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REPRODUCTIVE BIOLOGY OF THE CASTANHA *UMBRINA CANOSAI* (PISCES, SCIAENIDAE) IN SOUTHERN BRAZIL

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(With 10 figures)

RESUMO

Biologia da Reprodução da Castanha *Umbrina canosai* (Pisces, Sciaenidae) no Sul do Brasil

A desova, a maturação sexual e a fecundidade da castanha do estoque explorado no sul da Brasil foram estudadas a partir do exame de gônadas de aproximadamente 8000 exemplares e preparados histológicos de 350 ovários de peixes de diferentes tamanhos, épocas de captura e áreas de pesca. No Rio Grande do Sul, a castanha desova parceladamente entre fins do inverno e fins da primavera. A desova começa ao norte de Rio Grande e se desloca para o sul nos meses seguintes. As fêmeas maiores são as primeiras a migrar para o sul em direção as áreas de alimentação no litoral do Uruguai e Argentina. Os machos permanecem por mais tempo nas áreas de desova e, junto às fêmeas menores, são os últimos a migrar para o sul. Os comprimentos médios de primeira maturação gonadal do Rio Grande do Sul foram de 184mm para os machos e de 219mm para as fêmeas. Ao atingir os dois anos de idade, 60% dos machos e 27,4% das fêmeas apresentaram-se sexualmente maturos. Foram observados comprimentos e idades médias menores numa única amostra de Santa Catarina. Observou-se que algumas fêmeas jovens atingiam as primeiras fases de maturação porém apenas participariam da desova do ano seguinte.

Apesar da castanha apresentar desova parcelada, o ciclo anual de desenvolvimento ovocitário e descontínuo o que permite estimativas aproximadas de fecundidade a partir das contagens de ovócitos (F) pouco antes de começar a temporada de desova. As estimativas para 56 ovários de castanhas maturas com comprimentos totais de 187mm a 377mm, variaram de 44,6 a 1450,6 mil ovócitos e aumentaram consistentemente com o comprimento (L), peso (W), idade (A) e peso dos ovários (WG). As relações observadas foram: F = 4,0 x 10 exp-10 x L (mm) exp

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4,7993, F = 0,2695 x W(g) exp 1,5529, F = 47,26 x A (anos) exp 1,3512 e F = − 9,555 + 17,69 WG (g). A fecundidade relativa aumentou com o tamanho e a idade. Entre as características adaptativas que explicam a abundância da castanha no sul do Brasil cabe mencionar sua longevidade, seu comportamento migratório com áreas de alimentação diferentes de jovens e adultos, sua elevada fecundidade e estação de desova prolongada em uma ampla área geográfica.

Palavras-chave: Ciclo reprodutivo, Sciaenidae, Recursos Pesqueiros, Dinâmica Populacional, Brasil.

ABSTRACT

Spawning, sexual maturity and fecundity in the southern Brazil stock of the castanha *U. Canosai* were studied. Gonads of around 8,000 specimens and histological sections of 350 ovaries representing diverse fish sizes, seasons and fishing grounds were examined. Off Rio Grande do Sul, the castanha spawns in several batches between the end of the winter and the end of the spring. Spawning starts in the north of Rio Grande and moves south in the following months. Large females are the first to start spawning and also the first to leave southward towards the summer adult feeding grounds off Uruguay and Argentina. Males remain spawning longer and with the smaller females are the last to migrate. Average total lenght at first maturity off Rio Grande do Sul were 184mm for the males and 219mm for females and at age II, 60% of males an 27.4% of females were mature. Lower ages and lenght at maturity were recorded in a single sample of Santa Catarina. It was observed that some young females reached initial maturation stages but should not spawn until next season. Nevertheless the castanha is a serial spawner, the annual cycle of oocytes development was shown to be discontinuous, allowing rough estimates of the fecundity, as the ovarian egg counts (F) at the begining of the spawning season. Estimates for 56 ovaries of mature castanhas from 187mm to 377mm total length, ranged betwwen 44.6 and 1.450.6 thousand oocytes and increased consistenly with length (L), weight (W), age (A), and ovaries weight (WG). Established relationships were: F = 4.0 x 10 exp-10 x L (mm) exp 4.7993, F = 0.2695 x W(g) exp 1.5529, F = 47.26 x A(years) exp 1.3512 and F = − 9.555 + 17.69 WG (g). Relative fecundity aumented with size and age. Among the adaptative characteristics that explain castanha's abundance off southern Brazil are its high life expectancy, the migratory behaviour with different feeding grounds for youngs adults and its high fecundity and prolonged spawning season in a wide geographyc area.

Key words: Reproductive cycle, Sciaenidae, Fish Population Dynamics, Brazil

INTRODUCTION

The castanha *Umbrina canosai*, is a demersal coastal sciaenid found from Rio de Janeiro, Brazil (lat 22°S) to approximately Colorado River, Argentina (lat 41°S). It is a commercially important species, caught mainly in southern Brazil. Between 1975 and 1984, an avarage 18,783 tons have been landed annualy in Brazil, Uruguay and Argentina. Most catches occur from June to November off Rio Grande do Sul, Brazil and are landed in Rio Grande harbour, representing more than 32% of total landings of the local trawler fleet (Haimovici and Vieira, 1986).

Several aspects of the life history and fishery biology of this species have been studied. Gonzalez Alberdi and Nani (1967) studied various aspects of the population dynamics and fishery off Mar del Plata Argentina (38°S). Vazzoler (1975) and Zane Prado (1979) analysed seasonal changes in distribution, feeding, growth and reproduction

in southern Brazil. Zaneti and Vazzoler (1976) analyzed in a short note the distribution and first maturity size of the castanha north of Cape Santa Marta Grande (lat 28°40S) concluding that there was an independent stock with its distribution center in Rio de Janeiro. Papers on castanha's growth feeding and mortality have been reported and the fishery in southern Brazil described by Haimovici and Reis (1984), Haimovici (1988), Haimovici and Vieira, 1986 Haimovici *et al.*, 1989). This paper reports spawning, sexual maturity, fecundity and seasonal changes in sex-ratios in southern Brazil.

MATERIAL AND METHODS

Fish were collected from all seasons and fishing areas off Rio Grande do Sul. Samples were obtained from the commercial landings at Rio Grande from 1976 to 1980, from two trips on a commercial trawler in 1978 and 1979 and from seven exploratory fishing cruises on R/V "Atlântico Sul" between 1980 and 1982. Five cruises were between Chui (lat 34°20'S) and Solidão, except two, one up to Capão da Canoa (lat 29°45'S) and other up to Cape Santa Marta, all hauls at depth from 10 to 100m (Fig. 1). Over 8,000 specimens were examined.

In the field total length (TL, mm), total weight (W, g) gonad weight (WG, g), sex and maturity stage was recorded for each specimen. Sexual maturity was assessed according to a seven stage scale for serial spawners following Christensen and Cousseau (1971) (Table I).

Ovaries representing different developmental stages, length and seasons were collected for histological studies. They were preserved in 7% neutralized formalin or in a Bouin's aquous solution. Sections were embedded in paraffin, cooled, sectioned to 5-7 μm and stainded with hematoxilin and eosin. Intraovaric oocytes diameters were measured using a micrometer ocular and a microscope from ovaries in different developmental stages, lenght and seasons.

The length at which 50% of the specimens were sexually mature (LM) and 95% confidencial intervals were determined from moving averages in a linear model according to Pope *et al.* (1975).

Fecundities were determined, as intraovaric maturing egg numbers, by the wet gravimetric method (Bagenal and Braun, 1978). Formalin preserved ovaries were weighted and 0.120 to 0.200 g, samples were taken from transverse cross section in order to

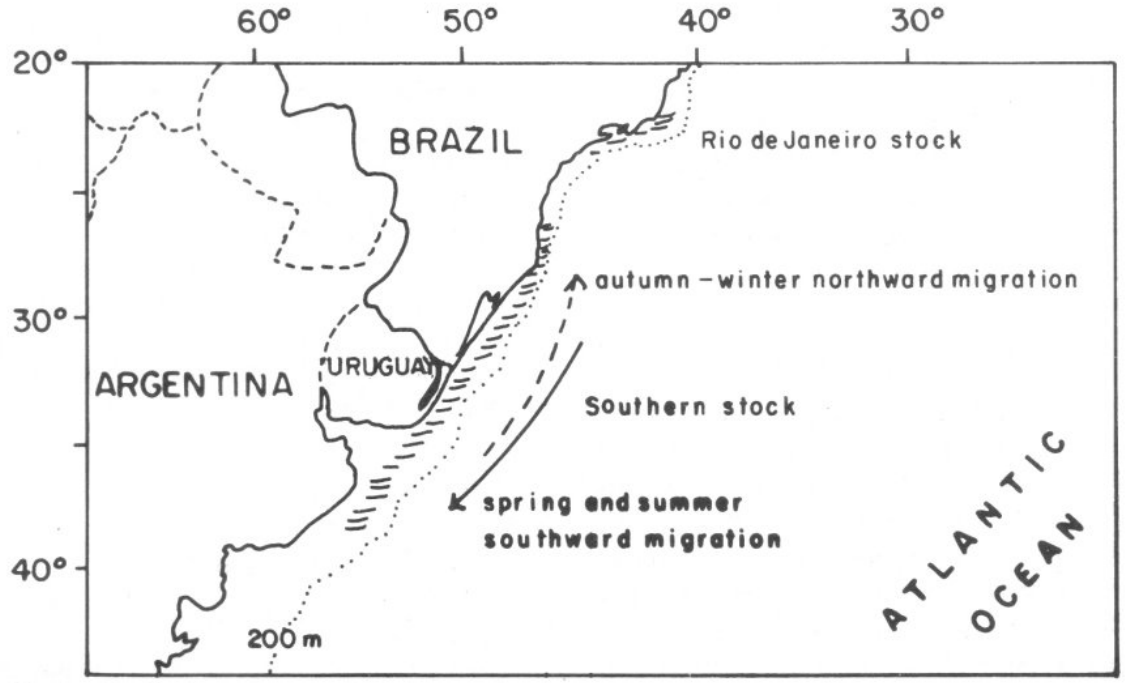

Fig. 1 – Distribution of castanha Umbrina canosai and migratory circuit of the southern stock between south Brazil and Argentina.

TABLE I

Scale of gonadal maturation stages for the castanha *Umbrina canosai*

	Testes	Ovaries
Stage I virginal imature	Filifrom and transucent, 1/3 to 1/2 of the length of the body cavity. Sex determinations are difficult in small specimens.	Pink, translucent, round seccion, occupy less than 1/3 of body cavity. Oogonia and primary oocytes well organized in groups on the ovicerous lamellae. Ovarian tunic thin.
Stage II developing virginal or spent recovering	Flattened, white, 2 to 4mm broad, occupy 1/2 to 2/3 of the body cavlty.	Pink, opaque, thin, rounded section, ocupy 2/3 of body cavity. Marked vascularization, oocytes not visible to naked eye. Ovaric organization advanced: primary oocytes predominate but vacuolated oocytes appear in increasing numbers.
Stage III developing	Triangular section, white, firm to touch, 2/3 to 3/4 of body cavity.	Orange to yellow, trick, turgid occupy more than 2/3 of body cavity. Thick ovarian tunic and ovary transversed by lamellae. Predominance of vacuolated and yolky in oocytes.
Stage IV advanced development	White or greyish, develped lobules, visible vascularization, ocupy 3/4 to whole body cavlty's length. Milt. runs when sectioned.	Turgent, light yellow, occupying 3/4 of the body cavity, opaque oocytes clearly visible Yolky II oocytes very abundant in histological sections.
Stage V running	Same as stage IV but milt runs on light pressure on the abdomen.	Pinkish gray, almost transparent filling almost all the body cavity. Hyaline hidrated oocytes running easily on slight pressure of the abdomen.
Stage VI partly spent	White, brownish in patches, longitudinal grooves present, milt running when sectioned. Occupy 3/4 of body cavity.	Yellow, somewhat fiaccid, structurally emptier, sometimes hemorragic at the posterior end, occupy 3/4 of body cavity. Atretic yolked oocytes in rebsortion present.
Stage VII recovering	Brown and thin, occupy 3/4 of body cavity, no milt.	Dark red or pinkish grey, thin rounded section, ocupy 2/3 of body cavity, Reorganization of ovigerous lamellae, primary oocytes predominate. Thick tunic that invades parenquima creating septas.

have medial to lateral parts proportionaly represented. In previous tests with two specimens ovaries it was determined that ova do not develop sequentially from anterior to posterior parts within ovaries by comparing ooctye size distributions by non parametric test of Kolomogrov Smirnov (Sokal and Rohlf, 1969). Accuracy of egg count estimates was assessed from 6 samples of each of the two specimens. Standard errors of the mean egg counts were 5.7% and 3.6% and variation coefficients were 0.114 and 0.84 respectively. Accuracy was comparable to the volumetric method often employed (Bagenal, 1957, Macer 1974).

Funcional regessions of fecundity in thousands of intraovaric maturing eggs (F) on length, weight and age (A) were calculated by minimum squares after logarithmic transformation of the variables (Bagenal 1978).

Ages were determined from scales or otoliths according to Haimovici and Reis (1984).

RESULTS

Seasonality and spawning

Several lines of evidence suggest tha castanha are late winter and spring multiple spawners.

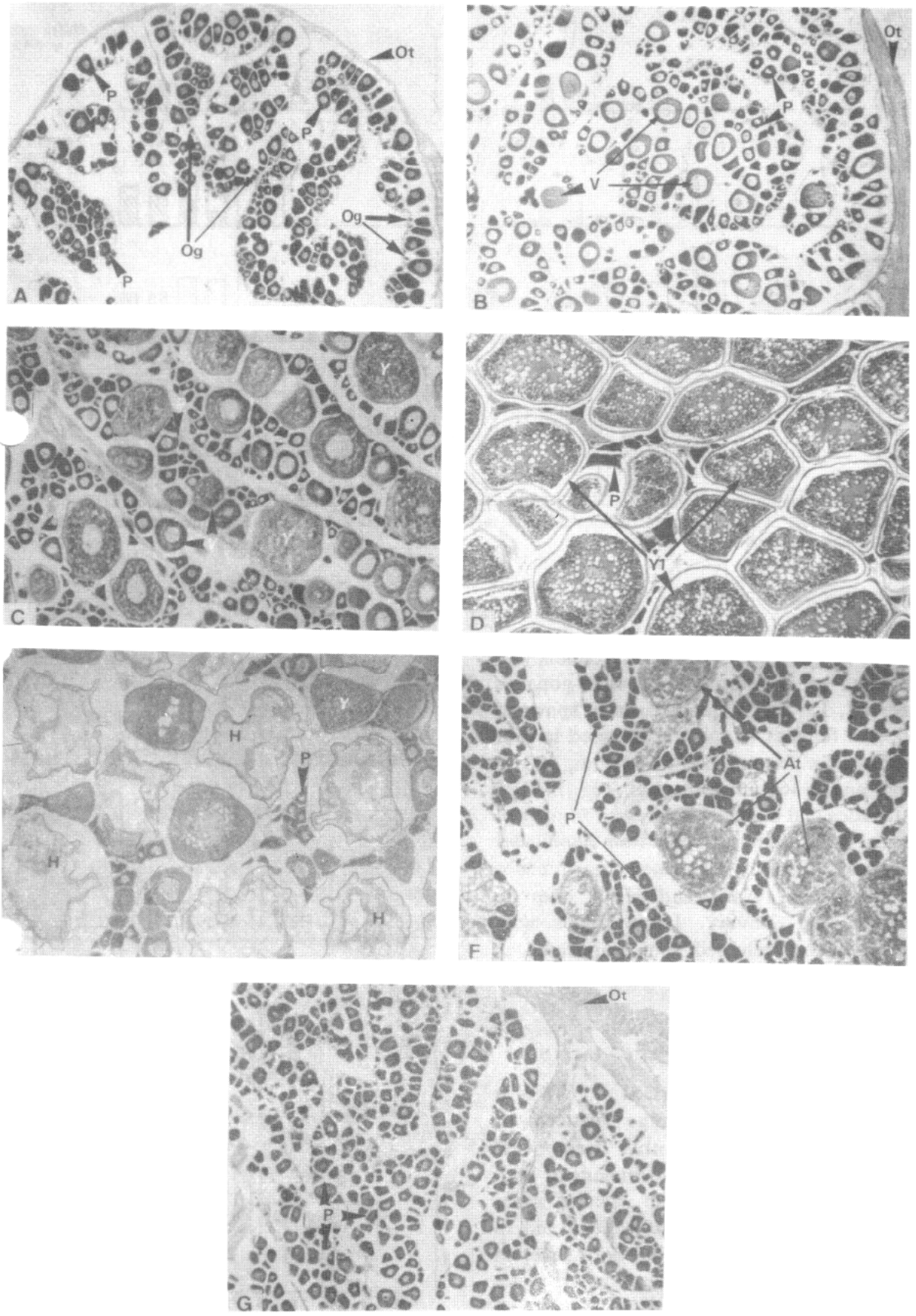

Fig. 2 – Stages I(A), II(B), III(C), IV(D), V(E), VI(F) e VII(G) in the development of ovaries. Ovarian tunic (Ot), oogonia (Og), primary oocyte (P), vacuolated oocyte (V), yolk I oocyte (Y) yolk II oocyte (Y1), hyaline oocyte(H), atretic oocyte (At). H and E, 35x.

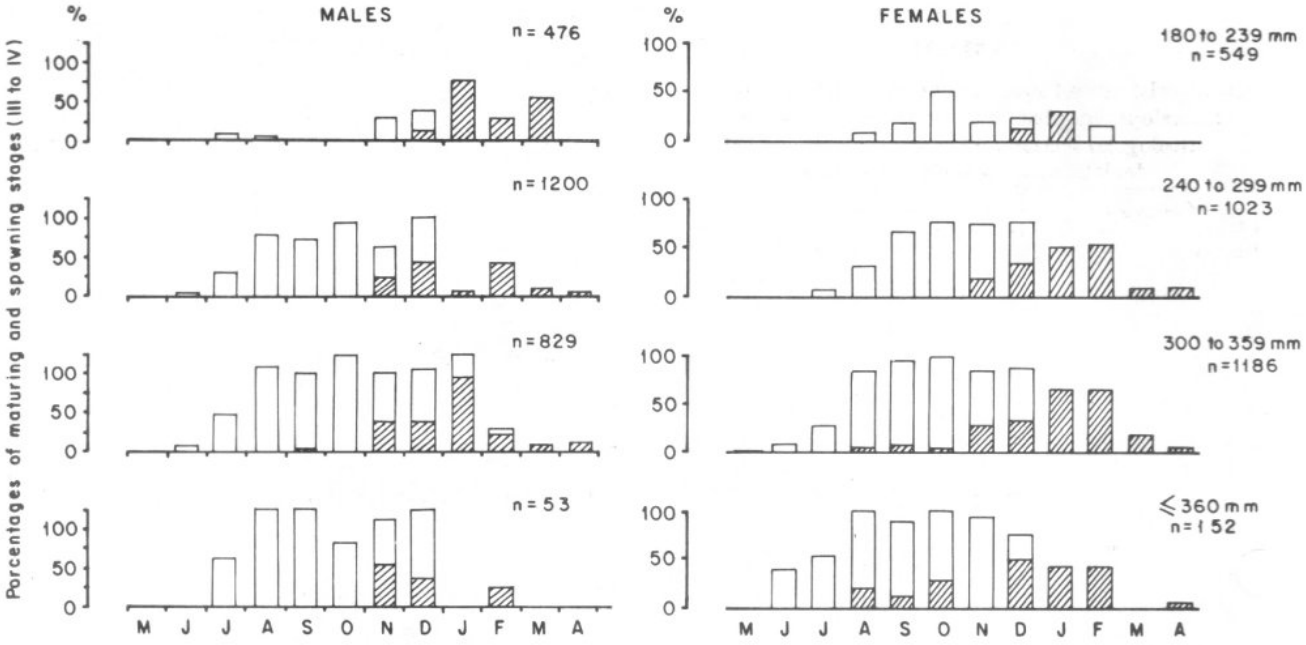

Fig. 3 – Monthy percentages of females and males of *U. canosai* in maturation and spawning stages (III to VI) in different size groups in the commercial landings at Rio Grande between 1976 and 1980. Motted pattern indicates partly spent (stage VI) males and females.

a. Visual gonadal stageing

Seasonal maturation and spawning were indicated by the monthly relative frequency of occurrence of developing and ripe gonadas (stages III, IV and V) and partially spawned males and females (stage VI) grouped in four TL groups: <239mm, 240 to 299mm, 300 to 359mm and >360mm castanhas (Fig. 3). Big ripe females and males were present from June to January and small specimes from September to January. Partially spawned big females from August to April and small ones in December and January. Large males with signs of having released sperm appeared in August and small ones in November, and were found until April.

b. Gonadosomatic index

Gonadosomatic index (GSI = WG/W x 100) values show a similar pattern of spawning seasonality. Monthly mean GSI indices increased for larger specimens of both sexes from June on and for smaller since August. The maximum values were found in October for all size groups and both sexes in October, except for larger males with maximum in September (Fig. 4).

c. Frequency distribution of oocytes diameters.

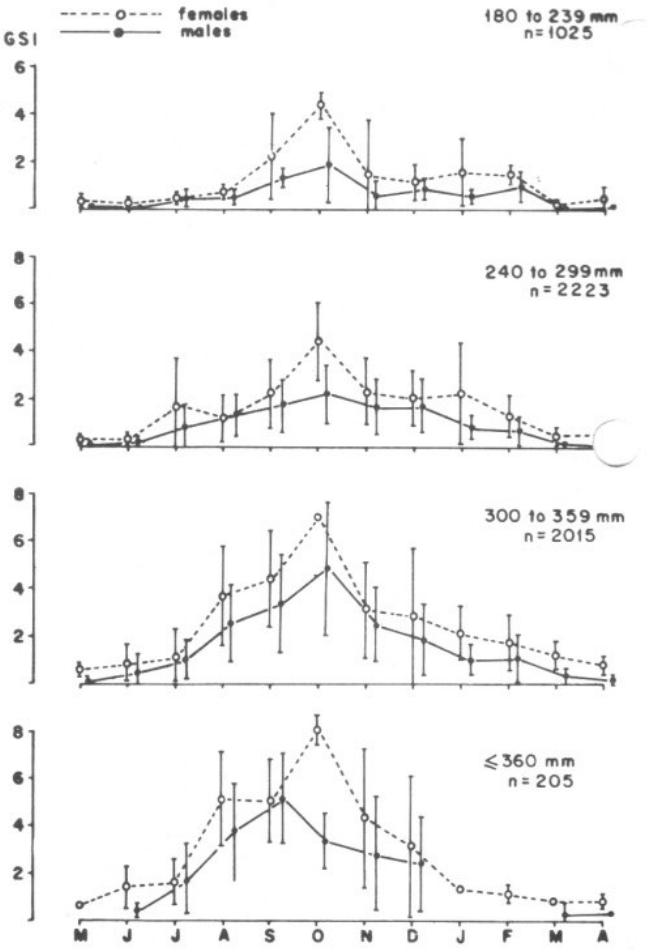

Fig. 4 – Montly mean gonadosomatic indices (GSI) o males and females castanha *Umbrina canosai* in different size groups in the commercial landings at Rio Grande between 1976 and 1980.

TABLE II

Caracteristics and sizes of oocytes in different stages of development observed and measured in mm on histological sections (x= mean, ds= standard devlation, n= number measured)

Types of oocytes	Caracteristics
Primary	Polihedrical, with strongly basofile cytoplasm rounded nucleus surounded by necleoll, 0.013 to 0.084mm. (x=0.037, ds=0.014, n=193).
Vacuolated	Surounding membranes and follicular cells with visible nucleus. Cytoplasm with liplid vacuoles, 0.069 to 0.190mm (x=0.117, ds=0.032, n=142).
ky I	Well developed membranes and surounding epitelium. Proteinous granules in cytoplasm and lipidic vacuoles surounding nucleus, 0.156 to 0.311mm (x=0.241, ds=0.042, n=60).
Yolky II	Well developed membranes, cytoplasm filled with yolk vesicles, nucleus appears as homogeneous mass. 0.259 to 0.458mm (x=0.352, ds=0.037, n=60).
Hyaline	The oocytes frequently collapsing during histological processing. Membranes reduced, cytoplasm appears as a homogeneous mass with large "Lipidic" vacuoles.
Atretic	Oocytes in resorbtion with large vacuoles: rupture of membranes and signs of lysis of nucleus and cytoplasm.

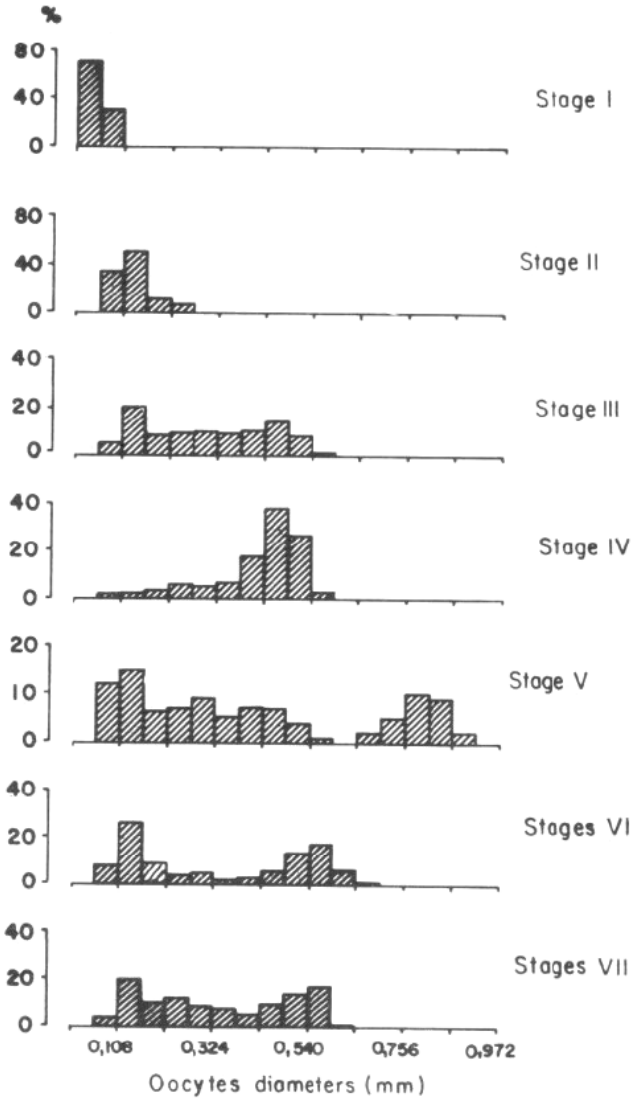

Fig. 5 – Frequency distributions of diameters of oocytes in ovaries of castanha *U. canosai* in different maturity stages.

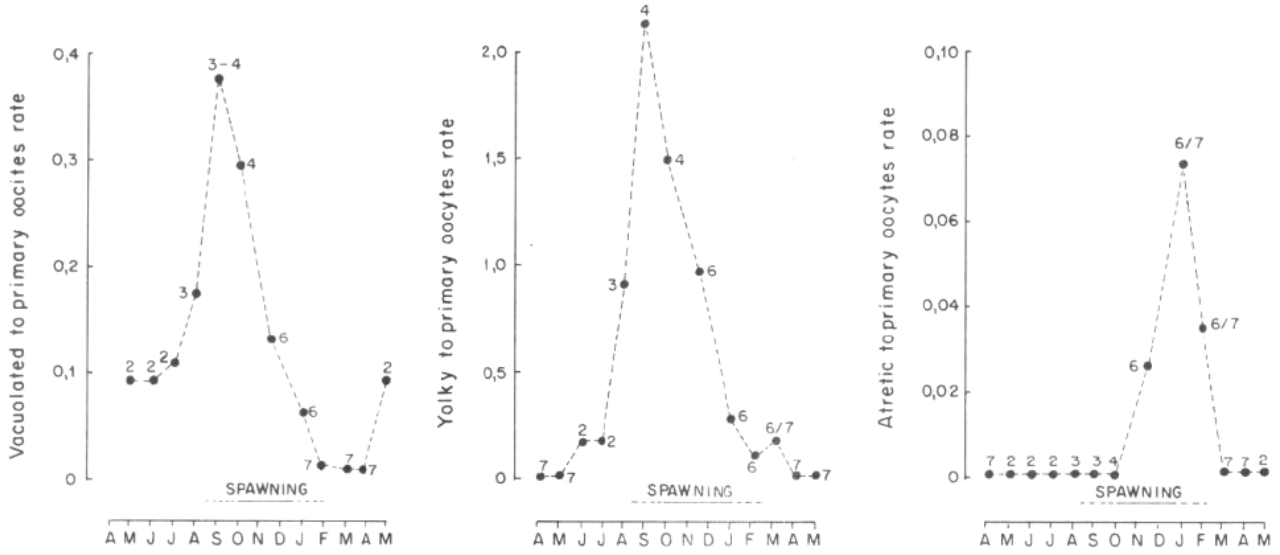

Fig. 6 – Monthly indices of relative abundance of vacuolated, yolky and atretic oocytes in relation to the abundance of primary oocytes on histological slices of ovaries of castanha *U. cansoai.*

Figure 5 shows the diameters of oocytes that appear in ovaries typical of each gonadal stage. Unimodal distributions with all oocytes under 0.3mm were observed between January and July in ovaries in stages II and VII. Polymodal distributions including oocytes above 0.3mm were observed from June to January in ovaries in stages III to VI.

d. Ovarian structure and development.

The structure and development of the ovaries of castanha are fairly typical of most marine teleost fishes (Table I and II and Fig. 2). The annual cycle of oocyte development was established in ovaries of castanhas measuring 300 to 330 TL. The number of primary, vacuolated, yolked and atretic oocytes that intercepted a strip from the center to the external membrane of the ovaries were counted in three slides representing each of the phases observed in each month. The ratios between vacuolated, yolked and atretic oocytes were calculated (Fig. 6). These indices represented only approximately the relationship between the abundance of the different types of oocytes, since the probability of intersection depends on the diameter of the oocytes and the number of primary ovocytes increases in the month immediatly past spawning (Foucher and Beamish, 1977).

Vacuolated oocytes started appearing in May, attained the peak in September and decreased rapidly afterwards. From November on, almost no vacuolated oocytes were observed in ovaries. Yolked oocytes started to appear in June and were abundant from August to December but were still observed in some ovaries until March. Yolked atretic oocytes were found from November to April in stages VI and VII ovaries.

Maturity

Sexual maturity results indicated that, like many fishes, males mature at smaller size and younger in age than females and th

TABLE III

Mean gonadosomatic indices (GSI) in different group sizes of castanha *U. canosai* caught in the trawi fishery from Chui to Solidao (south) and Solidao to Santa Marta Grande (north) between July and November (1976-1980), n: samples sizes.

	total lenght intervals	Females						Males					
		North			South			North			South		
Month	(mm)	IGS	ds	n	IGS	ds	n	IGS	ds	n	IGS	ds	n
July	270-299	0.86	0.34	3	1.41	1.78	29	0.82	0.87	2	0.98	1.17	48
	300-329	2.55	2.08	5	1.24	1.13	32	1.72	0.73	10	1.10	0.85	28
	330-359	2.44	1.22	28	1.19	0.94	41	2.59	0.96	18	1.04	0.72	20
	> 360	3.34	1.23	21	1.58	0.88	12	3.42	1.64	14	1.76	1.48	2
August	270-299	–	–	–	1.01	0.77	14	2.14	1.21	9	1.01	0.65	18
	300-329	2.37	1.29	10	2.53	1.15	10	3.65	1.32	6	1.49	0.71	12
	330-359	3.79	1.74	29	2.20	0.98	9	4.43	1.50	11	2.04	0.90	5
	> 360	4.10	1.39	10	2.77	–	1	3.31	2.20	4	4.22	–	1
September	270-299	4.15	2.08	8	–	–	–	3.72	2.00	11	2.71	1.00	6
	300-329	5.00	1.20	36	3.55	1.22	3	4.22	1.34	28	3.12	1.60	5
	330-359	6.77	1.76	41	3.86	1.56	28	5.35	1.36	22	2.66	1.55	17
	> 360	8.41	2.18	14	4.52	1.50	22	4.86	0.58	4	4.34	1.53	8
October	270-299	4.40	2.31	8	4.51	1.98	8	2.89	1.02	10	2.17	1.24	16
	300-329	5.27	2.80	11	5.60	2.31	30	4.43	1.34	8	4.11	2.90	21
	330-359	6.96	2.38	11	8.13	3.57	21	6.39	1.26	3	5.88	2.53	12
	> 360	4.91	1.83	3	8.07	0.23	2	–	–	–	2.59	–	1
November	270-299	–	–	–	1.89	1.29	52	–	–	–	1.71	1.10	37
	300-329	–	–	–	2.11	1.05	38	–	–	–	1.51	1.32	17
	330-359	–	–	–	2.93	1.69	28	–	–	–	2.86	0.91	9
	> 360	–	–	–	3.67	2.35	10	–	–	–	1.40	0.37	2

castanhas mature at bigger sizes and older ages at the higer latitudes and lower water temperature.

Size and age at maturity was estimated using specimens collected on commercial trips or research cruises during the spawning season form October to January (Table VI). Only females in stages III to VI were considered mature because histological study of ovaries of young females showed that not all fish in stage II participated spawning. Additional evidence of incomplete development was that maximum proportion of females that attained stages III to VI in each ason was 50% for fishes up to 239 mm TL, male was 140mm TL and the largest with virginal filiform testes was 230mm TL. First maturity length in several trips samples ranged from 198mm to 229mm for females and 171mm to 188mm for males. Pooled means were 214 ± 5mm and 184 ± 4mm respectively (Table V). Maturity was attained at age II by 27.4% of females and 60% of males and at age III by 80.1% and 97.6% respectively (Table VI).

A sample collected in Santa Catarina in November 1982 indicated that castanha were mature at smaller sizes and ages. Smallest mature female measured 130mm and male 120mm. All females above 160mm and males

TABLE IV

Seasonal percentages of males of *U. canosai* per size groups and ages in the landing samples in Rio Grande from 1976 to 1980, number of examined specimens between parentethes

Age groups	Jan. – Mar. summer	Apr. – Jun. automn	Jul. – Sep. winter	Oct. – Dec. spring
2 – 3	62,7 (405)	52,2 (508)	57,4 (567)	51,0 (571)
4 – 5	58,2 (275)	55,4 (303)	42,5 (308)	48,5 (456)
6 – 7	52,7 (93)	56,1 (173)	33,6 (149)	43,5 (214)
8 or more	43,8 (80)	47,1 (119)	33,5 (215)	35,3 (252)
Size groups (mm)				
210 – 269	64,4 (368)	50,5 (412)	51,6 (419)	54,3 (481)
270 – 329	57,6 (455)	58,0 (576)	48,3 (632)	47,9 (725)
330 or more	48,6 (111)	39,5 (223)	28,9 (336)	35,3 (343)

72% for the 240-299 mm TL group and 100% for bigger castanhas. Males in stages II to VII ere considered mature since all non filamentous testis released sperm under slight pressure.

In Rio Grande do Sul no females were mature below 170mm TL and all those above 250mm TL were mature. The smallest mature over 170mm were mature. Respective LM were 140±6mm and 133±5mm (Table V). At age I, 47% of females and 32% of males were mature and at age II almost all of both sexes were mature (Table VI).

Seasonal movements related to reproduction.

Landings of castanha in Rio Grand

TABLE V

Mean length and 95% confidential intervals at first maturity of *U. canosai* in onboard samples from Rio Grande do Sul and Santa Catarina States

Date	Latitudes Range	Females	Males
Rio Grande do Sul			
Nov. 1979	32°30'S – 34°20'S	228 +/– 12 (144)	188 +/– 15 (125)
Oct. 1980	29°20'S – 30°40'S	222 +/– 16 (123)	183 +/– ? (72)
Nov. 1980	30°40'S – 34°20'S	198 +/– 9 (217)	171 +/– 6 (190)
Jan. 1982	30°40'S – 34°20'S	222 +/– 16 (218)	188 +/– 6 (227)
Pooled samples		219 +/– 6 (702)	184 +/– 4 (614)
Santa Catarina			
Nov. 1982	28°40'S	144 +/– 6 (198)	133 +/– 5 (99)

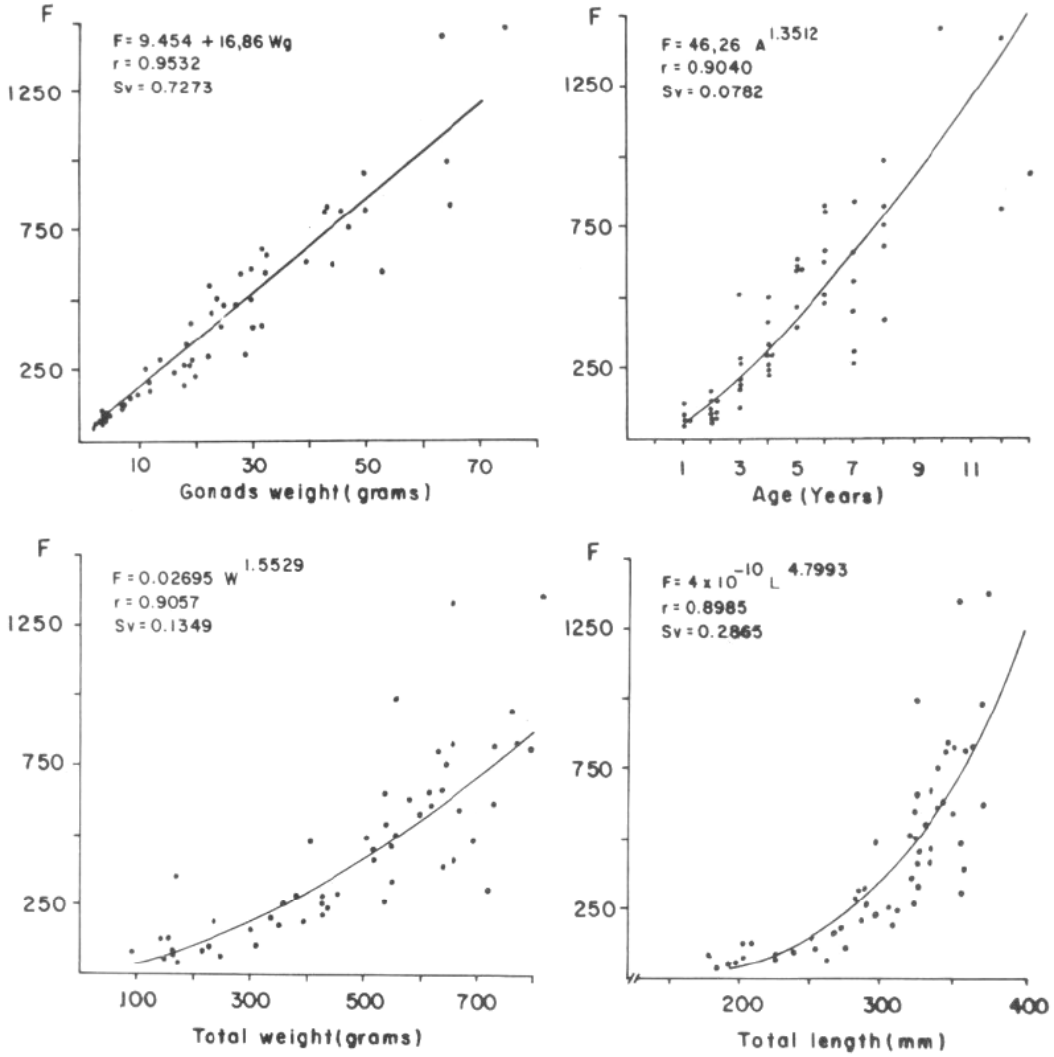

Fig. 7 – Relationships between the fecundity (F) – in thousand of intraovaric maturing eggs – of castanha *U. canosai* with tota length, age, weight and total weight. (Sv: standard deviation, r:corr. coef.).

changes seazonally. Most catches occurs from late fall to early spring (Haimovici and Vieira, 1986), when the fish moves towards and back from its spawning grounds along Rio Grande do Sul. Seasonal movements related to reproduction were studied from GSI and data in samples from catches in different fishing grounds (Table III) and sex ratios (Table IV).

Spawning moves southward along the season. Mean monthly GSI from north Solidão were higher from July to September and lower from October and November when compared with those from south of Solidão (Table III). Mean size at age and sex-ratios in the landings from catches at different latitudes suggested there were no geographic differences from July to November, when trawlers fished all along Rio Grande do Sul (Haimovici, 1982).

Trimestral sex ratios along the year showed clear differences (Table IV). Females predominated in winter and spring, and ma' in summer and automn. Sex ratio differences were more pronounced for larger and older castanhas indicating that larger females were the first to move south towards Uruguay and Argentina in spring, while smaller females and males remained longer spawning in Rio Grande do Sul.

Fecundity

Several evidences support serial spawning in the castanha: various simultaneous groups of maturing oocyte (Fig. 2), high GSI and ripe and partially spawn females along several month (Figs. 3 and 4). Along the year, the development cycle of oocytes i discontinuous and the passage from primary to vacuolated seems to occur mainly prior to the

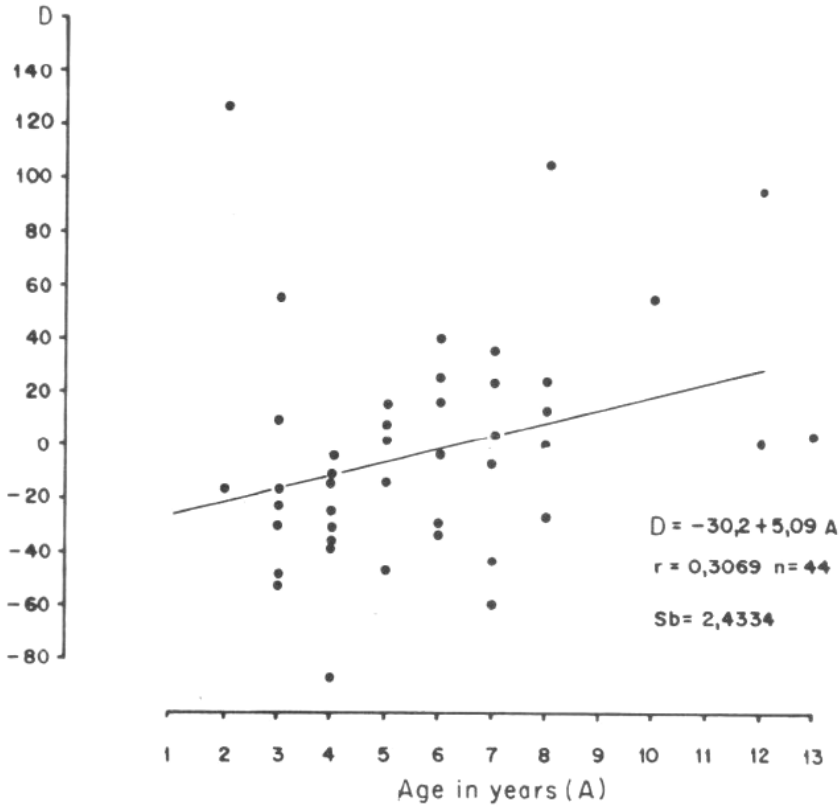

Fig. 8 – Percentual deviation of individual estimated fecundities and those calculated from the fecundity – total length equation at differente ages of castanha *U. canosai.* (St: standard deviation, r: corr. coef.)

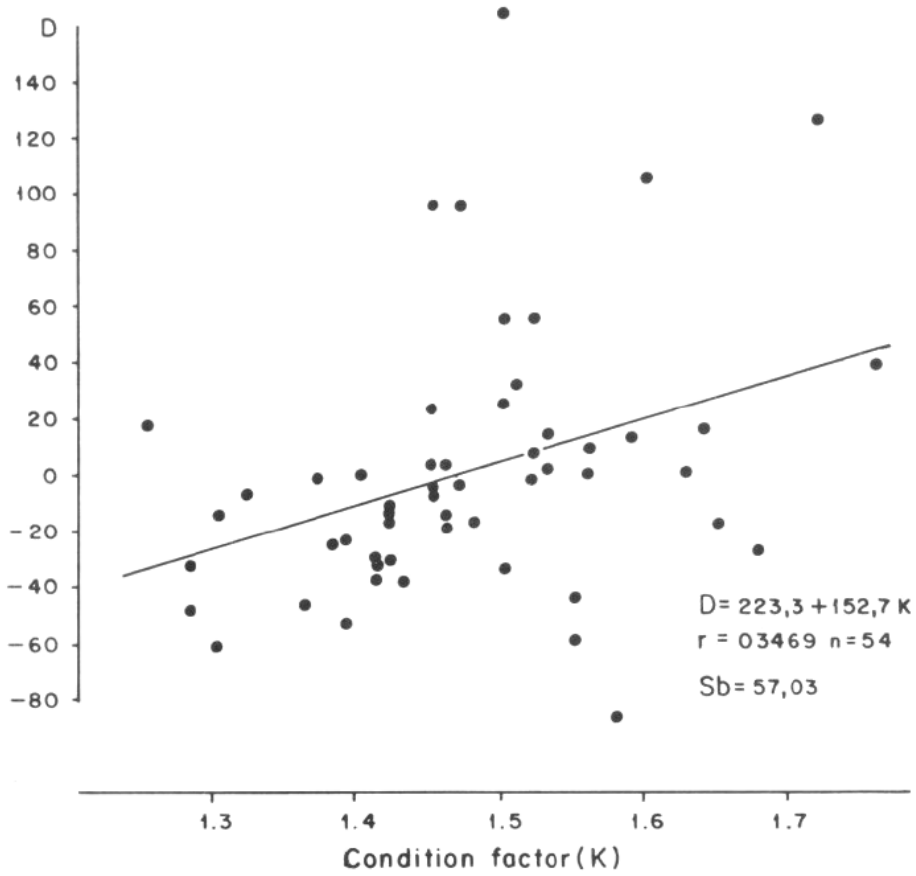

Fig. 9 – Percentual deviation of the individual estimated fecundities and those calculated from the fecundity – total length equation for different observed condition factors. (SV: standard deviation, r: coor. coef.)

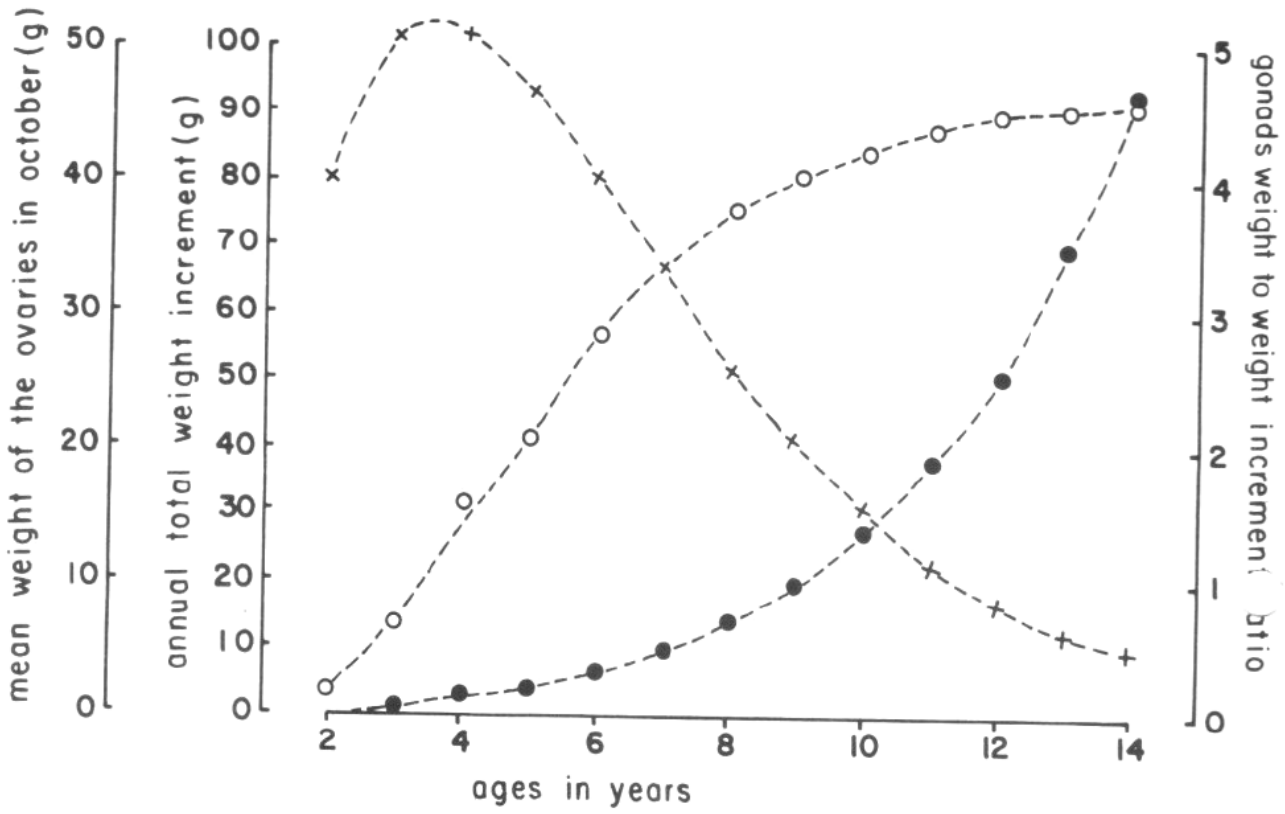

Fig. 10 – Energy partition between growth and reproduction at different ages infered from (o) mean weights of ovaries in October, (*) mean increments in weigth between ages and (#) rations between both.

TABLE VI

Percentages of sexually mature males and females of castanha *Umbrina canosai* at different ages in the samples from Rio Grande do Sul and Santa Catarina Estates.

Latitudes	Rio Grande do Sul 29°20'S – 34°20'S October to January (1976-1980)		Santa Catarina 28°40'S November 1982	
Ages in years	Males	Females	Males	Females
I	7.6 (26)	0 (30)	32.4 (37)	46.7 (15)
II	60.0 (60)	27.4 (62)	96.8 (12)	100.0 (12)
III	97.6 (42)	80.1 (47)	100.0 (2)	100.0 (2)
IV	100.0 (42)	97.2 (36)	–	

begining of spawing (Fig. 6). So, rough estimates of fecundity could be obtained from vacuolated and yolky maturing oocytes count of ovaries just before spawning.

Maturing oocytes numbers were estimated from 56 ovaries in stages III and IV. Ovaries of larger castanhas were selected from samples of August and September and those from the smaller ones from October and November, taking into account the time lag in the maturation cycle of different sized females. Primary and vacuolated oocytes size distributions on histological sections overlaped between 0.069 and 0.086 mm (Table II). As paraffine inclusion shrinks oocytes around 10% (Macer, 1974) only oocytes over 0.1 mm were included in the countings.

Ovarian egg numbers varied from 44.6 thousand in a 193 mm TL female to 1450.6 thousand in 377 mm TL one. Even though the great variability between individuals, egg counts (F x 1000) increased consistently with total length, total weight and age and ovaries weight (Fig. 8). The correspondent equations were: F = 4.0 x 10 exp - 10 x L exp 4.7999 ;

F = O.02695 x W exp 1.553 ; F = 47.26 x A exp. 1.351 and F = – 9.555 + 17.69 WG.

Relatives fecundities, defined as number of maturing oocytes per gram of fish (Nikolskii, 1969) increased with the size of the castanhas, as indicated by the exponent greater than one in the egg count-weight equation.

The relationship between age and fecundity, apart from the influence of the size, was investigated plotting percentual deviations between observed and calculated ovarian egg numbers at each lenght against the ages. The regresion coeficient was significatively positive (r = 0.307, P> 0.01), indicating increasing fecundity with age (Fig. 8). Similar results were obtained for observed and expected egg numbers at each length plotted against conditionn factors ($K= W/L^3$), (r = 0.346, P>0.01, in Fig. 9).

Partition between growth and reproduction energy expenses was analysed comparing annual mean growth increment with mean weight of ripe ovaries in the month they attained maximum size (Fig. 10). At age 2, somatic growth represented almost all stocked energy during the year. At age 7, maximum ovaries weight prior to spawning was equal to the annual somatic weight gain and at age 14 it was 5 times greater (Fig. 10).

DISCUSION

Castanha migrates from Rio Grande do l southward to Uruguay and Argentina by the end of the spring and back northward in fall. This is well known by brazilian fisherman that, until 1973, used to follow it along the entire migratory circuit (Yesaki and Bager, 1975). Summer and automn feeding grounds are off Uruguay and Argentina. Gonzalez Alberdi and Nani (1967) found that large spawned females were the first to arrive off Mar del Plata in October and November, at the same time of the year when catches along Rio Grande do Sul diminish (Haimovici *et al.* 1989).

The number of batches in which the spawning is divided is difficult to estimate in natural conditions for most teleosts that spawn elagic eggs (Bagenal, 1978). Individual females spawning season should be of two to three months and the number of batches small. This can be deducted because larger female start spawning in August or September (Fig. 3), and migrates southward from October on.

Smaller females arrive and leave the spawning grounds later than bigger females and males remains longer. The stratified spawning by size groups along several months in an extense area favours the dispersion of eggs, decreases intraespecific competition and avoids that adverse conditions affect the totality of the eggs spawned in a season.

Multiple spawning is common in sciaenids of low and intermediate latitudes were cycles of production are long (Powels, 1981). It is the rule among southern Brazil, Uruguay and Argentina sciaenids: *Macrodon ancylodon* (Vazzoler, 1963, Yamaguti, 1967), *Micropogonias furnieri* (Vazzoler, 1971; Haimovici, 1977) and *Cynoscion striatus* (Cassia, 1986), and *Pogonias cromis* and *Cynoscion jamaicensis* (Haimovici, unpublished). The adaptative value of multiple spawning in this area can be atributed to the variability of the oceanographic characteristics of the region due to the influence of the changing position of the convergence of Malvinas (Falkland) and Brazil currents.

Length at first maturity for Rio Grande do Sul (males 184mm, females 214mm) were higher than those previously found by Zaneti Prado (1979) (males 167mm, females 177), probably because she considered females in stage II as mature and spawning in the current season. For Rio de Janeiro, Zaneti Prado and Vazzoler found lower values (males 112mm, females 113mm) well below those found in our sample from Santa Catarina (males 133mm, females 140mm). This suggests a strong gradient of sizes and ages at first maturity with increasing latitudes and decreasing water temperatures. Fecundity estimates of Zaneti Prado (1979) were similar to ours for the size range of her samples. Castanhas introvaric maturing eggs counts (44,600 to 1450,000) were higer than other abundant sciaenids from the same region as *Micropogonias furnieri*, from 50.000 to 760.000 (Vazzoler, 1970) and *Macrodon ancylodon*, 60,000 to 358,000 maturing eggs (Juras, 1979).

The castanha is an iteropareous fish of

low natural mortality, which may live over 20 years (Haimovici and Reis, 1984). Its somatic growth diminish gradually with age, while the fraction of energy spent in reproduction increases greatly Bigger females swim faster, thus can stay longer in the feeding grounds and arrive earlier and move further north in the spawning grounds. The swich from growth to reproductive expenditure allow the larger females to provide a greater contribution to the reproductive potential of the stock. This is an important aspect of the reproductive strategy of the castanha with implications in its fishery management, since the reproductive potential of the stock depends on the age structure and its growth pattern, besides its total biomass (Haimovici, *et al.*, 1988).

Some of the adaptative characteristics that explain the abundance of the castanha are the high life expectancy and fecundity, the migratory behaviour with different feeding for youngs and adults and a long spawning season over a wide geographic area.

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REFERENCES

BAGENAL, T.B., 1957, Annual variations in fish fecundity. *J. Mar. Biol. Ass. U.K., 36*:377-382.

BAGENAL, T.B., 1978, Aspects of Fish Fecundity. In: "Ecology of Freshwater Fish Production" (ed. S.D. Gerking): 75-101. *Blackwell, Oxford,* 520p.

BAGENAL, T.B., and BRAUM, E., 1978, Eggs and early life History. In: "Methods for Assessment for Fish Production in Fresh Waters." ed. Bagenal, T.B.: 165-201. IBP Handbook Num. 3, 3rd. edn. *Blackwell, Oxford,* 365p.p

CASSIA, M.C., 1986, Reproduccion y fecundidad de la pescadilla de red *Cynoscion striatus*. Publicaciones de la Comision Mixta del Frente Marítimo. Vol. 1 Primera Parte: 191-203, Montevideo.

CHRISTENSEN, H.E. and COUSSEAU, M.B., 1971, La reproducción de la merluza en el Mar Argentino. 2. La reproducción de la merluza y su relación con otros aspectos biológicos de la especies. Bol. Inst. *Biol. Mar., Mar del Plata, Argentina, Nro. 20*:43-75.

FOUCHER, R.P. and BEAMISH, E.J., 1977, A review of oocyte development in fishes with special reference to pacific hake *Merluccius productus*. Fisheries and Marine Service of Canada, *Technical Raport* Num. *755*:16p.

GONZALEZ ALBERDI, P. and NANI, A., 1967, Contribución al conocimiento de la biología del pargo blanco *Umbrina canosai*, de la región de Mar del Plata, CARPAS - Docum. Téc. Num. *10*:1-36.

HAIMOVICI, M., 1977, Age growth and aspects of the biology of the croacker *Micropogon opercularis* (Quoy et Gaimard, 1824). *Atlantica 2*(1):21-49, Rio Grande.

HAIMOVICI, M. 1982, Estructura y dinámica poblacional del pargo blanco *Umbrina canosai* (Pisces, Sciaenidae) del litoral de Rio Grande do Sul, Brasil. Tesis de Doctorado, Univ. de Bs.As. 279 p.

HAIMOVICI, M., (1988), "Analisis de cohortes del stock de pargo blanco *Umbrina canosai* explotado en el sur de Brasil, Uruguay y Argentina." Publicaciones de la Comisión Mixta del Frente Marítimo, Vol 2.

HAIMOVICI, M. and REIS, E.G., 1984, Determinação de idade e crescimento da castanha Umbrina canosal, (Pisces, Sciaenidae) do sul do Brasil. *Atlantica, 7*:25-46, Rio Grande.

HAIMOVICI, M. and CASTELLI VIEIRA, P., 1986, "Captura e esforço na pesca de arrasto de fundo no litoral sul do Brasil, no período 1975-1984". Anais do IV Congresso Brasileiro de Engenhiaria de Pr[illegible] 215-234, Curitiba.

HAIMOVICI, M. e TEIXEIRA, R.L., CASTRO ARRUDA, M. DE, 1989, Alimentação da castanha *Umbrina canosai* (Pisces: Sciaenidae) no sul do Brasil. *Rev. Bras. Biol., 49*(2):~~172-182~~. 511-522

JURAS, A.A., 1979, Estudo sobre reprodução e regime alimentar de *Macrodon ancylodon* (Bloch e Schneider, 1801) capturada nas costas de Rio Grande do Sul (Latitudes 29° S a 32° S) Tese de Mestrado. *Univ. de São Paulo, Brasil,* 126p.

MACER, C T., 1974, The reproductive biology of the horse mackerel *Trachurus trachurus* (L) in the North Sea and the English Chanell. *Journal of Fish Biology, 6*:415-438.

MAC GREGOR, J.S., 1957, Fecundity of the pacific sardine *Sardinops caerulea. Fish. Bull. vol. 57*:427-449.

NICKOLSKII, G.V., 1969. "Theory of Fish Populations Dynamics as the Biological Background for Rational Explotation and Management of Fishery Resources." Oliver and Boyd, London 323 p.

POPE, J.A., MARGETTS, A.R., HAMLEY, J.M. and AKYUZ, E.F., 1975, Manual of Methods for Fish Stock Assessment. Part III. Selectivity of fishing gear. FAO Fls. *Tech. Paper Num. 41*: 65p. Rome.

POWELS, H. 1981, Eggs and larvae of North Amer. Sciaenid fishes. (99-110), in "Proceedings of the Sixth Anuual Marine Recrational Fisheries Symposium, Sport Fishing Institute, Washinton D.C. 196p.

SOKAL, R.R. and J.F. ROHLF, 1969, The Principles and P ractice of Statistics in Biological Research. W.H. Freeman and Company, San Fransisico, 776p.

VAZZOLER, A.E.A., 1970, *Micropogon furnieri*, Fecundidade e tipo de desova. CARPAS/4/D. Tec. *20*:1-10, Rio de Janeiro.

VAZZOLER, A.E.A., 1971, Diversificação fisiológica e morfológica de *Micropogonias furnieri* (Desmarest, 1822 ao sul de Cabo Frio, Brasil, *Bolm. Inst. Oceaogr., 20*(2):1-70. São Paulo.

VAZZOLER, G., 1975, Distribuição da fauna de peixes demersais e ecologia dos Sciaenidae da plataforma continental brasileira entre as latitudes 29°21'S (Torres) e 34°44'S (Chui). *Bolm. Inst. Oceanogr., São Paulo. 24*:85-169.

YAMAGUTI, N., 1967, Desova da Pescada Fogue. *Macrodon ancylodon. Bolm. Inst. Oceanogr. 16*(1):101-106. São Paulo.

YESAKI, M. and BAGER, K.J., 1975, Histórico da evolução da pesca industrial em Rio Grande. Programa de Pesquisa e Desenvolvimento do Brasil PNUD/FAO: Ministério de Agricultura, SUDEPE, Ser. Doc. *Técnicos no. 11*:1-15. Rio de Janeiro.

ZANETI PRADO, E.M., 1979, Bionomia e ciclo de vida de *Umbrina canosai* Berg, 1895. *Bolm. Inst. Oceanogr. 28*(1):119-165. São Paulo.

ZANTI PRADO E.M. and A.E.A. VAZZOLER, 1976, Algums aspectos do ciclo de vida de *Umbrina canosai* na região da plataforma continental brasileira entre Cabo Frio (lat 23°S) e Torres (lat 29°21'S). *Resumos da 28 Reunião Anual da Soc. Brasileira para o Progressos da Ciência*:244.