SCI. MAR., 63 (3-4): 317-325 SCIENTIA MARINA 1999

BIOLOGY AND FISHERY OF DOLPHINFISH AND RELATED SPECIES. *E. MASSUTÍ and B. MORALES-NIN (eds.)*

Growth and reproduction of the dolphinfish (*Coryphaena equiselis* and *Coryphaena hippurus*) in the Canary Islands, Central-East Atlantic (preliminary results)*

J.J. CASTRO[1], J.A. SANTIAGO[1], V. HERNÁNDEZ-GARCÍA[1] and C. PLA[2]

[1]Departamento de Biología, Universidad de Las Palmas de Gran Canaria, Apdo. 550, Las Palmas de Gran Canaria, Canary Islands, Spain. E-mail: josejuan.castro@biologia.ulpgc.es
[2]Lab. Ictiologia Genètica, Universitat de Girona, Campus Montilivi, 17071 Girona, Spain.

SUMMARY: The size, growth and spawning characteristics of pompano dolphin (N=150) and common dolphinfish (N=36) caught off the Canary Islands between May and September 1995 and between July and September 1996 were examined. Fork length (FL) of pompano dolphin was in the range 28.3-62.8 cm. In 1995, the mean length increased significantly from June to September. However, in 1996, the mean length was significantly larger in July than in September. The overall length-weight relationship was $W=0.0287*FL^{2.774}$ (r=0.97), while these relationships by sex were as follows: $W=0.031*FL^{2.758}$ (r=0.98) and $W=0.0282*FL^{2.776}$ (r=0.97), for males and females respectively. Spawning takes place at the beginning of the Summer (June-July). All the individuals obtained showed developing gonads, but females showed a higher gonadosomatic index (GSI) than males. The highest GSI values were obtained in June ($\bar{x}$=3.10±1.73), and decreased progressively towards the end of the season (September), when the average of this index was $\bar{x}$= 1.86±0.87. Similarly, the condition index decreased significantly from June to September. The proportion of females was always significantly higher than males, except in July 1996 when it was 1:1. There was a high correspondence between growth rates determined by annuli scale interpretation and modal progression analysis. According to scale annuli interpretation, the individuals caught showed more than five age classes. However, there are doubts about age assignation from scales. Fork length of common dolphinfish was in the range of 76.5-103.0 cm. The length-weight relationships obtained for all the specimens caught was $W=0.00095FL^{3.527}$ (r=0.96), while these relationships by sex were as follows: $W=0.00398FL^{3.222}$ (r=0.94) and $W=0.01656FL^{2.873}$ (r=0.91), for males and females respectively. Spawning probably takes place at the beginning of the Summer. All the individuals obtained showed developing gonads, although the GSI of females were higher than males. The highest GSI values were obtained in June ($\bar{x}$=5.50±2.17). In the same way, the condition index decreased from May to June. The proportion of females was always slightly higher than males (1:1.4), but the ratio was not significantly different from 1:1.

Key Words: *Coryphaena equiselis*, *Coryphaena hippurus*, growth, reproduction, Canary Islands.

INTRODUCTION

Coryphaena is the only genus in the Coryphaenidae family and is made up of two species, *Coryphaena hippurus* (Linnaeus, 1758) and *Coryphaeana equiselis* (Linnaeus, 1758). According to Collette (1981) and Palko *et al.* (1982), *C. equiselis* is differentiated from *C. hippurus* by the fact that the adult of the pompano dolphin has a body depth of over 25% the standard length, and that the tooth patch on the tongue of *C. hippurus* is smaller and oval in comparison with the broader and square

*Received October 28, 1997. Accepted October 8, 1998.

tooth patch of the *C. equiselis*. There are also differences in the number of rays on the different fins of both species, although their ranges overlap. In view of these distinctive characteristics, it might seem that these two species would be easy to distinguish, however they are not. During the CORY programme financed by the Commission of the European Communities (D.G. XIV), we were only able to segregate them using a genetic marker (Morales-Nin *et al*., 1995; Pla and Pujolar, 1999), because none of the morphological characteristicss allowed for quick and reliable recognition.

Coryphaena hippurus grows very quickly and its maximum longevity has been estimated at four years (Beardsley, 1967; Oxenford and Hunter, 1983; Uchiyama *et al*., 1986). Morales-Nin *et al*. (1995) from otoliths, reported that fish of 55 cm of FL, caught off Majorca, were 176 days old, and from scales, found that specimens of *C. hippurus*, caught off the Canary Islands within a range of between 76 to 103 cm FL, were two and three years old. However, there is no data relating to the longevity of *C. equiselis* although, according to Palko *et al*. (1982), the life span is believed to be shorter than for that of *C. hippurus*. However, Morales-Nin *et al*. (1995) found that specimens of *C. equiselis*, within a range of between 32 to 52 cm FL, were spread over four year classes. This fact indicates that the pompano dolphin has a slower growth rate and greater life span than the common dolphinfish.

Coryphaena hippurus is a circumtropical oceanic pelagic species that is common in waters of the Atlantic, Pacific and Indian Oceans (Briggs, 1960; Beardsley, 1967; Rose and Hassler, 1968; Johnson, 1978), and is generally restricted by the 20°C isotherm (Gibbs and Collette, 1959). *C. equiselis* generally inhabits open waters, and less frequently occurs in coastal waters. There is little information with respect to its geographical distribution, but it is probably distributed in more tropical and subtropical waters than *C. hippurus* (Collette, 1981), but is generally not found in waters with surface temperatures lower than 24°C (Mather and Day, 1954). In the East Atlantic, common dolphinfish have been observed from the Gulf of Biscay to SouthAfrica (Shcherbachev, 1973), and are also frequent in the Mediterranean (Massutí and Morales-Nin, 1995). However, pompano dolphin have been observed from the Azores to Senegal (Palko *et al*., 1982), although their range is not known to any degree of exactitude because sometimes they are confused with *C. hippurus*. They have also been reported in the Mediterranean sea (Shcherbachev, 1973), although they could possibly be confused with the juvenile of the common dolphinfish (Massutí *et al*. 1997). *C. hippurus* has occasionally been observed in coastal waters (Johnson, 1978) and during the Summer of 1995, we observed several common dolphinfish swimming into the port of Arguineguín (Gran Canaria), at only 2-4 m depth.

Dolphinfish are abundant in the waters of the Canary Islands, although the volume of commercial catches of these species is not large. There are three reasons which may explain these low catches. The first is cultural. In some islands, and especially among the fishermen, these species are known by the local name of "corpse eater" mainly as a result of their tendency to aggregate under floating objects (Fedoryako, 1988), including corpses. The second reason for low catches, relates to the absence of a large scale marketing and distribution network for these species beyond the insular markets. All catches of dolphinfishes are currently sold fresh to local restaurants or to the local market, whose capacity level is very limited. Thirdly, the seasonal presence of the skipjack tuna (*Katsuwonus pelamis*), coincides with that of the *Coryphaena* species in Canary waters, strongly depressing the potential catches of dolphinfish. This results from the fact that skipjack has a well structured marketing network and is exported to foreign markets (i.e. Japan) so that the coastal fishing fleet is exclusively devoted to fishing tuna. So, dolphinfish are only taken by tuna boats as by-catch.

The aim of the present paper is to report the first information on growth and reproduction of *Coryphaena equiselis* and *C. hippurus* in waters off the Canary Islands.

MATERIAL AND METHODS

A total of 150 specimens of pompano dolphin and 36 specimens of common dolphinfish were obtained from commercial catches off Gran Canaria (Canary Islands) between May and September 1995 and between July and September 1996. Fish samples were caught by the artisanal tuna fleet using live bait. Examination of the samples was undertaken immediately after landing. Each fish was measured, to the nearest millimetre, for fork length (FL), standard length (SL), distance to the anal fin (AL), distance to the ventral fin (VL), distance to the pectoral fin (PL), distance to the dorsal fin (DL), cephalic

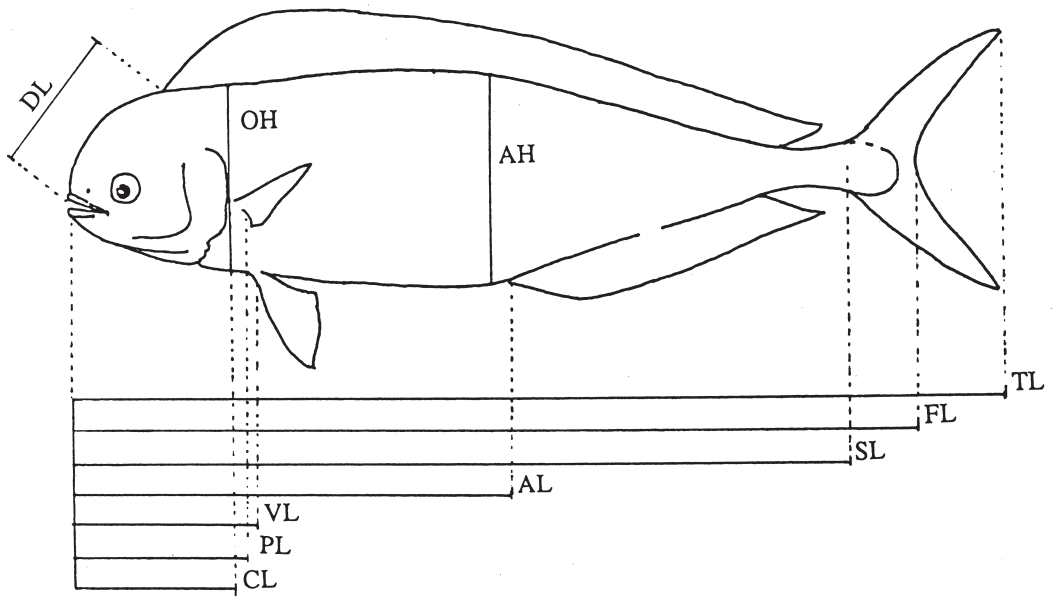

FIG. 1. – Morphometric measurements taken for *Coryphaena equiselis* and *Coryphaena hippurus*: Total length (TL); fork length (FL); standard length (SL); distance to the anal fin (AL), distance to the ventral fin (VL); distance to the pectoral fin (PL); distance to the dorsal fin (DL); cephalic length (CL); opercular height (OH); and anal height (AH).

length (CL), opercular height (OH) and anal height (AH) (Fig. 1). The total weight (W) and the eviscerated weight were also recorded to the nearest 0.1 g. The gonads and the liver were weighed to the nearest 0.01 g. The sex and stage of maturity of each specimen were ascertained from head morphology and by macroscopic observation of the gonads, following the classification proposed by Holden and Raitt (1975) (I, immature; II resting; III, ripe; IV, running ripe; V, spent). The gonadosomatic index (GSI) was calculated as GSI=100GW/W (Anderson and Gutreuter, 1983), and used to determine the spawning season.

All fish sampled were genetically analysed with protein electrophoresis technique using 11% starch gel. Tissue extraction, electrophoresis and procedures for visualizing proteins generally followed the methods outlined in Aebersold *et al.* (1987) with minor modifications (García-Marín *et al.*, 1991).

The length-weight relationship was established by linear regression, using logarithm values. The relative condition factor (Kn) was calculated as Kn=100W/TW, where TW is the estimated weight of fish of the same length, derived from the length-weight equation (Anderson and Gutreuter, 1983).

Morphometric relationships between FL, taken as an independent variable, and each of the remaining variables taken as dependent variables, were calculated in the following way: $Y_{ij}=a_i FL_j^{bi}$, where FL is the fork length of individual j, Y is the i variable of individual j and a_i and b_i are the parameters of the relationship between fork length and variable i. Calculations were carried out using logarithmic values.

Statistical analyses were carried out with CSS statistic software (StatSoft, Inc.).

Growth rates were determined by modal progression analysis of length frequency distributions obtained in 1995 and 1996. These were fitted at the 95% confidence level by the computer programme NORMSEP (Hasselblad, 1966) included in the FISAT software (Gayanilo *et al.* 1994).

RESULTS

Sample composition

Pompano dolphin sampled ranged in size from 28.3 to 62.8 cm FL, and weighed between 292 and 2810 g. The length of females ranged from 28.3 to 57.9 cm FL and the weight ranged from 292 to 2184 g. Males ranged from 29.2 to 62.8 cm FL and from 352 to 2810 g in weight. The length distributions in 1995 and 1996 were significantly different (ANOVA, $F=21.85$, $P<0.0001$; Table 1). The 1995 sample ranged from 32 to 52 cm FL and in 1996, from 28 to 63 cm FL (Fig. 2). In 1995, the mean length increased significantly from June to September (ANOVA, $F=3.824$, $P=0.014$). In 1996 the mean length was significantly larger in July than in September (ANOVA, $F=49.838$, $P<0.001$; Table 1).

TABLE 1. – Number (N) of *Coryphaena equiselis* and *Coryphaena hippurus* measured each month during 1995 and 1996, mean fork length ($\bar{x}$), standard deviation (SD), and length range (MINimal and MAXimal fork length).

		1995					1996			
		JUN	JUL	AUG	SEP	TOTAL	JUL	AUG	SEP	TOTAL
Coryphaena equiselis	N	22	14	14	14	64	40	-	46	86
	$\bar{x}$	41.9	37.6	41.6	43.1	41.1	40.7	-	34.0	37.1
	SD	05.3	04.6	04.3	03.2	04.9	05.5	-	03.1	05.5
	MIN	32.0	31.7	35.0	38.0	31.7	31.6	-	28.3	28.3
	MAX	52.2	47.7	49.5	49.5	52.2	62.8	-	41.6	62.8
		MAY	JUN		TOTAL					
Coryphaena hippurus	N	10.0	25.0		35.0					
	$\bar{x}$	88.3	86.1		86.8					
	SD	10.3	07.3		08.1					
	MIN	76.5	77.0		76.5					
	MAX	103.0	99.5		103.0					

Common dolphinfish measured ranged in size from 76.5-103.0 cm FL (Fig. 2), weighing between 3368 and 13718 g. The length of females ranged from 76.5 to 99.0 cm FL and weight from 3368 to 9800 g. Males ranged from 80.5 to 103.0 cm FL and from 5600 to 13718 g in weight. During 1995, 35 individuals were sampled, but in 1996 only one spent female (91.0 cm FL) was sampled. The mean length did not increase significantly from May to June (ANOVA, F=0.552, P=0.462). Females did not increase in length (ANOVA, F=0.727, P=0.405), but males did (ANOVA, F=9.280, P=0.0094; Table 1) during the same period.

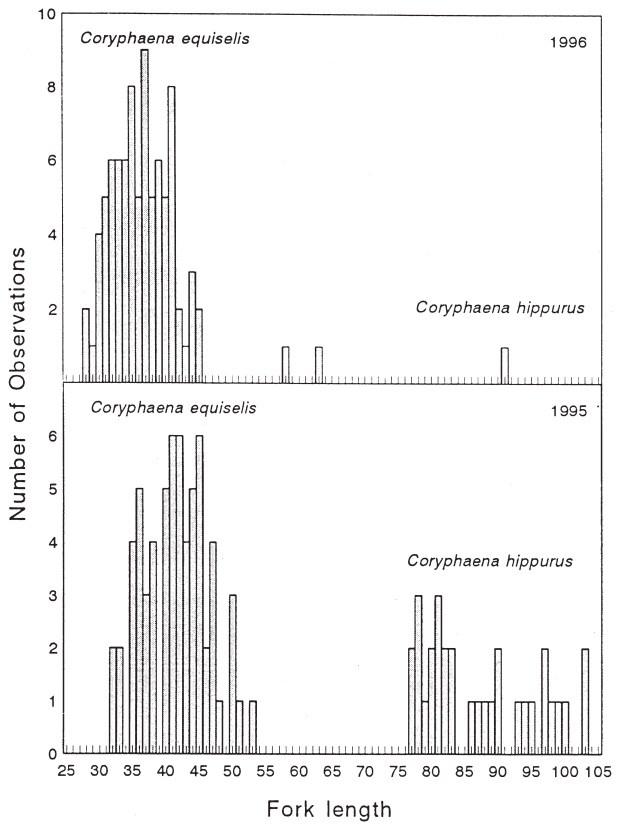

FIG. 2. – Length-frequency histograms for dolphinfishes caught in 1995 and 1996.

Growth

For pompano dolphin, the modal progression analysis shows the existence of four (χ^2 = 72.812, df=9, P<0.05) and five size classes (χ^2=62.904, df=10, P<0.05) in 1995 and 1996 respectively (Table 2). There was a high correspondence between annuli scale interpretation and the modal progression analysis for the individuals caught in 1995 (Mann-Whitney U-test, U=14.0, Z=-0.57, P=0.57), and also for the individuals caught in 1996 (Kruskal-Wallis ANOVA, H=2.04, P=0.36) (Table 2).

For common dolphinfish, the modal progression analysis shows three age classes (χ^2=99.334, P<0.05) (Table 2). There was also a high correspondence between modal length classes and the half year classes (Observed vs. expected χ^2= 0.149, P<0.93).

Relative growth

Length-weight relationships were calculated separately for females, males and all fish (Table 3).

For the pompano dolphin, analysis of variance showed no significant difference between the length (ANOVA, F=0.652, P=0.42) and weight distributions (ANOVA, F=1.226, P=0.269) of the two sexes. Analysis of covariance indicated no significant differences in the length-weight relationships between the two sexes (ANCOVA, F=1.229, P=0.27). The slopes of the length-weight regressions indicated

TABLE 2. – Size-at-age data derived from scale annuli interpretation by Morales-Nin *et al*. (1995) and its correspondence with the size groups (mean length and standard deviation) obtained from the modal progression analysis of the size distribution of *Coryphaena equiselis* and *Coryphaena hippurus* caught in 1995 and 1996.

	Age (years)	Size at age (Morales-Nin *et al*., 1995)	Modal Progression Analysis 1995	1996
Coryphaena equiselis	1.0			27.5±0.3
	1.5	32.0	31.9±0.5	31.0±1.4
	2.0	37.1±3.3	35.0±0.6	35.0±2.1
	2.5	38.5±4.5	37.7±1.8	39.8±1.8
	3.0	41.2±4.7	42.6±2.4	-
	3.5	43.2±4.1	-	-
	4.0	46.3	-	45.0±0.5
	4.5	50.0	50.1±0.8 -	
	Plus	-	-	58.0-63.0
Coryphaena hippurus	2.0	81.0±4.0	78.8±2.0	
	2.5	81.5±3.7	-	
	3.0	88.7±8.1	87.5±3.3	
	3.5	98.6±3.8	96.6±3.6	

TABLE 3. – Parameters of the allometric relationships of *Coryphaena equiselis* and *Coryphaena hippurus* (Interval at the 95% confidence level).

		Males				Females				All Fish			
		a	b	R	Interval	a	b	R	Interval	a	b	R	Interval
C. equiselis	W	0.03	2.76	0.98	(2.59-2.92)	0.03	2.78	0.97	(2.63-2.90)	0.03	2.77	0.97	(2.67-2.88)
	SL	0.99	0.98	0.99	(0.95-1.00)	1.05	0.97	0.98	(0.93-1.00)	1.03	0.97	0.99	(0.95-1.00)
	DL	0.33	0.80	0.84	(0.65-0.94)	0.44	0.73	0.85	(0.63-0.83)	0.40	0.75	0.84	(0.66-0.82)
	AL	-0.11	0.89	0.98	(0.84-0.95)	-0.69	0.89	0.87	(0.78-0.99)	-0.08	0.88	0.89	(0.80-0.95)
	VL	-0.45	0.89	0.95	(0.81-0.97)	0.36	0.85	0.94	(0.77-0.90)	0.39	0.86	0.94	(0.81-0.91)
	PL	-0.55	0.94	0.96	(0.86-1.01)	-0.55	0.94	0.95	(0.88-1.00)	-0.55	0.94	0.96	(0.89-0.98)
	CL	-0.49	0.87	0.96	(0.81-0.94)	-0.46	0.86	0.95	(0.80-0.91)	-0.48	0.87	0.96	(0.82-0.91)
	OH	-0.84	1.15	0.89	(1.04-1.26)	-0.89	1.14	0.89	(1.06-1.26)	-0.92	1.16	0.85	(1.08-1.24)
	AH	-0.68	1.04	0.85	(0.89-1.19)	-0.69	1.04	0.89	(0.94-1.14)	-0.73	1.07	0.87	(0.98-1.16)
C. hippurus	W	0.004	3.22	0.94	(2.66-3.78)	0.02	2.87	0.91	(2.15-3.58)	0.001	3.53	0.96	(3.13-3.92)
	SL	-0.10	1.04	0.99	(0.89-1.09)	-0.01	0.99	0.99	(0.87-1.11)	0.00	0.99	0.99	(0.94-1.03)
	DL	-1.37	1.26	0.84	(0.78-1.75)	-0.23	0.65	0.41	(-0.43-1.73)	-1.77	1.46	0.90	(1.03-1.88)
	AL	-0.38	1.04	0.98	(0.76-1.32)	-0.26	0.99	0.87	(0.78-1.20)	0.03	0.84	0.95	(0.70-0.97)
	VL	-0.18	0.75	0.85	(0.36-1.14)	-1.34	1.35	0.83	(0.67-2.03)	-0.65	0.99	0.89	(0.74-1.24)
	PL	-0.21	0.77	0.86	(0.52-1.01)	-0.60	0.96	0.95	(0.38-1.53)	-0.87	1.10	0.94	(0.87-1.32)
	CL	-0.48	0.88	0.76	(0.65-1.10)	-0.80	1.04	0.76	(0.64-1.43)	-0.73	1.00	0.97	(0.86-1.13)
	OH	-1.18	1.28	0.81	(0.72-1.83)	-0.72	1.01	0.57	(0.40-1.61)	-2.01	1.69	0.93	(1.34-2.03)

negative allometric growth in both sexes. There were significant differences between the mean opercular height (ANOVA, F=10.318, P=0.002) and mean anal height (ANOVA, F=9.094, P=0.003) of the two sexes. The mean cephalic length was larger in males than in females, although not significant (ANOVA, F=1.901, P=0.17). Analysis of covariance only indicated significant differences in the relationships between the CL-FL (F=4.707, P=0.03), FL-AL (F=19.58, P<0.001), FL-OH (F=57.922, P<0.001) and FL-AH (F=14.015, P<0.001) of the two sexes. Negative allometric growth was found in the relationships between FL and all the other variables, except with AH which behaved isometrically, and with OH which showed a positive allometric growth (Table 3).

For the common dolphinfish, analysis of variance showed significant difference between the length (ANOVA, F=20.199, P<0.001) and weight distributions (ANOVA, F=30.84, P<0.001) of both sexes. The slopes of the length-weight regressions indicated positive allometric growth. Positive allometric growth was found in the relationships FL versus DL and OH. Isometric growth was found in FL versus SL, VL, PL and CL. Negative allometric growth was only found in the relationship FL versus AL (Table 3).

The relationships between the body height (OH and AH) and the body length (FL or SL) did not show a clear lower limit as proposed by Collette (1981) which could be used to differenciate *Coryphaena equiselis* from *C. hippurus* (Table 5).

TABLE 4. – Mean values and range of variation of gonadosomatic index (GSI) and relative condition factor (Kn) per month, for females and males of *Coryphaena equiselis* and *Coryphaena hippurus*.

		Males					Females				
		N	GSI		Kn		N	GSI		Kn	
			$\bar{x}$	range	$\bar{x}$	range		$\bar{x}$	range	$\bar{x}$	range
Coryphaena equiselis											
1995	JUNE	5	1.11±0.18	0.92-1.41	1.04±0.07	0.91-1.09	17	3.68±1.53	0.95-6.28	1.02±0.07	0.87-1.09
	JULY	6	1.10±0.32	0.83-1.68	0.99±0.05	0.94-1.07	8	3.10±1.70	0.93-6.07	0.94±0.08	0.82-1.14
	AUGUST	3	0.96±0.25	0.64-1.14	0.95±0.05	0.90-1.01	11	3.35±0.62	2.17-4.09	0.99±0.12	0.66-1.12
	SEPTEMBER	5	1.04±0.13	0.83-1.16	0.94±0.05	0.86-1.00	9	2.32±0.74	0.93-3.43	0.92±0.09	0.77-1.01
	TOTAL	19	1.05±0.23	0.64-1.68	0.98±0.07	0.86-1.09	45	3.22±1.32	0.93-6.28	0.97±0.10	0.66-1.14
1996	JULY	22	1.54±0.64	0.58-3.51	1.54±0.08	0.93-1.21	18	3.79±0.77	2.50-5.20	1.06±0.06	0.94-1.18
	SEPTEMBER	13	0.91±0.35	0.40-1.91	0.99±0.07	0.87-1.10	33	1.51±0.74	0.42-3.15	0.97±0.06	0.97-1.08
	TOTAL	35	1.29±0.62	0.40-3.51	1.04±0.08	0.87-1.21	51	2.32±1.33	0.42-5.20	1.00±0.07	0.79-1.18
Coryphaena hippurus											
1995	MAY	4	1.47±0.10	1.35-1.57	1.13±0.09	1.14-1.25	6	4.97±1.20	3.29-6.46	0.90±0.10	0.76-1.03
	JUNE	10	1.53±0.63	1.14-2.26	1.03±0.07	0.94-1.16	12	5.78±2.17	3.81-8.30	0.90±0.07	0.81-1.01
	TOTAL	14	1.49±0.37	1.14-2.26	1.06±0.08	0.94-1.25	18	4.81±2.23	3.21-8.30	0.90±0.08	0.77-1.03

Only the relationship between SL and AH showed an average similar to the 25% reported by Collette, but its range (22.4 to 29.9 %) did not allow us to use it as a valid and definitive criteria of identification.

Sex ratio

Of the total number of pompano dolphin examined, 96 were females (45 in 1995 and 51 in 1996) and 54 were males (19 in 1995 and 35 in 1996). The overall ratio of males to females was 1:2 and the proportion of females was always significantly higher than males (χ^2 observed vs. expected= 88.97; P< 0.001), except in July 1996 when it was 1:1. Females predominated (1:2) in size intervals lower than 45 cm FL, while in larger size intervals the proportion between males and females was 1:1.

Common dolphinfish sampled were 21 females (20 in 1995 and 1 in 1996) and 15 males (all sampled in 1995). The overall ratio of males to females was 1:1.4 and the proportion of females was always higher than males (1:1.5 in May and 1:1.3 in June). Females predominated in size intervals lower than 85 cm FL, while in size intervals larger than 90 cm the males predominated.

Spawning period

During the sampling periods, ovaries and testes of both species were well developed with all the individuals in the stage III of the scale of Holden and Raitt (1975). We did not find any specimens in stages IV or V.

The monthly GSI values of females of pompano dolphin were usually higher than those of males (Table 4). In 1995, the highest values of the GSI in both sexes ocurred between June and July, with a peak in June for females and July for males. In 1996, the maximum GSI for both sexes was recorded in July. However, there were no samples in June and August of that year (Table 4). In 1995, the GSI decreased, from June to September in both sexes (Kruskal-Wallis ANOVA; H=7.39, P=0.06 in females and H=1.01, P=0.79 in males). The mean Kn showed a peak during July, while the lowest was observed in September for both sexes (Table 4). In 1996, Kn followed a similar pattern as in 1995

TABLE 5. – Mean ratio (%), standard deviation (SD) and range in the % ratios, between the fork length (FL) or standard length (SL) and the body height measured at the level of the operculus (OH) or at the anus (AH), in females and males of *Coryphaena equiselis*.

	OH/FL			AH/FL			OH/SL			AH/SL		
	%	SD	range	%	SD	range	%	SD	range	%	SD	range
Males	22.8	1.30	19.6-25.7	24.3	1.48	21.9-28.0	24.4	1.47	21.0-28.2	25.9	1.72	23.1-29.9
Females	21.2	1.24	17.9-24.9	23.3	1.01	21.1-25.4	22.5	1.32	19.9-26.3	24.6	1.00	22.4-27.2
Total Fish	21.8	1.50	17.9-25.7	23.7	1.34	21.1-28.0	23.2	1.64	19.9-28.2	25.1	1.55	22.4-29.9

(Table 4). In 1995, Kn decreased from June to September in both sexes but it was only significant in females (Kruskal-Wallis ANOVA; H= 9.90; P=0.02).

The monthly GSI values of females of common dolphinfish were usually higher than that of males (Table 4). The highest values of the GSI in both sexes ocurred in June. The GSI increased, although not significantly, from May to June in both sexes (Kruskal-Wallis ANOVA; H=0.24, P= 0.62 in females and H=0.50, P=0.48 in males). There were no significant variations in Kn values during both months (Table 4).

DISCUSSION

Off the Canary Islands, captures of *Coryphaena hippurus* and *Coryphaena equiselis* are reported together as "dorados". The data series of dolphinfish species landed in the port of Mogán (Southwest of Gran Canaria) from 1981 onwards, is very irregular and shows an abundance peak catch in Summer and a slough in January-April. During 1995 and 1996, catches of *C. equiselis* were more frequent, especially from June to September. However, *C. hippurus* seems to be more abundant during May and June. Nevertheless, *Coryphaena* species are caught almost all the year round, although the majority of captures outside of the normal fishing season are reported by long-liner or sport fishing. On 15th June 1994, a fishing vessel reported a capture of over 3 tons, caught under a drifting object off the east coast of Gran Canaria. Daily captures of 1030 Kg and 760 Kg per boat were reported on 27th October and 19th November 1994 respectively, but in any case it was not recorded which species of dolphinfish was captured nor the length range. In 1994, the average catch per day per boat was 223.1 Kg, while in 1995 it decreased to 99.8 Kg. Catches in 1996 and 1997 were negligible. The low rates of capture between years are caused, among other factors, by the total lack of commercial network for these species beyond the insular markets, and the strong market for skipjack tuna, in the same season and fishing ground.

Pompano dolphin and common dolphinfish caught in the Canary Island waters reveal an unbalanced sex ratio in favour of females. However, in pompano dolphin in the size intervals of over 45 cm fork length, the sex ratio was 1:1, and in the case of common dolphinfish, in size intervals larger than 90 cm, the males predominated. This may be due to a different life-span for both sexes, with a higher mortality rate in females than in males when larger in size. However, unbalanced sex ratios in dioecious species is extremely rare, and it is probably safer to assume that the sex ratios observed were a consequence of sampling caused by differences in the behaviour (and hence in catchability) of males and females, and of fish of different sizes, as has been reported for common dolphinfish (Rose and Hassler, 1974; Gibbs and Collette, 1959; Beardsley, 1967). Differential growth rates for both sexes of common dolphinfish, with adult males larger than females of the same age (Kraul, 1999), also should be considered as another motive for unbalanced sex ratio according to the size class.

Adult males of the dolphinfish species develop a bony crest on the front of head (Collette, 1981). Shcherbachev (1973) noted that sexual dimorphism in the pompano dolphin is noted only at a length of more than 35 cm SL and at smaller sizes, males and females are externally indistinguishable, while male common dolphinfish start to develop the bony crest at approximately 40 cm FL (Beardsley, 1967). We did not find differences in the cephalic length between males and females of *C. equiselis* for the overall length range measured. However, the analysis of covariance indicates that there are significant differences in growth of the head with the body length of the two sexes. Both sexes also differ morphometrically in that males have a greater body depth than females.

While the slopes of the length-weight relationships of common dolphinfish were allometrically positive, these indicated a negative allometric growth in both sexes of pompano dolphin. That is to say, contrary to what occurs with the common dolphinfish, pompano dolphin increase more quickly in length than in weight during growth. Positive allometric growths were only found in the relationships between fork length and opercular height and anal height in both sexes of pompano dolphin. However, in common dolphinfish, the dorsal part of the body and body height of males show a positive allometric growth, the posterior region (opercular, pectoral and ventral lengths) grows isometrically, while the anal region shows negative allometric growth. This could be related to a progressive bend of the dorsal region of the body and the development of the bony crest on the front of the head in the adult males (Collette, 1981). Females did not show this positive allometric growth in the dorsal region. Positive allometric

ratios were found in the relationships between fork length and height in both sexes.

Individuals caught of both species were normally adults. The modal progression analysis of the size distribution of pompano dolphin in 1995 shows four age classes. Morales-Nin *et al*. (1995), from scale annuli interpretation of 66 of these individuals, found four age classes which correspond to between 1.5 to 4.5 years old (Table 2). According to this, in 1996, four age classes were also recorded and another age class made up of two individuals of 58 and 63 cm. The high correspondence between modal length classes and the half year classes suggests that the population of pompano dolphin is made up of two cohorts each year, as a consequence of two separate and well-defined recruitment periods. On the other hand, the modal progression analysis of the size distribution of common dolphinfish caught in 1995 shows four size classes. Morales-Nin *et al*. (1995), from scale annuli interpretation of 17 of these individuals, found two age classes which correspond to between 2 to 3.5 years old.

Uchiyama *et al*. (1986) using age from daily increment on the sagitta otoliths, reported that *Coryphaena equiselis* appeared to grow as rapidly as *C. hippurus* during the first four months, then grew at a slower rate. Pompano dolphin also reached sexual maturity at about four months (Uchiyama *et al*., 1986). Growth checks on scales due to spawning or migrations (Summerfelt and Hall, 1987) could bias annuli scale interpretation if validation has not previously been carried out.

Spawning of the pompano dolphin in the Canary Islands area takes place at the beginning of the Summer (June-July). All the individuals obtained showed ripening gonads, although the highest GSI values were obtained in June-July and decreased progressively towards the end of the season. The Kn decreased in the same way, indicating a weight loss toward the end of the season, probably due to spawning. Common dolphinfish spawn in surface waters. Their reproductive season is extensive with frequent multiple spawning (Johnson, 1978; Massutí, 1997). Due to the scarce number of fish sampled, it is difficult to specify the spawning season of the common dolphinfish off the Canary Islands. However, this probably takes place at the beginning of the Summer. The highest values of the GSI were obtained in June, coinciding with the lowest Kn values.

The results obtained during this study are regarded as preliminary due to the small number of individuals analysed. Large numbers of specimens are required in order to confirm the trends shown over the data reported in this paper.

ACKNOWLEDGEMENTS.

We are grateful to Silvia Hildebrandt for her assistance in data collection. Thanks are also given to Dr. Beatriz Moralez-Nin, Dr. Enric Massutí and the two anonymous referees for their valuable suggestions. This research was financed by the Commission of the European Communities (Projects DG. XIV, 94/013 and 95/73).

REFERENCES

Aebersold, P.B., G.A. Winans, D.J. Steel, G.B. Milner and F.M. Utter. – 1987. Manual for starch gel electrophoresis: a method for detection of gel variation. *NOAA. Tech. Rep*., 61:1-19

Anderson, R.O. and S.J. Gutreuter. – 1983. Length, weight, and associated structural indices. In: L.A. Nielsen and D.L. Johnson (Eds.): *Fisheries Techniques*. American Fisheries Society, pp. 283-300. Bethesda, MD.

Beardsley, G.L. – 1967. Age, growth, and reproduction of the dolphin, *Coryphaena hippurus*, in the Straits of Florida. *Copeia*, 1967:441-451.

Briggs, J.C. – 1960. Fishes of worldwide (circumtropical) distribution. *Copeia*, 1960:171-180.

Collette, B.B. – 1981. Family Coryphaenidae. In: Fischer, W. G. Bianchi and W.B. Scott (eds): *FAO Species identification sheets for fishery purposes. Easter Central Atlantic; fishing areas 34, 47 (in part)*. Canada Funds-in-Trust. Ottawa, Department of Fisheries and Oceans Canada, by arrangement with the Food and Agriculture Organization of the United Nations.

Fedoryako, B.I. – 1988. Skopleniya ryb v otkrytom okeane u stat-sionarnykh buev. *Okeanologiya Oceanology Mosc*., 28(4): 667-669.

García-Marín, J.L., P.E. Jorde, N. Ryman, F.M. Utter and C. Pla. – 1987. Management implications of genetic differentiation between native and hatchery population of brown trout (*Salmo trutta*) in Spain. *Aquaculture*, 95: 235-249.

Gayanilo, F.C. Jr., P. Sparre and D. Pauly. – 1994. The FAO-ICLARM stock assessment tools (FISAT) user's guide. *FAO computerized Information Series*. Rome, FAO.

Gibbs, R.H. Jr. and B.B. Collette. – 1959. On the identification, distribution, and biology of the dolphins *Coryphaena hippurus* and *C. equiselis*. *Bull. Mar. Sci. Gulf. Caribb*., 9: 117-152.

Holden, M.J. and D.F.S. Raitt. – 1975. Manual de ciencia pesquera. Parte 2. Métodos para investigar los recursos y su aplicación. *Doc. Téc. FAO Pesca*, 115, 211 pp.

Hasselblad, V. – 1966. Estimation of parameters for mixture of normal distributions. *Technometrics*, 8: 431-444.

Johnson, G.D. – 1978. Development of fishes of the Mid-Atlantic Bight. An atlas of eggs, larval, and juvenile stages. Vol. IV Carangidae through Ephippidae. *U.S. Dep. Inter., Fish Wildl. Serv., Biol. Serv. Prog*. FWS/OBS-78/12 ja. 1978: 123-128.

Kraul, S. – 1999. Seasonal abundance of the dolphinfish, *Coryphaena hippurus,* in Hawaii and the tropical Pacific Ocean. *Sci. Mar*., 63(3-4): 261-266.

Massutí, E. – 1997. Biology of *Coryphaena hippurus* Linnaeus, 1758 (Pisces: Corypahenidae) in the Western Mediterranean. Ph. D. thesis, Univ. Illes Balears.

Massutí, E. and B. Morales-Nin. – 1995. Seasonality and reproduction of the dolphinfish (*Coryphaena hippurus*) in the Western Mediterranean. In: C. Bas, J.J. Castro and J.M. Lorenzo (eds.), *International Symposium on Middle-sized Pelagic Fish. Sci. Mar*., 59(3-4): 357-364.

Massutí, E., B.B. Collette and P. Oliver. – 1997. Does the pompano

dolphin, *Coryphaena equiselis* (Osteichthyes, Coryphaenidae), occur in the Mediterranean Sea? *Workshop on the biology and fishery of the dolphinfish and related species*. 20-23 October 1997. Palma de Mallorca (Spain).

Morales-Nin, B., P. Oliver, J.J. Castro, L. Cannizaro, A. Potoschi and C. Pla. – 1995. Biology and fishery of the dolphinfish in the western Mediterranean and Canary Islands Area. Final Draft Report. Commission of the European Communities. Directorate General for Fisheries (DG XIV). 94/031.

Oxenford, H.A. and W. Hunte. – 1983. Age and growth of dolphin, *Coryphaena hippurus*, as determined by growth rings in otoliths. *Fish. Bull*., 84(4): 906-909.

Palko, B.J., G.L. Beardsley and W.J. Richards. – 1982. Synopsis of the biological data on the dolphinfishes, *Coryphaena hippurus* Linnaeus and *Coryphaena equiselis* Linnaeus. *FAO Fisheries Synopsis* No. 130.

Pla, C. and J.M. Pujolar. – 1999. Genetic homogeneity of dolphinfish (*Coryphaena hippurus*) in the western Mediterranean and the eastern Atlantic. *Sci. Mar*., 63(3-4): 337-341.

Rose, C.D. and W.W. Hassler. 1968. Age and growth of the dolphin, *Coryphaena hippurus* (Linnaeus), in the North Carolina waters. *Trans. Am. Fish. Soc*., 97: 271-276.

Rose, C.D. and W.W. Hassler. – 1974. Food habis and sex ratios of dolphin *Coryphaena hippurus* captured in the western Atlantic Ocean off Hatteras, North Carolina. *Trans. Am. Fish. Soc*., 103: 94-100.

Shcherbachev, Yu.N. – 1973. The biology and distribution of the dolphins (Pisces, Coryphaenidae). (In Russ.) *Vopr. Ikhtiol*., 13:219-230. (Trasl. in *J. Ichthyol*., 13: 182-191).

Summerfelt, R.C. and G.E. Hall. – 1987. *Age and growth of fish*. Iowa State University Press/Ames. 544 pp.

Uchiyama, J.H., R.K. Burch and S.A.Jr. Kraul. – 1986. Growth of dolphins, *Coryphaena hippurus* and *C. equiselis*, in Hawaiian water as determined by daily increments on otoliths. *Fishery Bulletin*, 84(1): 186-191.