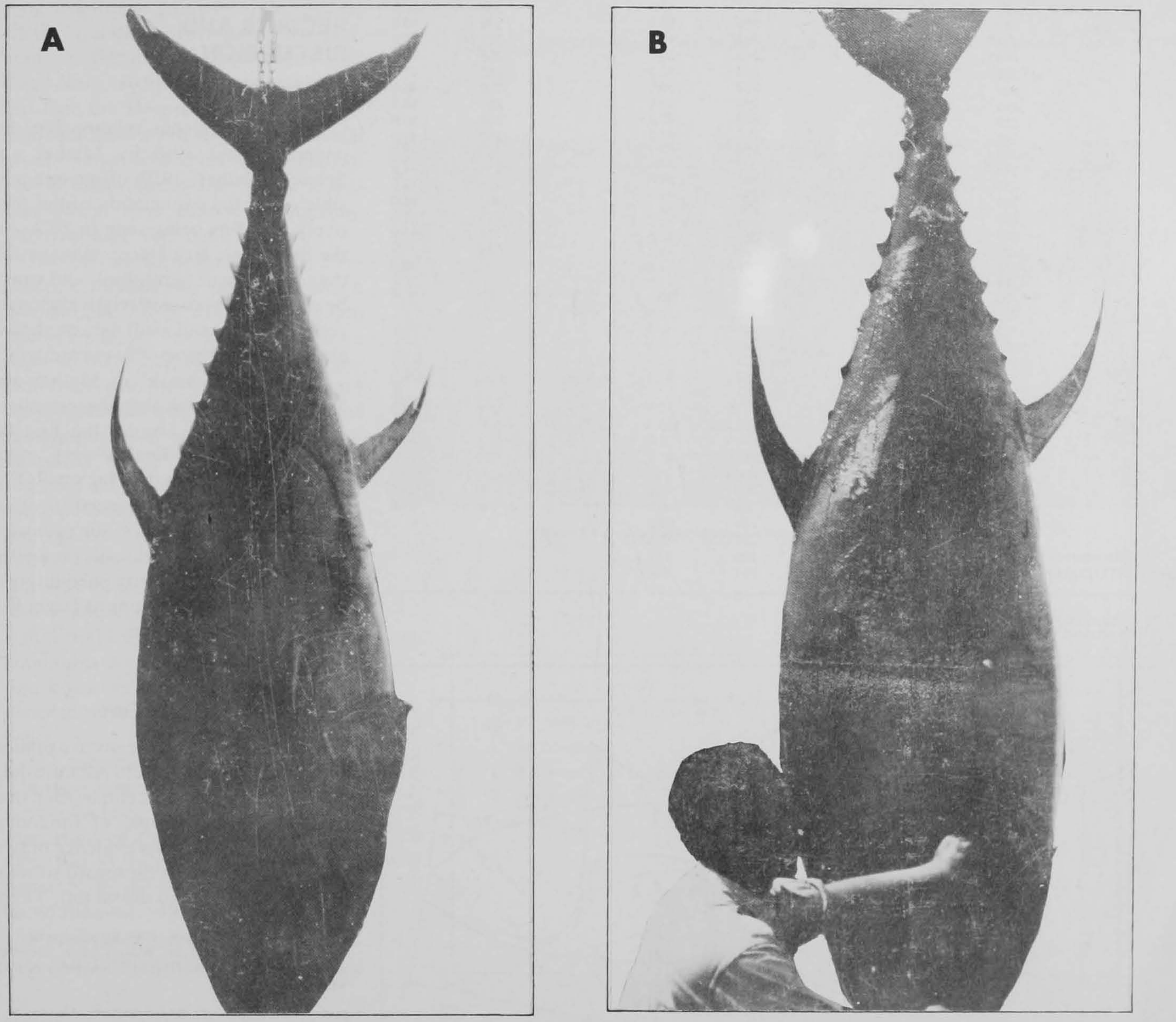

Figure 4.—Two of Sara's "unusual proportioned" tuna.

In addition, the relationship between fish length and weight is highly curvilinear, as would be expected.

Thus, the use of two-value regression analysis was dictated, rather than the convenient use of single-value ratios or percentages of one body parameter to another.

5) Another factor affecting the type of analysis was the nonrepresentativeness of the data. In all three cases where "abnormal" fish were thought to be perceived, these and only these fish were measured, and the rest of the landings were not measured for the observed characteristic. This is true for the one "long fin" measurement of Despres (of 73 fish landed), of the one "long fin" measured by SEFC personnel (of 60 tons landed), and even of the five European fish of Sara (of 2,080 fish). These samples must be treated as selected samples. And without knowledge of the length of fins (and other characteristics) of the rest of the population from which these samples were drawn, one will be limited in the conclusions that may be drawn.

6) In view of the paucity of 1974 data available, visual inspection of plotted regressions was deemed adequate, rather than transformations and then least squares regression or covariance analysis.

7) Within the constraints of quality and quantity of data available, the following section attempts to glean all that appears warranted from the existing data.

RESULTS AND DISCUSSION

General

1) The curvilinear relationship discovered about 1950 by Mather and Schuck (Mather, 1959) offers one possible or partial explanation of the relatively long fins being seen in 1974—as the 1974 giants are of larger average size than in any year heretofore, and would be expected to possess relatively longer second dorsal (and anal) fins, on the average, than are generally encountered.

2) The early work[5] of Mather and Schuck also shows that the measured scatter of points around the fin-total length regression line is very much greater for large fish than for small (Fig. 7)[6]. This increasing dispersion offers one possible explanation for occasionally very long second dorsals (as well as very short dorsals) being encountered, especially if one is looking at larger fish than usual.

Western Atlantic

Length of Fins

Figure 8 provides a means to examine all available 1974 Western Atlantic data on relative fin length. It can be seen that within the total sample of randomly selected fish there is no evidence of two distinct types of fish (in regard to relative length of second dorsal fin). There

Table 5.—Summary of available 1974 data on relative fin lengths.

Place, date	Fork lg. (cm)	2nd dorsal (cm)	Place, date	Fork lg. (cm)	2nd dorsal (cm)	Plate, date	Fork lg. (cm)	2nd dorsal (cm)
Bailey Isl.	246	[1]50.0		240	35.5		277	47.0
July 1974	239	[1]36.0		243	35.5		277	51.0
				259	42.0		255	46.0
Gloucester	235	37.0		237	40.0		258	37.0
23 Sept.-	263	34.0		256	39.0		279	49.0
1 Oct.	244	44.8		262	49.5		271	42.0
	249	39.0		263	39.0		258	42.0
	255	39.7		234	35.5		251	41.0
	235	41.5		262	39.5		259	44.0
	244	42.5		249	39.0		256	43.0
	253	44.0		256	38.0		246	36.0
	248	43.0		263	41.5		260	41.0
	259	50.5		250	49.0		263	42.0
	216	36.5		258	49.5		261	44.0
				264	51.5			
	243	41.0		259	42.0		251	49.0
	262	38.5		253	36.5		263	57.0
	259	40.5		247	44.5		240	41.0
	257	41.5		264	36.0		250	43.0
	269	49.0		251	42.0		269	42.0
	210	34.0		278	44.5		246	42.0
	259	44.0		262	47.0			
	266	41.5		278	39.5	*A. A. Ferrante*	[1,2]238	[1,2]61.0
	238	41.5		193	26.0	15 Sept.		
	243	40.5		212	34.5			
	263	37.0		246	40.5			
	270	42.5		261	53.0	Bailey Isl.	[2]253	[2]45.0
	246	38.5		254	35.0	26 Aug.	[2]263	[2]44.0
	217	35.0						
	265	45.0	Prince	257	53.0	14-15 Sept.	[2]265	[2]43.0
	252	42.0	Edward	264	46.0		[2]242	[2]42.0
	262	56.0	Island	271	39.0		[2]255	[2]41.0
	261	41.0	2-4 Oct. 1974	254	47.0		[2]270	[2]41.0
	251	41.0		266	46.0		[2]248	[2]38.0
	218	37.5		266	40.0		[2]243	[2]36.0
	241	38.5		259	40.0		[2]258	[2]36.0
	265	46.5		284	47.0			
				257	37.0			
Gloucester	265	43.0		239	37.0			
2-11 Oct. 1974	258	47.0		267	50.0			

[1]Non-random or selected sample.
[2]Estimated from plotted points of Figure 3.

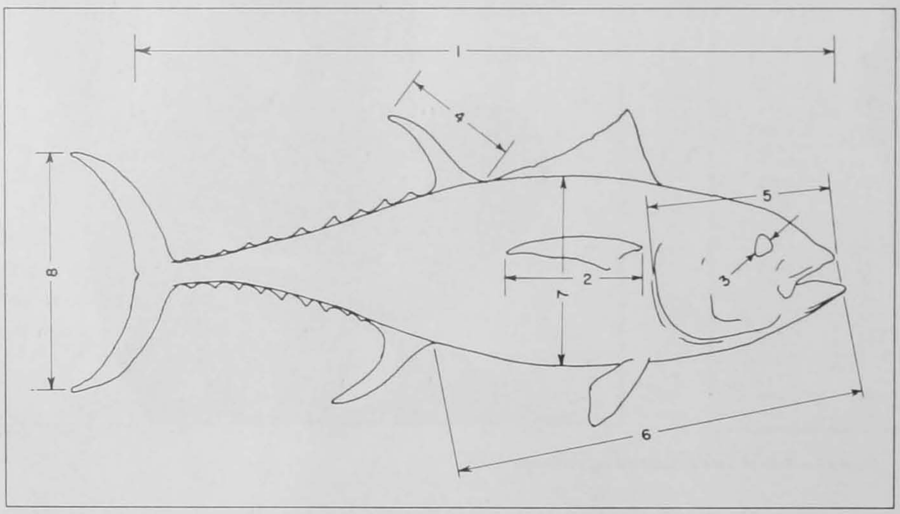

Figure 5.—Diagram of measurements taken: (1) Fork length (snout of upper jaw to fork of tail); (4) length of second dorsal fin (measured from end of groove of first dorsal fin to tip of second dorsal lobe).

[5]See Mather and Schuck, 1960 for description.
[6]Unpublished data from Woods Hole Oceanographic Institution (WHOI) files, courtesy of F. J. Mather, III.

appears, instead, a gradation from relatively very short to relatively very long second dorsal fins.

To illustrate further, the ratios of all[7] the "randomly" selected 1974 fish are tabulated in Table 6 and plotted in Figure 9. The result is obviously close to a normal curve—a single modal frequency with ratios ranging from 0.120 to 0.220. There is no evidence of a two modal distribution of relative fin lengths.

Next we add the two selected "long fin" fish in both the regression (Fig. 8) and the histogram of ratios (Fig. 9).

It can be seen that the Despres fish (ratio = 0.203) is not substantially longer than many others of the "single mode" random distribution. In fact, some of the normal single-mode randomly selected fish had relatively longer fins than the Despres fish. The conclusion that there were two distinct modal groups (long- and short-finned fish) of the 73 taken during the Bailey Island tournament thus cannot be substantiated with present data.

The SEFC fish from the *A. A. Ferrante* estimated by author from a graphed point to be 238 cm fork length and 61 cm length of second dorsal; for a ratio of 0.256 lies clearly beyond the limits of all previously measured second dorsals. If this fish had been selected randomly, and if others had also been measured, and if this single value represented an average of several, and if these were clustered closely around this point and not spread between it and the smaller fins and if we were sure how this fish was measured, then this observation would certainly be considered as significantly different. But since these conditions do not prevail, the observation does not provide conclusive evidence as to the existence of two types of fish.

The question of whether 1974 fish had relatively larger fins than fish in earlier years was tested by superimposing the regression of 1950 (Fig. 7) onto 1974 data (Fig. 8). It is doubtful that a line of better fit to the 1974 points could be found than the 1950 line.

If ratios are compared, the 1974 Despres fish (ratio of 0.203) is exceeded by

[7] "All" means all fish within the size range of 210 to 279 cm fork length. One fish of 193 cm was excluded due to this necessary constraint if ratios were to be utilized.

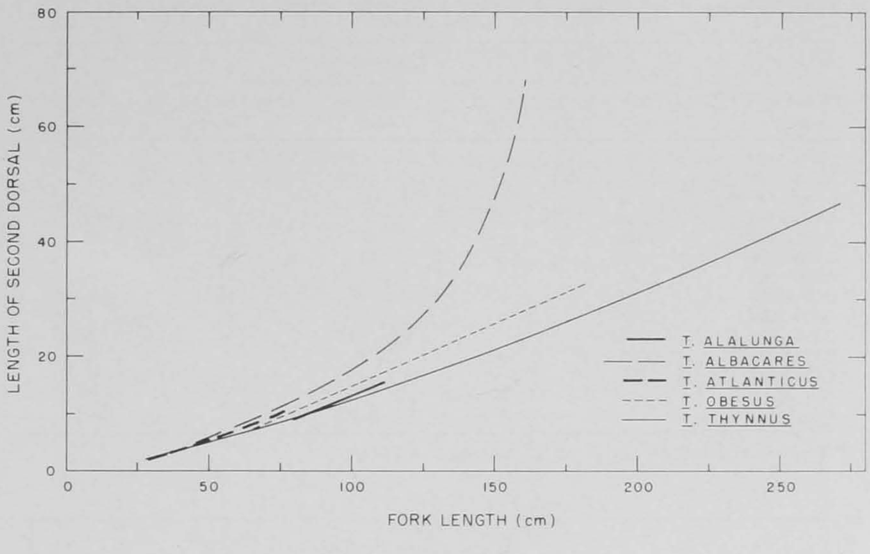

Figure 6.—Length of second dorsal fin plotted against fork length for species of *Thunnus*.

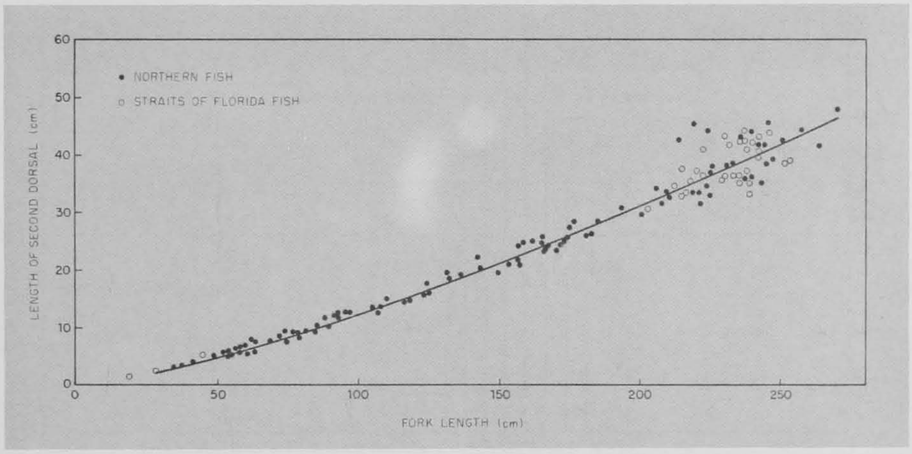

Figure 7.—Relationship of second dorsal to fork length, 1950 era fish.

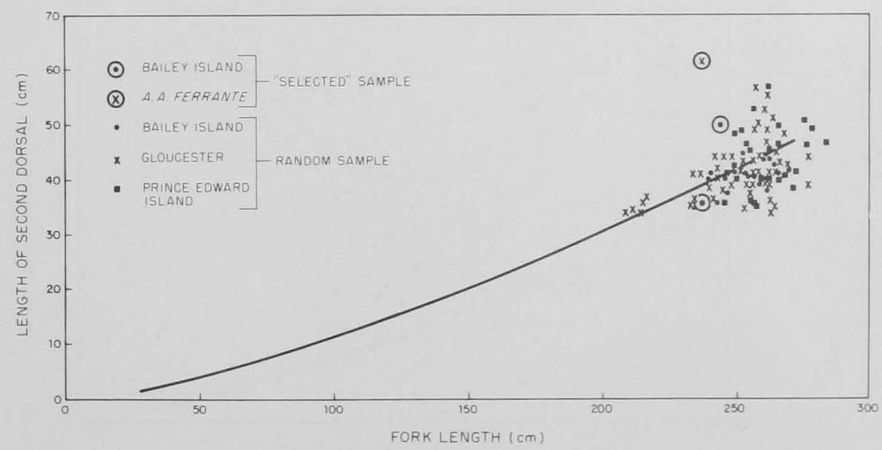

Figure 8.—All 1974 western Atlantic data on fin length.

Table 6.—Ratios of 2nd dorsal to total length-1974-Western Atlantic-all[1] random samples of 210 to 279 cm fish.

Ratios range	Mid-point	Number of fish: Bailey Isl., Maine	Gloucester, Mass.	Prince Edward Isl., Canada	All samples
0.120-0.129	0.125	—	1	—	1
0.130-0.139	0.135	—	3	—	3
0.140-0.149	0.145	1	8	4	13
0.150-0.159	0.155	3	12	6	21
0.160-0.169	0.165	3	17	6	26
0.170-0.179	0.175	2	10	8	20
0.180-0.189	0.185	—	4	4	8
0.190-0.199	0.195	—	4	1	5
0.200-0.209	0.205	—	1	1	2
0.210-0.219	0.215	—	1	1	2
0.220-0.229	0.225	—	1	—	1
0.230-0.239	0.235	—	—	—	—
All ratios		9	62	31	102

[1]One Gloucester fish was not plotted as it was less than 210 cm.

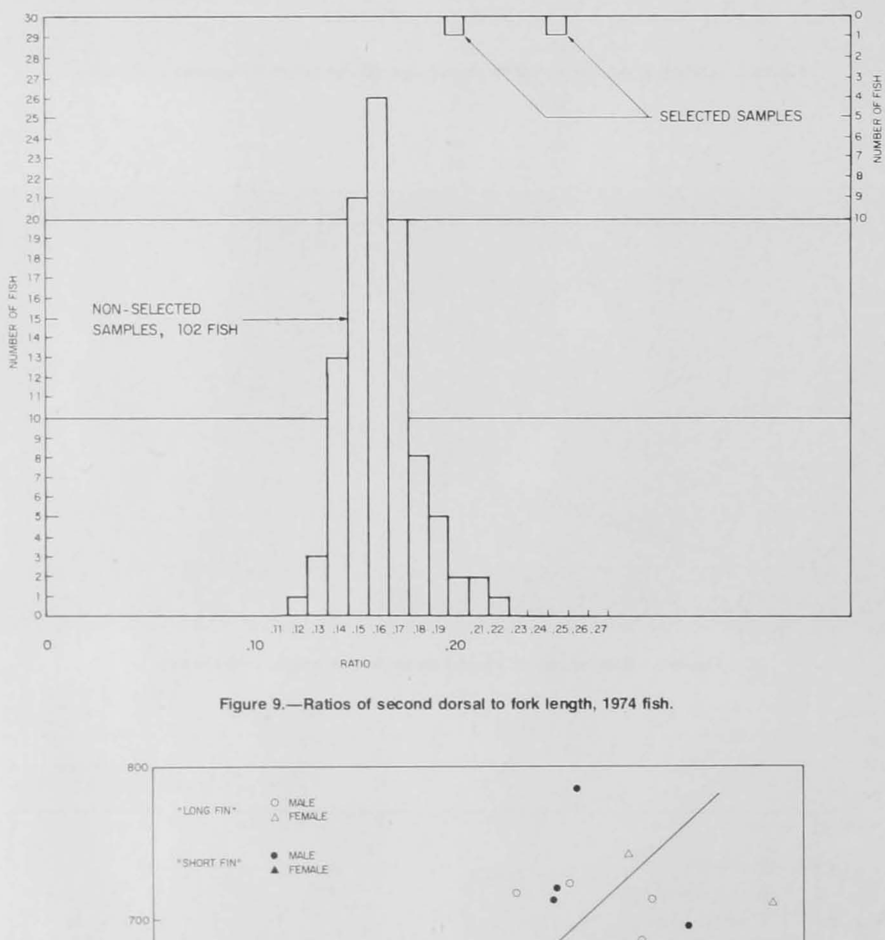

Figure 9.—Ratios of second dorsal to fork length, 1974 fish.

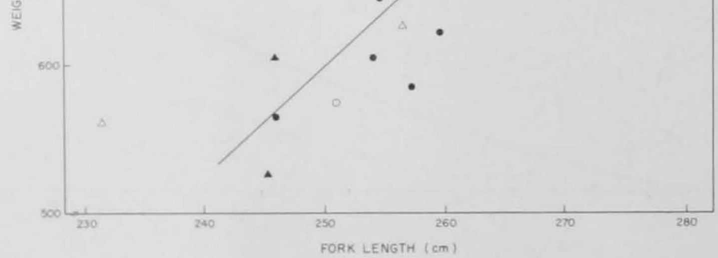

Figure 10.—Relative heaviness, Bailey Island, Me. tournament.

one fish of the 1950 era (ratio of 0.207). (There were also ratios of 0.200 and 0.198 in 1950.)

What is apparent is a greater spread in the 1974 data than in 1950. Thus, in 1974, while there were some fish with relatively long fins, there were also some with relatively shorter fins than in 1950. Why should there be greater biological variation now than then? One explanation would be that it could be merely greater error in measurements. The data in 1950 were collected by experienced personnel using rigorously standardized methods and definitions of end points, with resultant small "manipulative" error in the measurement process. The 1974 data were collected by a number of people, some relatively inexperienced and untrained in measuring tunas, using a variety of tapes and calipers, and measuring sometimes curved distances, sometimes straight line. This fact would increase the errors of measurement, and thus produce a greater "artificial" scatter of points than actually exists in nature.

Relative Heaviness

Although no Western Atlantic observer has mentioned that the "unusual" fish were relatively fat, it is worth a moment to check this possible difference, inasmuch as Sara definitely believed his "long fins" to also be fatter than normal. The data collected by Despres form the basis for one possible test, as she obtained lengths and weights on 26 of the fish classified as either "long" or "short" fin. The average fork length was 101 inches for both groups, and the average weight was 664 pounds for long fin and 640 for short. Inspection of the scatter of these 26 points (Fig. 10) gives no indication that this slight difference in the mean weight is significant.

Turning now to speculation that the "long-finned" may be predominantly of one sex, or are predominantly caught by harpoon (vs bait), we see that: 1) Of 40 fish observed at the Bailey Island tournament, Despres classified 17 (42 percent) as "long fin," 23 as "regular." 2) Of the 17 "long fin," sex determinations were made on 10. Of these 10 "long fin," 6 were males (60 percent), 4 were females (40 percent). However, most (81 percent) of the "regular fin" fish were also males. 3) Of the 17 "long fin," 13 (76 percent) were taken by harpoon, and only 4 (24 percent) with bait. However, 65 percent of the "regular fin" fish were also taken by harpoon. 4) None of these differences are statistically significant. Thus these speculations are not supported by the available data.

European Waters

Length of Fins

Sara's five fins ranged from 53 to 55 cm, for fish of 250 to 260 cm total length. There is no way to compare these five apparently "selected" second dorsals with the rest of the population (for instance with the rest of the 2,000 fish taken in the area in 1974), as no other measurements were apparently taken—merely these five "unusual" fish.

A poorer basis of comparison could be with the 1974 Western Atlantic fish by superimposing these five points on Figure 8 and provided as Figure 11. The lengths, although longer than average, do not form a five fish group beyond the normal range of dispersion.

Sara's measurements could also be compared to European fish of earlier years. By courtesy of Frank Mather, such a regression[8] of second dorsal to total length is available. Superimposing the five points on this regression (Fig. 12) shows that the early data do not include fish of these large sizes. However a reasonable amount of extrapolation of the data upward to larger-sized fish—and with increasing dispersion (as was found in Western Atlantic fish)—could reasonably place the five fish in the upper limits of a normal dispersion.

The five fish could also be compared to earlier Western Atlantic fish (of our Figure 7). "Superimposing" the five points and providing the result as Figure 13 indicates that the five points are above the dispersion. However, it must be noted that the early data did not include many fish above 250 cm. Also, the ratio of the five fish averages 0.211, and the earlier data do include fish with almost as relatively long a second dorsal fin (ratio of 0.210).

From the photographs provided to Frank Mather by Sara in January 1975 (Fig. 4), it is not possible by known

[8]An amalgamation of early measurements of Mather, Roda, and Rivas.

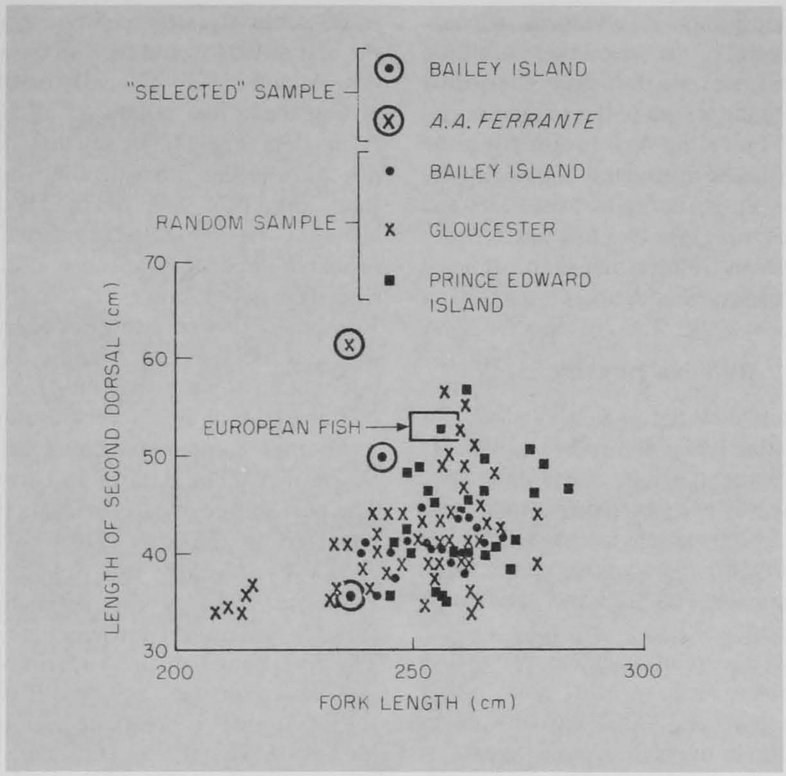

Figure 11.—European fins compared to 1974 western Atlantic.

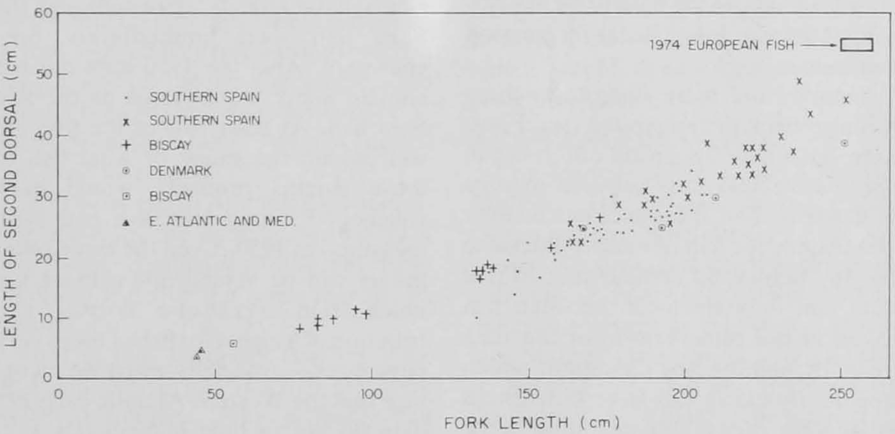

Figure 12.—European fins compared to early era European fish.

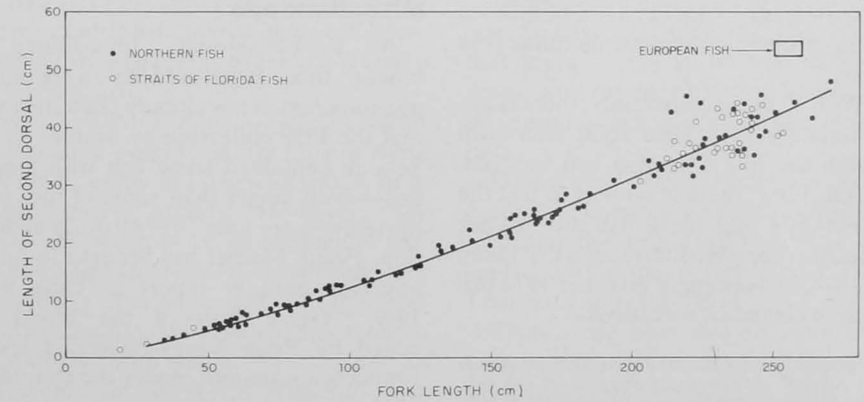

Figure 13.—European fins compared to early era western Atlantic fish.

photointerpretative techniques to establish lengths of the second dorsal of the fish. It is possible, however, to roughly estimate the length of the second dorsal in relation to the fork length (i.e., the ratio). These estimated ratios for the two fish shown in Figure 5 are 0.210 and 0.205. Thus these two fish did not possess clearly longer fins than, at least some, observed and measured in earlier times.

Relative Heaviness

As recalled, Sara's fish weighed 796, 893, 1,014, 1,053, and 1,067 pounds. He is convinced that these fish are significantly heavier than "normal" fish of 250 to 260 cm length range. This is a good juncture to note the constraints on the comparing of "relative" heaviness of bluefin tuna.

First, the relationship between fish length and fish weight is a highly curvilinear[9] one. This virtually eliminates the convenient use of the simple ratio between length and weight as the parameter to be compared. It also forces transformations of at least log-log in order to allow the data to be statistically compared by linear regression methods.

Second, and more important, there has also been demonstrated (see Footnote 9) a highly significant difference in the relative heaviness between seasons of the year. This difference can be over 100 pounds for fish of exactly the same length. Thus valid comparisons of raw data can only be made between fish taken in the same season of the tuna year. In addition, the conditions which apparently cause the large differences (spawning, then a long migration to the feeding grounds, fattening up prior to winter, and then wintering preparation to spawning) do not occur on both sides of the Atlantic in the same months of the year.

With all these constraints, there is unfortunately very little solid data with which the five Sara fish can be compared. First, there is no way to test the hypothesis that these fish are heavier than the other Mediterranean fish taken in 1974, as seemingly no other 1974 fish were weighed or measured.

[9]Unpublished manuscript of early work of Mather and Schuck utilizing measurements of 693 fish. Length-Weight Relationship of Atlantic Bluefin Tuna-Early Era 1948-1952., by H. A. Schuck, in press.

The only basis for comparison with the rest of 1974 would be with the Western Atlantic 1974 fish. By superimposing these five points on all Bailey Island data (Fig. 14), we see that the five fish do appear considerably heavier than any 1974 fish of the Western Atlantic—seemingly far above the probable upper limit of normal dispersion. It is noted, however, that the five European fish were just prior to spawning, and the Western Atlantic data do not contain any pre-spawning fish; thus this comparison is not very useful.

Another comparison could be with Western Atlantic data of an early era. The best source of early era data is that collected in the late 1940's to early 1950's by Mather and Schuck (see Footnote 9). A plot of the 693 fish measured in that era is shown as Figure 15. The five Sara fish are superimposed, and shown as black squares. It can be seen that all five points lie well above the line of "best fit" and the dispersion. However, the 1950 data do not include immediately pre-spawning fish (the first month sampled was May, when most giants have already spawned) and the Sara fish were immediately prespawners. Also the 1950 data did not contain many fish as large as the five Sara fish. At least two of the five are well within the range of what fish of these lengths probably would have weighed if larger-sized fish had been measured in 1950. Even the three other points can be visualized, without too much strain, as part of a "normal" distribution of weights for fish of these very large sizes—especially when we recognize that the Western Atlantic early era data do not include immediately prespawning fish.

Miscellaneous

As to occasional "long-finned" bluefin tuna being strictly a recent phenomenon, it has already been shown that the 1950 collection by Mather and Schuck contained some fish with long fins—even longer than some of the reportedly "very long" 1974 fish. In addition, Frank Mather has brought to our attention another report as early as 1949. "Game Fish of the World," edited by Brian Vesey-Fitzgerald and Francesca Lamonte, under the chapter on Nova Scotia, contains this statement: "It can be generally accepted that

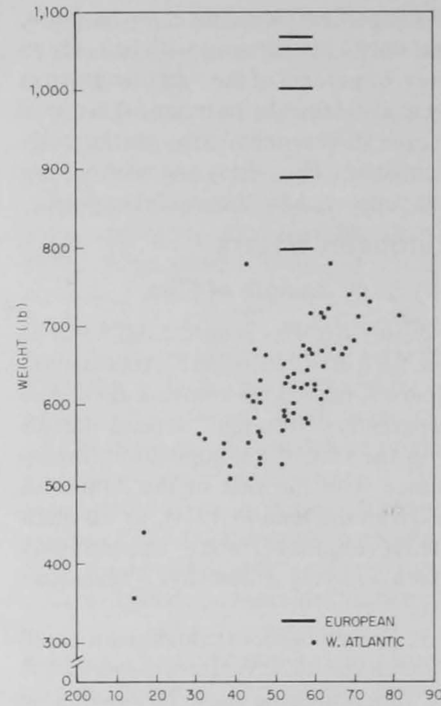

Figure 14.—Relative heaviness of European fish compared to 1974 western Atlantic fish.

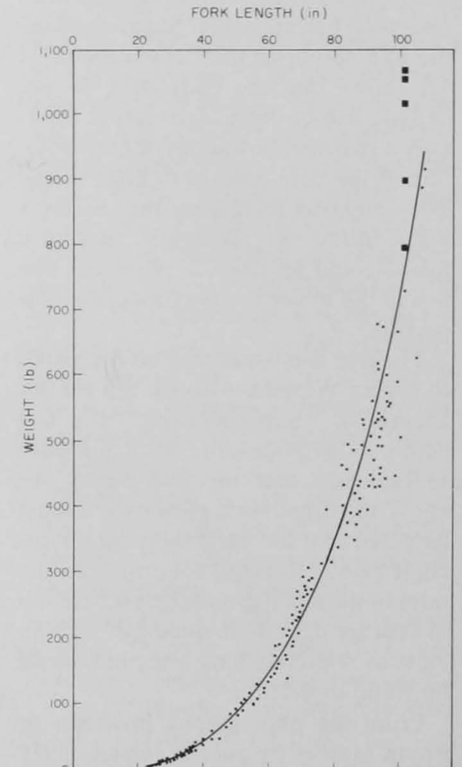

Figure 15.—Relative heaviness of European fish compared to early era western Atlantic fish.

the whole south and east coast of Nova Scotia is potential tuna ground. Long fin are occasionally taken, but bluefin are the usual run." Unfortunately, Francesca Lamonte, now retired, cannot recall the author of this particular bit of information, thus we can do no more than speculate whether this refers to a relatively "long-finned" bluefin tuna, or to another species of tuna—e.g. albacore or bigeye. However, the known range of these species makes the latter extremely improbable. Also small-sized tuna (a characteristic of these species) are rare in Nova Scotia waters. It appears probable therefore, that what is referred to is a relatively long-finned Atlantic bluefin tuna—of the type noticed in 1974.

Another bit of evidence that "unusual" fish (in terms of fatness in this case) have occasionally been taken in early years is found in Farrington (1974), page 18:

> "Mr. Holden then got busy. Around eight in the morning he promptly hooked a fish that weighed 871 pounds. It was only 106 inches long but had an amazing girth of 83 inches—by all odds the most unusual tuna that old-timers at Wedgeport had ever seen. Small wonder Holden caught the fish in fifty minutes; it was so fat it looked like a pompano."

Unfortunately, we have been unable to determine what length measurement was used. Neither Kip Farrington nor the International Game Fish Association (IGFA) official scorer at Wedgeport (Israel Pothier) could recall. It is probable that the "106 inches" is a curved rather than straight distance. But whether it is fork length, or the Wedgeport occasionally-used maximum length (to the end of the caudal lobes), cannot be ascertained.

The very heavy (in terms of length) Canary Island fish was undoubtedly a bluefin tuna of the type measured by Sara, and not a bigeye tuna as identified by its captors. The weight of 1,094 pounds seemingly prevents it from being considered a bigeye. Frade (1931) believed that bigeyes probably reached sizes no greater than 188 cm; Mather (1962) lists their probable sizes as "up to 400 lbs"; Hammond and Cupka (1974) list the present rod and reel record for the species maintained by the IGFA to be 321¾ pounds; and the International Commission for Conservation of Atlantic Tunas lists its maximum size at 190 cm (Miyake and Hayasi, 1972).

CONCLUSIONS

1) It is a fact, known since 1950, that larger bluefin tuna possess relatively longer dorsal fins than do smaller fish—i.e., longer in relation to total length. Thus, as we examine unusually large specimens, we must expect the second dorsal to appear out of proportion to the rest of the body (as judged by the familiar appearance of lesser-sized tuna).

2) The Western Atlantic 1974 data made available for this analysis are not adequate to substantiate the hypothesis that there were two different types of giant bluefin tuna off the U.S.-Canada coast in 1974 and recognizable by relative fin lengths or any other characteristic. In fact, the reported phenomenon (as represented by the data presently available for analysis) can readily be explained by a combination of: (a) chance variation within a single-mode population; (b) actual selection of the longest-finned fish as the samples to be measured; (c) manipulative (measuring) errors, especially in measuring total fish length; and (d) the fact that larger-sized bluefin tuna are known to possess "disproportionately long" second dorsal fins (and also anals).

3) The Western Atlantic 1974 data do not allow for the conclusion that 1974 fish were significantly different from 1950 era fish (for the same reasons as above).

4) The five European fins are long. But considering that the five fish were selected samples, they probably fall within, rather than beyond, the normal expected dispersion for fish of these large sizes for either (a) the 1974 Western Atlantic fish, (b) the older-era European fish, and (c) the older-era Western Atlantic fish.

5) The five European weights are far above the weights of any tuna of these lengths, either in European waters or in the Western Atlantic. However, they are the weights of immediately prespawning fish. There is not immediately available data on weights of other prespawning tuna of large enough sizes to compare with these five, either in Europe or Western Atlantic data sources.

6) In summary, the presently available data representing 1974 fish on either side of the Atlantic do not support the contention that two separate, recognizable groups of *Thunnus thynnus thynnus* were present in 1974; or that the so-called "unusual" group differs significantly in certain body proportions from fish measured in earlier years.

7) It is still possible that, if and when large samples of randomly selected fish become available for analysis, the hypothesis of two distinct "types" of fish can be substantiated. But for now, the theory is unproven.

8) Until two discernible types are demonstrated beyond a reasonable doubt, there seems little to be gained in speculating as to what could be the cause of such a possible phenomenon—i.e. a hybrid with another species (e.g., bigeye tuna, *Thunnus obesus*), a mutant, a subpopulation not normally present in the areas sampled, an age effect (appearing in only very old fish), or a growth form in response to perhaps rapidly decreased population density of the species (which is occurring) and a resultant effect of decreased competition for food or space. Sexual dimorphism would appear eliminated as a possible explanation.

ACKNOWLEDGMENTS

Considerable credit is due to Frank J. Mather, III of the Woods Hole Oceanographic Institution, who has generously provided much background data and also publications that contain material relevant to this study. It was also Mather's translation of a letter for R. Sara of Italy that first divulged, on this side of the Atlantic, the interesting possibility that these seemingly abnormal fish exist.

Sara is to be acknowledged as the first one to have recorded the impression that there seems to be two different types, and the first to have knowingly measured seemingly abnormal bluefin tuna.

Despres of NEFC deserves much credit for her initiative in measuring and recording the weights of almost all fish landed during the Bailey Island Tuna Tournament in July 1974.

Thanks are also due to Francesca Lamonte, formerly of the American Museum of Natural History, to S. Kip Farrington, George Moses, and Israel

Pothier, IGFA measurer at Wedgeport, Nova Scotia, for helping to document the occurrence of "unusual" bluefin tuna during earlier years.

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APPENDIX

The following personal communication is a letter from Raimondo Sara, Sezione di Ricerca per le Conserve, e per i Derivati Agrumari, ESPI, Via Ricaseli, 45, Palermo, Sicily, to Frank Mather, WHOI, Woods Hole, Mass. Translation from Italian is by Frank Mather.

June 10, 1974

Dear Frank:

Excuse me for the delay with which I respond to your last. I have been engaged in work and have been to Favignana at last.

The fishing, at the 7th of June, and that is almost at the end of the campaign, has been:

-Favignana	1,520 tuna
-Formica	510 "
-S. Cusumano (Bonagia)	210 "
-Sardinia	Nothing (?)

Aside from a little group of about 60 tuna of 20/30 kg, the mean weight has been exceptional reaching peaks of 400 kg(!) with enormous fish, some of which were strange, about which I will tell you later.

Now I pose (?) you a problem which has kept me occupied for some weeks. At Favignana I have found some tuna (of 370-485 kg) which I find strange through:

—relatively long pectorals;
—2nd dorsal elongate terminating in a rounded filament, colored clearly in a yellow-orange, with 9 rays; terminates at the level of the IV dorsal finlet;
—anal similarly elongate and colored which terminates at the level of the V anal finlet;
—finlets 9/10 colored in intense yellow and bordered with black;
—liver almost all striated.

Fish of 250/260 cm should have had (according to my old measurements) pectoral fins around 40 cm of length; I find instead 48/50 cm and that is about 5 times (in ?) the length to the fork. The dorsal and the anal are respectively 53 and 52 cm. Furthermore the weight is disproportionate in respect to the length, and therefore, the specimen is fat.

I am sending you a drawing in proportion, while waiting to send you some photographs, if they come out.

I unfortunately was not prepared for such an encounter and therefore had to content myself with hurried measures and without appropriate means, without method of working.

What is happening in the Atlantic and therefore in the Mediterranean? On the one hand I think of the yellowfin, and on the other of the bigeye. But with such large sizes? And the isotherms of (their) distribution? Or is it a question of modifications of the bluefin, in relation to their size (and of their age) and of the areas from which they came, which had not been observed only because:

—fish of such great size and weight were not taken and were not so numerous;
—some populations (where do they come from?) substitute themselves for others?

I would be grateful to you for your opinion. I salute you cordially.

Dearly yours,

/s/

Raimondo Sara

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