SCRS/79/91

PRELIMINARY REPORT ON THE AGE AND GROWTH OF KING MACKEREL (SCOMBEROMORUS CAVALLA) FROM THE UNITED STATES

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SUMMARY

Preliminary results of a study of the age and growth of king mackerel from the recreational fishery of the south Atlantic and Gulf of Mexico coasts of the United States are presented. The age composition varied between locations. Ages of Texas fish ranged from 1 to 9 years, Louisiana from 1 to 14, northwest Florida from 0 to 10, South Carolina from 1 to 12, and North Carolina from 1 to 12. Generally Louisiana had the majority of the older fish, while northwest Florida had the majority of younger fish. The other areas had intermediate age distributions. The oldest males were 9 years old and the oldest females 14 years old.

Theoretical growth varied greatly between locations. Von Bertalanffy growth parameter (K, L_∞ in mm FL, and t_o in years) ranges were: Males - K = 0.32 to 1.38, L_∞ = 757 to 1071, and t_o = -1.39 to 0.44; Females - K = 0.04 to 0.62, L_∞ = 891 to 3203, and t_o = -3.76 to -0.21.

This study revealed differences between regions implying segregation of the population by age.

RESUME

Le présent document fait état des résultats préliminaires d'une étude sur l'âge et la croissance du thazard pris par la pêcherie sportive américaine au large des côtes sud-atlantiques et du golfe du Mexique. La structure démographique varie selon la région. Au Texas les poissons avaient de 1 à 9 ans, en Louisiane de 1 à 4, au nord-ouest de la Floride de 0 à 10, en Caroline du Sud de 1 à 12 et en Caroline du Nord de 1 à 12. La majeure partie des grands poissons ont été observés en Louisiane, et des petits poissons au nord-ouest de la Floride, les autres secteurs présentant une structure démographique intermédiaire. L'âge le plus avancé était de 9 ans pour les mâles et de 14 ans pour les femelles.

La croissance théorique variait beaucoup selon les endroits. La gamme des valeurs des paramètres de croissance de von Bertalanffy (K', L_∞ en mm FL, et t_o en années) était la suivantes:

mâles - K = 0,32 à 1,38, L_∞ = 757 à 1071, et t_o = -1,39 à 0,44

femelles - K = 0,04 à 0,62, L_∞ = 891 à 3203, et t_o = -3,76 à -0,21.

Cette étude a révélé des différences entre régions mettant en jeu une ségrégation de la population selon l'âge.

RESUMEN

Se presentaron resultados preliminares de un estudio de la edad y crecimiento de carita (Scomberomorus cavalla) de la pesca deportiva del Atlántico Sur y Golfo de México, costas de los Estados Unidos. La composición de edad varía según las zonas. La edad del pez de Texas, varía de 1 a 9 años, Lousiana de 1 a 14, el noroeste de Florida de 0 a 10, Carolina del Sur de 1 a 12 y Carolina del Norte de 1 a 12. Generalmente Lousiana tiene la mayoria de los peces de mayor edad, mientras que el noroeste de Florida, tiene la mayoría del pez joven. Las otras zonas tienen distribuciones de edad intermedia. Los machos más viejos eran de 9 años y las hembras tenian 14.

El crecimiento teórico varia bastante entre las zonas. Los parámetros de crecimiento de Von Bertalanffy(K, L_∞ en mm FL, y t_o en años) tenian una escala de: Machos- K=0.32 a 1.38, L_∞ =757 a 1071, y t_o= -1.39 a 0.44; Hembras K=0.04 a 0.62, L_∞ = 891 a 3203, y t_o= -3.76 a - 0.21.

Este estudio reveló diferencias entre regiones, lo que implica la segregación de la población por edad.

INTRODUCTION

The king mackerel (*Scomberomorus cavalla*) occurs from the Gulf of Maine to Rio de Janiero and sustains several commercial and recreational fisheries within its range. Although its age and growth has been studied (Beaumarlage, 1973; Nomura and Rodrigues, 1967) no study has included a broad geographic region of the United States. In the present study, we investigated the age and growth of king mackerel caught along the coast of the United States from Texas to North Carolina. We present evidence of: (1) otoliths being a valid structure for determining the age and growth of this species, (2) age distributions differing with locations, and (3) growth differing with time and area.

STUDY AREA AND METHODS

King mackerel, caught by recreational hook and line fishermen, were collected from Texas, Louisiana, northwest Florida, South Carolina, and North Carolina (Figure 1) from June 1977 through December 1978. These fish were sexed and measured to the nearest mm of fork length (FL). Sub-samples, consisting of a maximum of 10 fish of each sex and 50 mm FL size group by month and area were taken for determining age and estimating growth rates. Age data from the sub-samples and length-frequency distributions from each area were used to estimate age composition of the landings using the "age-length key" methods described by Ricker (1975).

The above samples were supplemented with small king mackerel obtained during experimental trawling in December 1978 for determining the otolith radius - fish length relation. A power curve was used to define the relation.

Otoliths were used for age and growth determinations. They were removed from the fish, cleaned, and either stored dry or in 100% glycerin. They were examined in a black-bottom watch glass containing 100% glycerin, under direct light, with a binocular dissecting microscope at 27.8X. The otolith radius (OR) was measured from the focus to the distal margin along the axis approximating the extension of the sulcus acousticus on the posterior surface of the otolith. All measurements were made in ocular micrometer units (1 omu = 0.0363 mm). Marks were counted and measured along the radius, with their distal edge being considered their end. The marks were opaque (light) under reflected light, while the interspaces were hyaline (dark), as described by Beaumariage (1973). These marks are considered annuli based on information from Beaumariage (1973) and the data from our study.

Our method of determining the time of mark deposition was to calculate the percentage of fish in each month whose otoliths had hyaline margins. The month(s) with the lowest percentages represented the time of mark formation.

The otoliths were classified into age groups based on the appearance of the margin (i.e., one light mark with a dark margin was classified as age 1+, while one light mark on the margin, with no dark edge, was classified as age 0+). Each otolith was examined by two readers. The percentage of agreement on age classifications between readers varied from 99% (fish from northwest Florida) to 85% (fish from Louisiana). Those fish whose age could not be agreed on were not used for this report.

In order to determine if differences occurred between age estimates based on surface examination of otoliths and ages based on examination of otolith cross sections, 133 otoliths were sectioned and examined. Ten otoliths from each age 0+ through 11+, eight 12+, three 13+, and two 14+ fish comprised this group. Between three and six sections, 0.15 mm thick,

were made through the focus of each otolith using a Norton[1/] diamond blade (SD519-N50m-1/8) on an Isomet low speed saw, rotating at 285 rpm. The otolith was mounted in thermoplastic (quartz) cement (No. 706 Lakeside). and cooled with mineral spirits during sectioning. Later, the cement was removed by soaking the specimen in 50% isopropanol. The free sections were then mounted on glass slides using Piccolyte cement and examined with a binocular dissecting microscope.

In order to calculate the size of a fish at an earlier age than that of capture, the relationship of the size of the aging structure (OR) to the size of the fish (FL) must be determined. Least-squares regressions of FL vs. OR (linear fit) and of ln FL vs. OR (power-curve fit) were computed to determine which showed a better correlation. Once the relationship was established, fork lengths at earlier ages were backcalculated from surface otolith measurements using methods adopted from Tesch (1971), Ricker (1975), and Everhart, Eipper, and Youngs (1975).

Von Bertalanffy growth curves were fitted by a computer program (Abramson, 1971). These curves were based upon mean backcalculated lengths at each age. An unweighted fit was used.

RESULTS AND DISCUSSION

Validation

The validity of using a body structure as an indicator of a fish's age and past growth depends on the structure meeting several requirements:

1. The structure must remain distinguishable and constant in number for the life of the fish.

2. The growth of the structure must be proportional to the fish's growth.

3. The marks being used as an indicator of age and growth must be laid down periodically, preferably annularly.

4. Body lengths calculated from earlier annuli should agree with empirical lengths from younger fish whose ages were determined from the marks on the aging structure.

We made the following observations regarding the above requirements:

1. Otoliths (sagittae) were present in fish as small as 23 mm standard length (Beaumariage, 1973), were constant in number, and retained their position and basic appearance throughout life.

2. Otolith radius and fork length had a positive relationship as shown by least squares regressions. The "power curve" equation, $FL = 1.2322\ OR^{1.3307}$ gave a satisfactory fit ($r = 0.987$) to the data (Figure 2) and had a higher correlation coefficient than the linear regression.

3. Opaque marks were deposited on the otolith mainly in the spring (Table 1). We thus considered the marks as annuli, which agrees with Beaumariage's data (1973).

4. The empirical and backcalculated fork lengths (at earlier ages) were in reasonable agreement for male and female king mackerel from northwest Florida in 1977 (Tables 2 and 3). The empirical and backcalculated lengths are shown graphically in Figure 3. Backcalculated tables were

1/ Reference to trade names does not constitute endorsement by the National Marine Fisheries Service, NOAA.

developed for all areas and all years, and the empirical and backcalculated lengths corresponded similarly. Based on this information, we concluded that otoliths can be used as valid age and growth indicators in king mackerel.

Although Beamish (1979) indicated that a fish's age may be underestimated using surface examination and that otolith sections are more reliable, we found 96.5% agreement between king mackerel age estimates based on surface and sectional readings. This indicates that king mackerel otoliths are structurally consistent and that cross sections can be used to age king mackerel whose otolith survace is unreadable.

Age Composition

Our king mackerel collections showed wide variation with regard to age composition (Table 4 and Figures 4, 5, and 6). The youngest fish were from northwest Florida, while the oldest fish were from Louisiana. Intermediate age fish were taken primarily in Texas, South Carolina and North Carolina. The oldest females in our samples that we could accurately age were 14+ years old (over 1400 mm FL), while the oldest males that we could age were 9+ years (970 mm FL).

A great amount of age variation occurred within a single length group in our data, as it did in Beaumariage's (1973) data. For example, females 850-899 mm FL were from 1 to 8 years old (Tables 5 and 6).

Growth

The Von Bertalanffy growth parameters computed from the backcalculated fork lengths vary greatly between sexes, and between areas and years. The three parameters are: K, the growth coefficient; L_∞, the ultimate length of fish in the population; and t_o, the time when the length would theoretically be zero. Growth parameters calculated from our data, and those available from the literature on king mackerel, are presented in Tables 7 and 8.

CONCLUSION

The age composition of the recreational king mackerel catch in the southeastern Untied States varies between locations. Older fish predominate in catches off Louisiana, younger fish off northwest Florida, and intermediate age fish off Texas, South Carolina, and North Carolina. Correspondingly, growth rates vary between areas. With further analysis we hope to determine if these fish belong to separate stocks, or are simply segregated by age.

LITERATURE CITED

ABRAMSON, N.J. 1971. Computer programs for fish stock assessment. FAO Fisheries Tech. Paper No. 101, Rome, Italy.

BEAMISH, R.J. 1979. Differences in the age of Pacific hake (Merluccius productus) using whole otoliths and sections of otoliths. J. Fish. Res. Bd. Canada 36:141-151.

BEAUMARIAGE, D.S. 1973. Age, growth and reproduction of king mackerel, Scomberomorus cavalla, in Florida. Fla. Mar. Res. Publ., No. 1, 45 p.

EVERHART, W.H., A.W. EIPPER, and W.D. YOUNGS. 1975. Principles of Fishery Science. Cornell Univ. Press, Ithaca, N.Y., 288 p.

NOMURA, H., and M.S.S. RODRIGUES. 1967. Biological notes of king mackerel, Scomberomorus cavalla (Cuvier), from northeastern Brazil. Arq. Est. Giol. Mar. Univ. Fed. Ceara (7)1:79-85.

RICKER, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Res. Bd. Canada, Bulletin 191, 382 p.

TESCH, R.W. 1971. Age and growth, p. 98-130. In W.E. Ricker (ed.) Methods of assessment of fish production in fresh waters. Blackwell Scientific Publ., Oxford.

Table 1. Percentages of otoliths having hyaline margins by month, area, and year.

Area and Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Percent											
TX-1977	-	-	-	-	-	73.3	71.4	100.0	-	-	-	-
TX-1978	-	-	-	-	-	100.0	100.0	97.5	-	-	-	-
LA-1977	-	-	-	-	-	100.0	-	-	100.0	100.0	100.0	-
LA-1978	100.0	83.3	100.0	59.4	100.0	84.6	93.5	86.5	100.0	100.0	95.0	-
FL-1977	-	-	-	-	-	81.8	90.6	96.9	100.0	95.7	-	-
FL-1978	-	-	-	-	-	100.0	100.0	100.0	100.0	88.9	-	-
SC-1978	-	-	-	-	-	-	-	-	-	97.1	-	-
NC-1978	-	-	-	-	100.0	36.4	61.5	73.3	96.2	91.1	-	-
TOTAL	100.0	83.3	100.0	59.4	100.0	88.1	93.8	95.4	99.2	92.8	97.4	-

Table 2. Backcalculated fork lengths (mm) for male king mackerel from northwest Florida in 1977.

Age Group	$\bar{x}$ length at capture	N	Avg. backcalculated length at age 1	2	3	4	5	6		
1	608.6	28	547.5							
2	693.7	23	411.6	660.8						
3	753.5	8	452.2	638.3	723.8					
4	764.3	11	461.0	599.1	669.1	738.6				
5	829.0	1	505.4	611.4	674.1	746.5	812.3			
6	881.0	2	258.8	542.9	627.8	715.9	791.5	849.6		
		73	472.7	635.4	685.5	735.9	798.4	849.6		Weighted Mean
				162.7	50.1	50.4	62.5	51.2		Annual Increment

Table 3. Backcalculated fork lengths (mm) for female king mackerel from northwest Florida in 1977.

Age Group	$\bar{x}$ length at capture	N	Avg. backcalculated length at age 1	2	3	4	5	6	7	
1	627.2	65	531.5							
2	735.1	51	399.4	689.6						
3	815.2	29	457.0	662.2	785.0					
4	847.7	18	440.4	655.5	744.0	818.5				
5	906.9	17	452.5	655.7	734.8	808.1	878.4			
6	913.0	1	439.1	546.0	658.3	745.8	828.4	897.5		
7	982.0	3	329.9	620.3	685.3	730.5	809.3	896.9	962.5	
		184	463.1	670.0	755.3	805.3	866.1	897.1	962.5	Weighted Mean
				206.9	85.3	50.0	60.8	31.0	65.4	Annual Increment

Table 4. Percentages of king mackerel within each age group by area and year.

Area and Year	Age in Years 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Number of Fish
							Males									
TX-1977	-	-	6.9	24.1	24.1	27.6	3.5	6.9	6.9	-	-	-	-	-	-	29
TX-1978	-	2.6	1.9	13.5	16.5	20.6	32.5	3.6	3.3	5.8	-	-	-	-	-	533
LA-1977	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	10
LA-1978	-	-	-	-	-	20.0	24.0	36.0	8.0	12.0	-	-	-	-	-	25
FL-1977	-	26.9	31.3	16.7	20.5	2.0	2.6	-	-	-	-	-	-	-	-	498
FL-1978	1.8	93.1	2.7	1.2	0.4	0.8	-	-	-	-	-	-	-	-	-	1,107
SC-1978	-	21.1	8.8	21.8	13.6	13.6	19.7	-	-	1.4	-	-	-	-	-	147
NC-1978	-	5.2	5.2	18.3	35.7	20.0	8.6	3.5	3.5	-	-	-	-	-	-	115
TOTAL	0.8	48.8	8.6	10.5	12.6	7.7	6.5	1.7	1.4	1.4	-	-	-	-	-	2,507
							Females									
TX-1977	-	-	27.9	48.8	7.0	9.3	4.7	2.3	-	-	-	-	-	-	-	43
TX-1978	-	4.1	8.5	5.8	37.3	23.6	9.9	10.8	-	-	-	-	-	-	-	780
LA-1977	-	0.4	0.8	12.6	28.9	30.1	10.9	6.7	2.9	6.7	-	-	-	-	-	239
LA-1978	-	-	0.4	1.3	6.0	14.4	24.4	11.9	7.7	7.7	10.9	8.8	4.4	1.3	0.8	479
FL-1977	-	39.6	30.4	12.5	10.0	5.8	0.6	0.6	0.4	-	0.1	-	-	-	-	1,393
FL-1978	2.0	85.0	5.9	2.5	2.1	1.6	0.8	-	-	-	0.1	-	-	-	-	1,463
SC-1978	-	17.3	3.6	26.5	21.7	5.6	11.2	-	4.4	5.6	2.4	0.8	0.9	-	-	249
NC-1978	-	4.5	3.7	19.7	20.4	19.2	16.4	8.5	4.0	3.2	-	-	0.4	-	-	402
TOTAL	0.6	37.9	10.9	9.9	11.1	8.6	0.3	4.0	2.2	1.7	1.7	1.1	0.7	0.2	0.1	5,216

Table 5. Percentages of male king mackerel per age within each length group from all locations, 1977-1978.

Length Group	Age in Years 0	1	2	3	4	5	6	7	8	9	10	11	12	Total Number of Fish
400-449		100.0												4
450-499	15.2	84.8												33
500-549		100.0												51
550-599		98.3		1.7										60
600-649		93.0	5.3		1.7									57
650-699		37.5	37.5	14.6	10.4									48
700-749		11.9	35.7	31.0	16.6	2.4	2.4							42
750-799			11.1	27.8	46.3	13.0	1.8							54
800-849			2.0	15.4	34.6	21.8	19.2	3.8	3.8					52
850-899				15.0	5.0	35.0	30.0	10.0	5.0					20
900-949					14.2	42.9	42.9							7
950-999							25.0	25.0	25.0	25.0				4
1000-1049								25.0		75.0				4
1050-1099														
1100-1149														
1150-1199														
1200-1249									100.0					1

Table 6. Percentages of female king mackerel per age within each length group from all locations, 1977-1978.

Length Group	Age in Years 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total Number of Fish
350-399	100.0															1
400-449	33.3	66.7														6
450-499	43.5	56.5														23
500-549		100.0														48
550-599		100.0														90
600-649		96.4	3.6													112
650-699		77.5	19.7	2.8												71
700-749		25.3	65.1	7.2	1.2	1.2										83
750-799		3.0	36.0	43.0	16.0	2.0										100
800-849		2.4	11.0	36.2	31.5	13.4	3.9	1.6								127
850-899		1.6	0.8	18.9	33.6	32.0	9.8	2.5	0.8							122
900-949			1.0	11.0	22.0	25.0	28.0	9.0	4.0							100
950-999				2.5	23.4	31.2	26.0	14.3	1.3		1.3					77
1000-1049					16.7	23.1	34.6	11.5	6.4	3.8	2.6		1.3			78
1050-1099					4.1	28.6	26.5	10.2	10.2	16.3	4.1					49
1100-1149					7.7	19.2	40.4	13.8	19.2	7.7	5.8					52
1150-1199						11.9	21.4	33.3	9.5	9.5	7.1	4.8	2.5			42
1200-1249						2.9	15.2	21.2	21.2	9.1	15.2	6.1	9.1			33
1250-1299							12.5	8.3	4.2	16.7	33.3	8.3	16.7			24
1300-1349							4.3	4.3	13.0	8.7	21.7	26.3	13.0	8.7		23
1350-1399									5.0	15.0	30.0	35.0	5.0	5.0	5.0	20
1400-1449										26.7	13.3	33.3	20.0		6.7	15
1450-1499											14.3		57.1	14.3	14.3	7
1500-1549																
1550-1599												50.0	50.0			2

Table 7. Von Bertalanffy growth parameters for male king mackerel.

Area/Year	K value	L_∞ (FL mm)	t_0 (years)
Texas/1977	0.50	801	-0.49
Texas/1978	0.21	1071	-1.39
NW Florida/1977	0.32	927	-1.33
NW Florida/1978	1.38	753	0.44
S. Carolina/1978	0.73	810	0.14
N. Carolina/1978	0.71	807	0.08
Florida/1968-69 (Beaumariage, 1973)	0.35	903	-2.50
Brazil/1966 (Nomura and Rodrigues, 1967)	0.18	1160	-0.22

Table 8. Von Bertalanffy growth parameters for female king mackerel.

Area/Year	K value	L_∞ (FL mm)	t_0 (years)
Texas/1977	0.62	891	-0.30
Texas/1978	0.51	927	-0.36
Louisiana/1977	0.04	3203	-3.76
Louisiana/1978	0.15	1526	-2.05
NW Florida/1977	0.39	986	-0.71
NW Florida/1978	0.53	957	-0.21
S. Carolina/1978	0.17	1178	-1.93
N. Carolina/1978	0.35	1024	-0.50
Florida/1968-69 (Beaumariage, 1973)	0.21	1243	-2.40
Brazil/1966 (Nomura and Rodrigues, 1967)	0.15	1370	-0.13

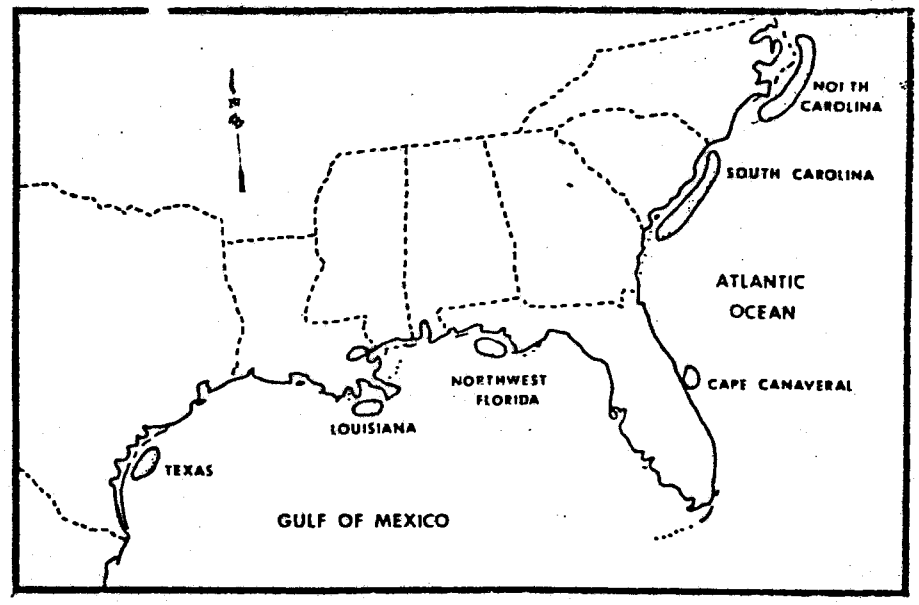


Figure 1. Study area and sampling locations in the southeastern United States.

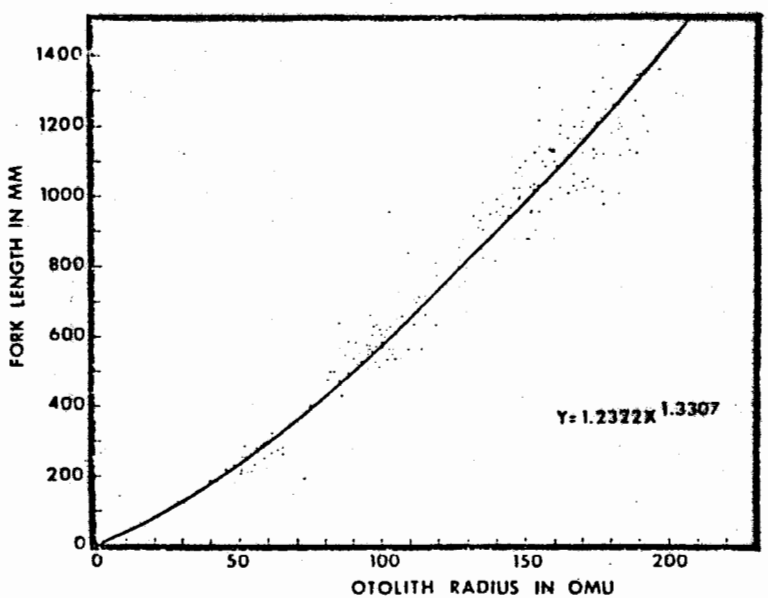


Figure 2. Scatter diagram and regression line of fork length vs otolith radius for king mackerel.

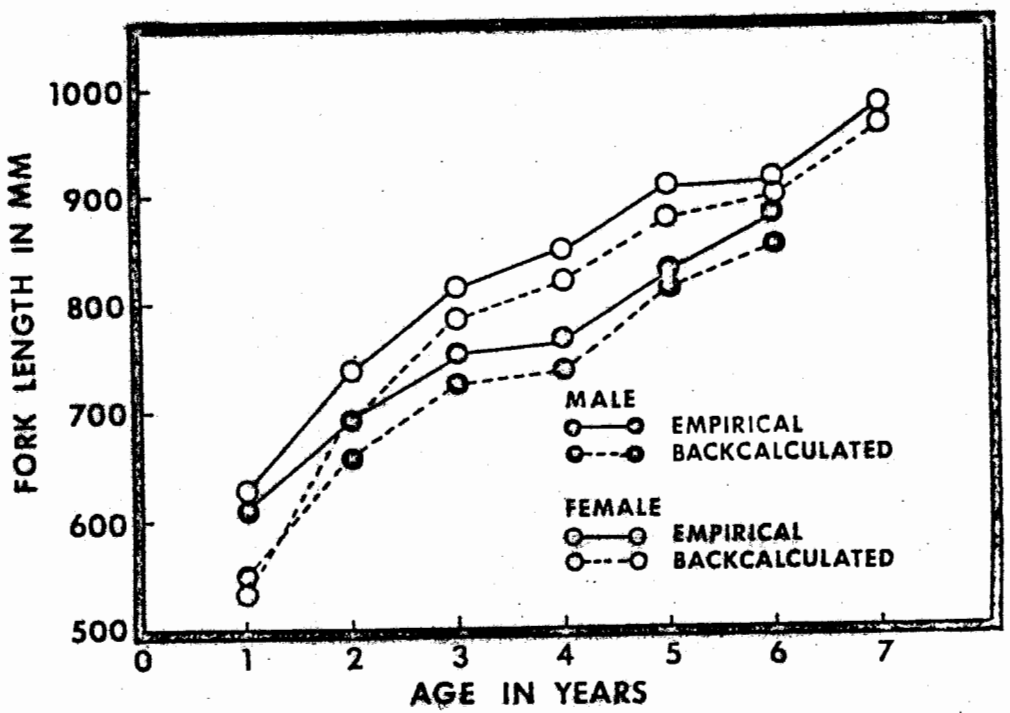


Figure 3. Empirical and mean backcalculated fork lengths for king mackerel from northwest Florida in 1977.

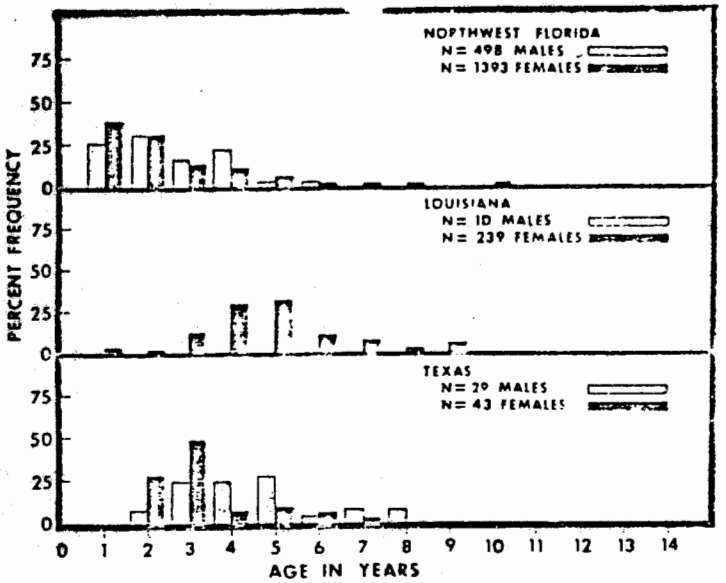
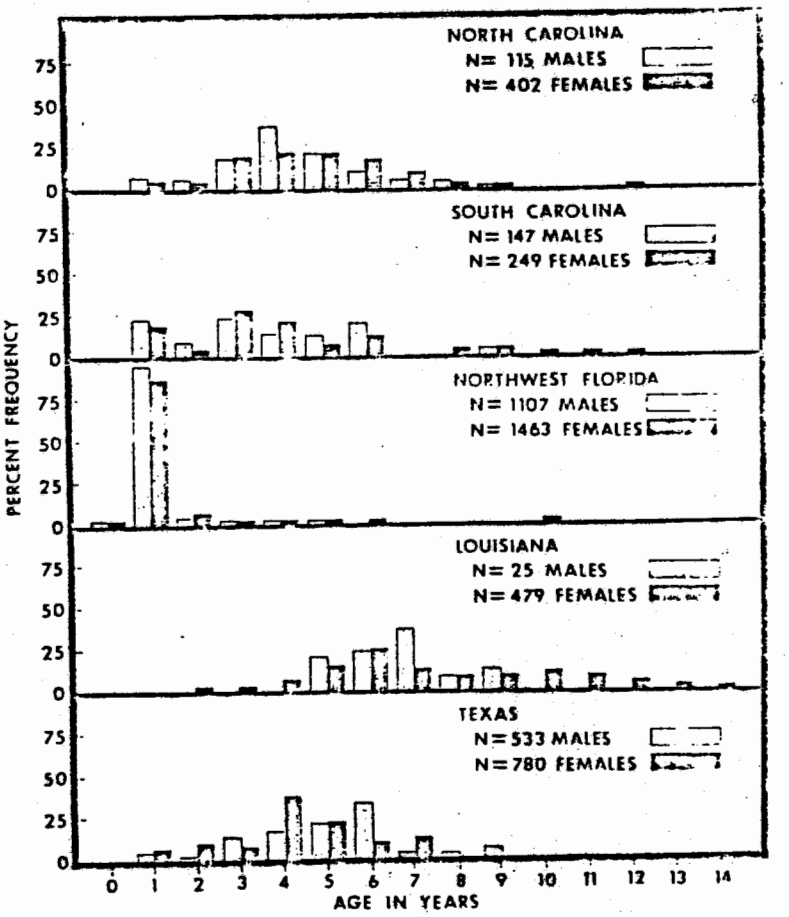


Figure 4. Age distribution of male and female king mackerel in 1977.

Figure 5. Age distribution of male and female king mackerel in 1978.



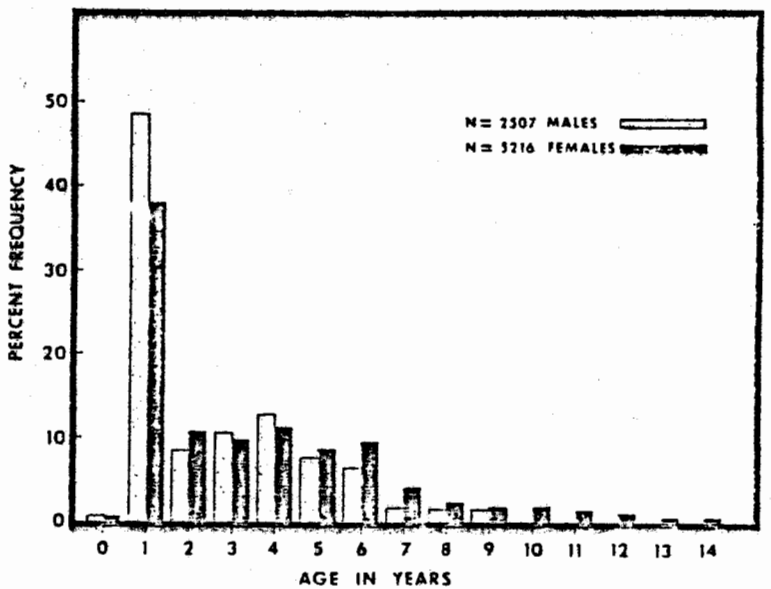


Figure 6. Age distribution of male and female king mackerel in 1977 and 1978 from all locations.

Volume IX of the "Collective Volume of Scientific Papers" contains documents presented at the meeting of the Standing Committee on Research and Statistics (Madrid, November 1979). Because of the quantity of papers, they are presented in three parts (Nos. 1, 2 and 3).

Vol. IX No. 1 - Tropical species (Yellowfin, Skipjack)
Vol. IX No. 2 - Temperate species (Bigeye, Albacore, Bluefin)
Vol. IX No. 3 - Billfishes and others

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Le Volume IX du "Recueil de Documents Scientifiques" rassemble les documents présentés lors des réunions du Comité Permanent pour la Recherche et les Statistiques (Madrid, novembre 1979). Etant donné la grande quantité de travaux présentés, ceux-ci ont été groupés en trois parties (Nº 1, Nº 2 et Nº 3).

Vol. IX Nº 1 - Espèces tropicales (Albacore, Listao)
Vol. IX Nº 2 - Espèces d'eaux tempérées (Thon obèse, Germon, Thon rouge)
Vol. IX Nº 3 - Xiphioidés et autres

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El Volumen IX de la "Colección de Documentos Científicos" contiene documentos presentados en la reunión del Comité Permanente de Investigaciones y Estadísticas (Madrid, Noviembre 1978). Debido a la gran cantidad de documentos, se presenta en tres partes (Nº 1, Nº 2 y Nº 3).

Vol. IX Nº 1 - Especies tropicales (Rabil, Listado)
Vol. IX Nº 2 - Especies de aguas templadas (Patudo, Atún blanco, Atún)
Vol. IX Nº 3 - Xifioideos y otros

Hemos incluídos únicamente los documentos que no han sido publicados previamente. Su inclusión en este volumen ha sido autorizada por los autores.

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