

Life History and Fishery of the Enchova, *Pomatomus saltatrix*, in Southern Brazil

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Abstract. Landings of the enchova, *Pomatomus saltatrix*, along the south-western Atlantic coast from Rio de Janeiro (23°S) to Argentina (38°S) averaged about 5000 t (1970-92) and attained a peak of about 15000 t in 1971. Most catches were with purse-seines and gill-nets along the coast of southern Brazil and were of immature and young adult enchovas moving northward in winter toward lower latitudes. Ring formation on scales occurs in winter in association with low water temperature and decreased feeding activity; the maximum observed age was 8 years and the largest specimens measured up to 800 mm total length (TL). Both young of the year and older enchovas fed on fishes and squid. Off southern Brazil, enchovas are multiple spawners from mid spring to late summer and first maturity is attained in the third year of life at 350 to 400 mm TL. *P. saltatrix* specimens from southern Brazil and Argentina seem to belong to a single stock, and observed migration patterns show similarities to those in other regions: movement toward lower latitudes in winter when surface temperatures decrease and toward higher latitudes in late spring and summer along both shelf and slope.

Introduction

Pomatomus saltatrix has a worldwide distribution, generally in temperate and warm-temperate continental shelf waters (Briggs 1960). Along the eastern coast of South America, it is commonly recorded between Buenos Aires Province in Argentina (40°S) and Rio de Janeiro State in Brazil (22°S) but occurs as far north as the gulf of Venezuela (Valdez and Aguilera 1987). Common names are 'anchoa' and 'anchoa de banco' in Uruguay and Argentina and 'enchova', 'anchova' or 'enchova marisqueira' in southern and south-eastern Brazil.

Despite the species being relatively abundant from northern Argentina to southern Brazil, present knowledge about it is rather poor. Early papers dealing with this species in southern Brazil include a description of the purse-seine fishery off southern Brazil in its early years (Yesaki and Bager 1975) and a report of aerial surveys to detect migrating enchova schools off Rio Grande (Barcellos 1976). Between 1976 and 1983, the landings by the purse-seine fishery of *Pomatomus saltatrix* in Rio Grande were monitored regularly (Haimovici 1987). Biological samples were collected between 1976 and 1987 from the purse-seine, gill-net, bottom-trawl and hand-line commercial fisheries and trawl research cruises from Solidão (30°40'S) to Chui (34°30'S), and young of the year were sampled from the mouth of Patos Lagoon caught with shrimp-trawls and beach-seines. Age, growth, feeding, first sexual maturation and annual reproductive cycle of the enchova were studied by Krug and Haimovici (1989) and Haimovici and Krug

(1992) and the fishery and seasonal and inter-annual changes in the size and age structures by Krug and Haimovici (1991).

The enchova is a highly migratory species shared by three nations, and so the existence of one or more populations is an important issue to be investigated. In this paper, aspects of the life history, population dynamics, stock structure and fishery of the species are reviewed and potential implications for the unity of the stock and its possible migratory patterns are discussed.

Landings and Fisheries

Fishery statistics were obtained from published and unpublished reports by the fishery research institutes of Argentina (INIDEP), Uruguay (INAPE) and Brazil (IBAMA); cooperation by these institutions is acknowledged. Mean annual landings of enchovas in southern Brazil (Rio Grande do Sul to Rio de Janeiro), Uruguay and Argentina in the 1970-92 period were 5012 t, with a peak of 14 838 t in 1971. Most landings were in Brazil (88.5%) followed by Argentina (11.4%) and Uruguay (0.1%) (Fig. 1).

Annual nominal catches in Argentina were highest in the early 1970s, attaining 2757 t in 1971 when *P. saltatrix* was caught by purse-seiners that had as their main target the bonito *Sarda sarda*. In later years, enchova landings decreased to a mean of 216 t (1975-91) and a peak of 1105 t in 1992. Most catches were by purse-seiners and by trolling with hook and line from small coastal fishing boats. The fishery occurs mostly in the warm months from January to

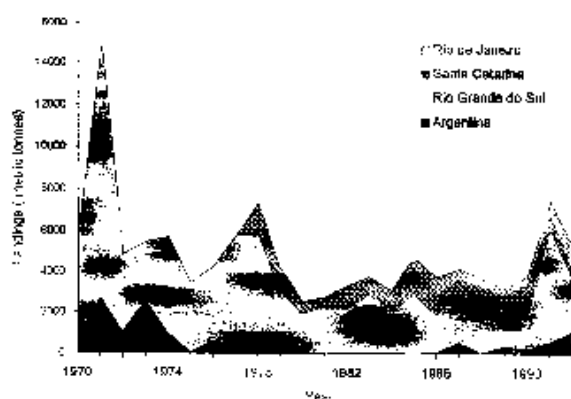


Fig. 1. Recorded landings of anchovas (*Pomatomus saltatrix*) in the ports of Argentina and those of Brazil (Rio Grande in Rio Grande do Sul State, Itajaí and Navegantes in Santa Catarina State, and Rio de Janeiro in Rio de Janeiro State) from 1970 to 1992.

May off Buenos Aires Province, and landings are at Mar del Plata and Necochea ports (Fig. 2).

In Uruguay, the anchova is caught only occasionally by coastal trawlers and by artisanal fishers with gill-nets (Nion and Rios 1991). Catches are insignificant, with the largest recorded landings being 30 t in 1987.

Off Rio Grande do Sul State in southern Brazil, a relatively large-scale fishery with purse-seines and gill-nets occurs seasonally in winter and early spring (Fig. 2). Total annual landings in Rio Grande until 1968 were under 1000 t. Mean landings in later years were 3528 t (1970–92) with an exceptional peak of 12 126 t in 1971. Purse-seine fishing started in 1962 (Yesaki and Bager 1975); the purse-seiners, called 'traineiras', are usually wooden or steel boats of 20–24 m and 250–450 horsepower. The nets measure 600–800 m long by 70–80 m high, with a mesh of 13 mm between adjacent knots (small meshes are used to avoid the anchovas chewing the nets). Recent technological advances have allowed crews to be reduced by half and fishing to occur in deeper waters (Krug and Haimovici 1991). Smaller

fishing boats catch anchova with monofilament floating gill-nets up to 3000 m long and 15 m high (and a mesh of 100–110 mm between opposite knots) in winter near the mouth of the Los Patos Lagoon at depths between 10 and 18 m along the coast between Albardão (32°49'S) and Solidão (30°40'S) (Reis *et al.* 1994). In Rio Grande, there are also small landings of anchovas caught in small numbers by bottom trawlers. In September and October 1994, some boats fishing with bottom gill-nets on the shelf break for demersal fishes caught several tonnes of large anchovas.

Landings in Santa Catarina (Brazil) averaged 1008 t (1978–92), of which 30% was caught by traineiras fishing in winter off Rio Grande do Sul and 70% by coastal gill-net fishing, mostly from July to December (Fig. 2). Landings in São Paulo State averaged 60 t (1970–90), mostly as by-catch of bottom trawling for shrimp and demersal fishes. Mean recorded landings in Rio de Janeiro from 1985 to 1992 were 592 t, caught mostly by purse-seiners and with hook and line off Cabo Frio (22°S), mainly in the summer months when the upwelling of cold waters is more intense.

In the rest of Brazil, artisanal fishers land small quantities of anchova, but no statistics are available.

Life Cycle

Age and Growth

Krug and Haimovici (1989) examined scales of 2332 anchovas fished along the coast of Rio Grande do Sul. Monthly changes in marginal increments showed annual ring formation on scales every winter in association with low water temperature and decreased feeding activity of schooling migrating fishes. Maximum observed ages were 8 years for females and 7 years for males. In a few large females (total length [TL] > 800 mm) sampled in a fish market in Santa Catarina up to 10 annual rings were counted.

Mean sizes of anchovas of the same ages caught by trawling and by hook and line were larger than those of anchovas caught by purse-seiners and were assumed to represent better growth in the population. This difference may be explained by the fact that, until recently, purse-seiners fished mostly in shallow coastal waters on schools of smaller migrating anchovas (see also Population Structure below). Back-calculated total length at ages of 0.6 year, 1.6 years, 2.6 years etc. are shown in Table 1 (the mean time elapsed between spawning and first ring formation was estimated to be 0.6 year). Females grew faster, larger and older than males. The parameters of the von Bertalanffy growth curves were calculated by using a Walford plot for both sexes. The corresponding equations (for a TL range of 140–670 mm) were:

$$\begin{aligned}
 TL_{\text{males}} &= 589\{1 - \exp[-0.461(t + 0.209)]\} \\
 TL_{\text{females}} &= 680\{1 - \exp[-0.368(t + 0.321)]\} \\
 TL_{\text{both sexes}} &= 662\{1 - \exp[-0.387(t + 0.321)]\},
 \end{aligned}$$

Table 1. Mean total length (mean TL, in mm) at successive ages as back-calculated from the formation of annual rings on scales of anchovas (*Pomatomus saltatrix*) from off southern Brazil (1976–83). n, number of specimens aged. Source: Krug and Haimovici (1989)

Age (years)	Males		Females		Both sexes, mean TL
	Mean TL	n	Mean TL	n	
0.6	185	29	201	36	196
1.6	342	33	361	45	356
2.6	418	34	441	46	438
3.6	484	17	510	24	506
4.6	528	6	564	16	562
5.6	568	2	608	14	600
6.6	602	2	629	2	618

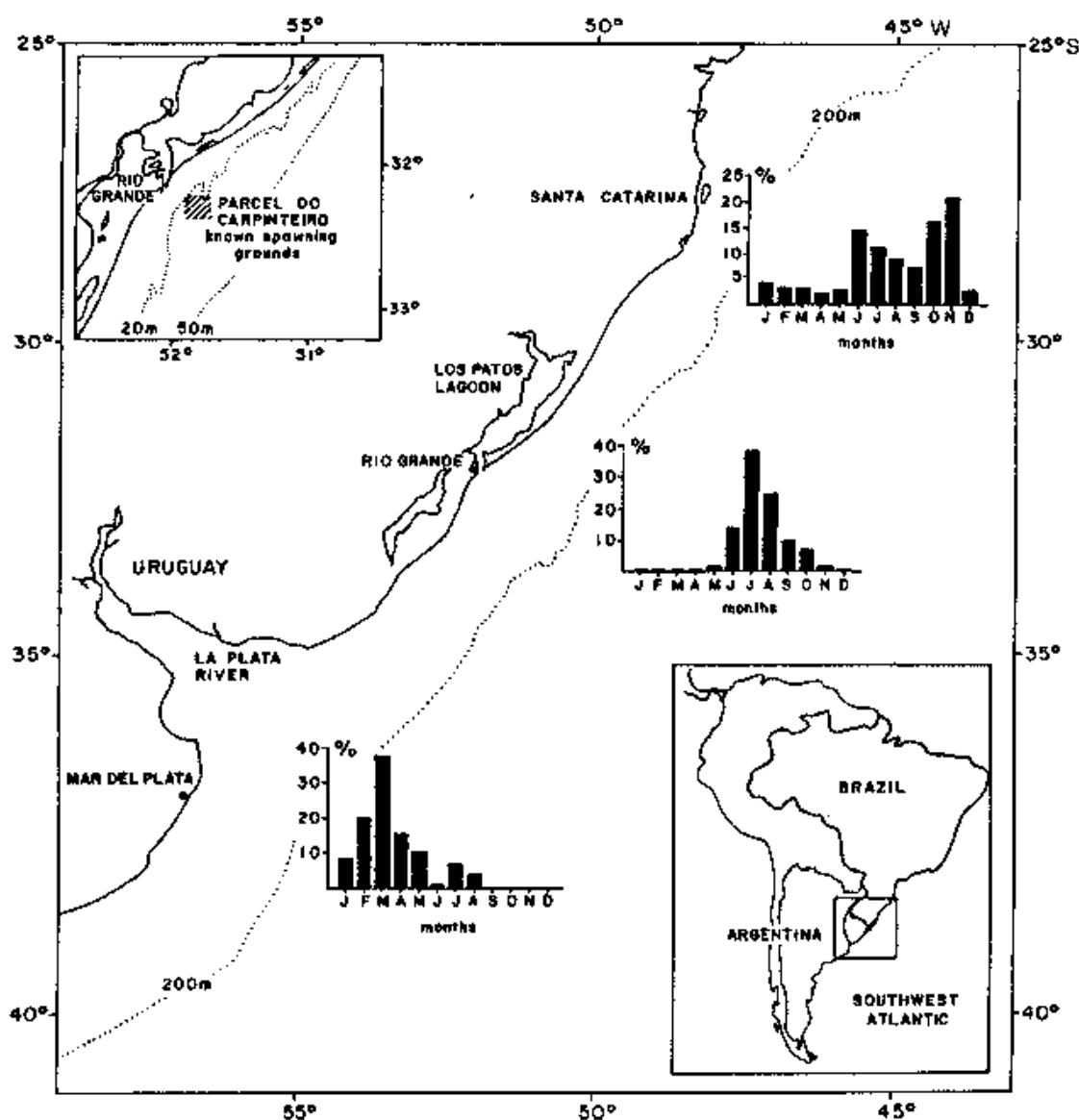


Fig. 2. Percentage monthly landings by coastal fisheries of enchovas (*Pomatomus saltatrix*) in the parts of Mar del Plata and Rio Grande and diverse ports in Santa Catarina State. The winter fishing grounds off Rio Grande and the spawning area (Parcel do Carpinteiro) are indicated.

where TL is in millimetres and t is time (age) in years. These equations probably underestimate growth at older ages, as large specimens were undersampled.

Reproductive Cycle and First Maturity

Various aspects of the reproduction of the enchovas off southern Brazil were studied by Haimovici and Krug (1992). Spawning occurs from late spring to summer. Monthly gonadosomatic indices of male and female enchovas over 350 mm TL were high between November

and March and low the rest of the year (Fig. 3). The enchova off southern Brazil may be considered to be a multiple spawner during several months. Evidence of continuous recruitment of mature oocytes during the reproductive season included the apparent three modes in the frequency distribution of the diameter of intra-ovarian oocytes of mature females and ovaries with large hydrated oocytes, characteristic of spawning females, that were observed from November to February (Fig. 4). Additionally, evidence of multiple spawning was that the number of maturing

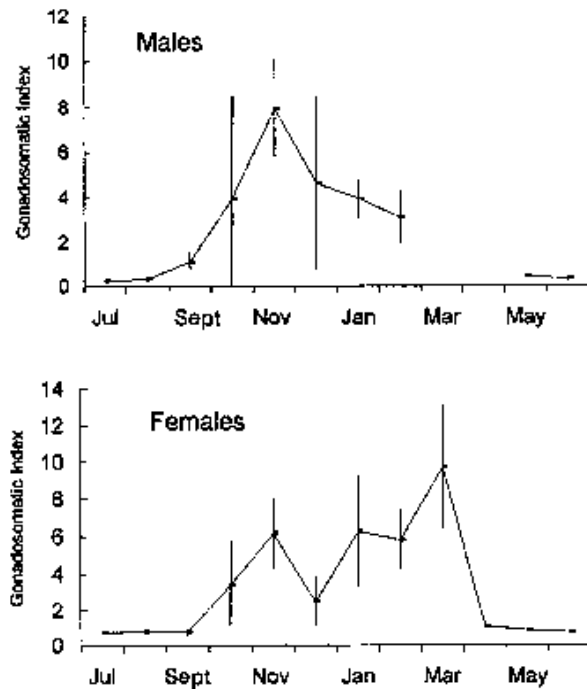


Fig. 3. Gonadosomatic indices of male ($n = 270$) and female ($n = 330$) enchovas (*Pomatomus saltatrix*) of >350 mm TL sampled monthly in Rio Grande (no data for males from March to May). Vertical lines represent 95% confidence intervals.

vitellogenic oocytes in the ovaries did not decrease during the spawning season, indicating continuous oocyte recruitment: counts in ovaries of 27 females (TL 410–560 mm) sampled in November ranged from 468×10^3 to 3006×10^3 and mean relative fecundity was 1292 oocytes per gram of somatic weight, compared with 638×10^3 to 2135×10^3 in ovaries of 7 females (TL 410–570 mm) and 1234 oocytes g^{-1} of somatic weight in February and March.

Age and length at first maturity were estimated from the percentages of immature specimens (thread-like testes and thin, translucent ovaries measuring less than one-third the length of the body cavity) and mature specimens (milky, large testes and yellow ovaries measuring over one-half the length of the body cavity with visible vitellogenic oocytes); these percentages are shown at 50-mm-TL intervals and for various age groups of enchovas sampled from November to March (Table 2). As most of the enchovas are fished in winter and early spring, samples from the reproductive season in late spring and summer are scarce, so data from 1976 to 1987 were pooled. Mature specimens were dominant in the TL classes over 350 mm. Half of the females at age 2+ years were mature and almost all at ages 3 and over.

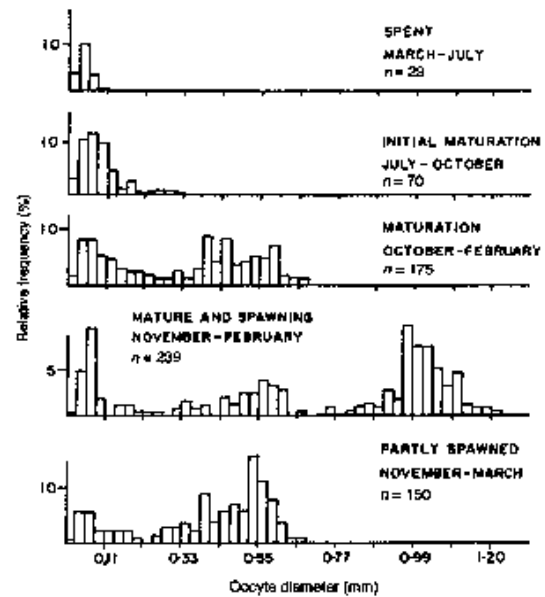


Fig. 4. Relative frequency distributions of intra-ovarian maturing oocytes of individual female enchovas (*Pomatomus saltatrix*) sampled in Rio Grande at different maturity stages and corresponding times of the year.

Off southern Brazil, a major spawning ground is located a few miles offshore from Rio Grande in the Parcel do Carpinteiro (Fig. 2), where concentrations of ripe enchovas were found in spring and summer. Off Buenos Aires Province in Argentina, enchovas caught in summer have ripe gonads (R. Roa, personal communication).

Table 2. Numbers of immature and mature specimens and percentages of mature specimens in different length and age classes of enchovas (*Pomatomus saltatrix*) from off southern Brazil. Source: Haimovici and Krug (1992).

Total length (mm)	Males			Females		
	Immature	Mature	Mature (%)	Immature	Mature	Mature (%)
200–249	14	0	0	10	0	0
250–299	10	0	0	12	0	0
300–349	–	–	–	–	–	–
350–399	3	14	82.4	2	3	60.0
400–499	6	39	86.7	5	31	86.1
>500	0	40	100.0	–	42	100.0
Age (years)						
1+	3	0	0	4	0	0
2+	2	7	77.8	5	5	50.0
3+	3	16	84.2	2	29	93.5
4+	2	13	86.7	1	29	96.7
5+	1	10	90.0	1	46	97.9

Food and Feeding

Prey of young of the year in the estuary of Los Patos Lagoon and nearby coastal waters included small coastal and estuarine fishes (*Engraulis anchoita*, *Anchoa mitchini* and *Mugil* sp.) and crustaceans (*Siriella* sp., *Artemesia longinaris* and *Callichirus mirim*). On the southern Brazilian shelf, older enchovas fed over the entire water column, mainly on pelagic fishes (*E. anchoita*, *Trachurus lathami*, *A. mitchini*, *Trichiurus lepturus*, *Macrodon ancylodon* and *Cynoscion guatucupa*) and squid (*Loligo sanpaulensis*). Interestingly, enchovas moving in schools caught by seines and gill-nets had fed significantly less than had those caught by the trawls (Haimovici and Krug, 1992).

Population Structure

Length, sex and age compositions of the landings in Rio Grande were recorded from 1976 to 1983 (Krug and Haimovici 1991). No evidence of sex segregation during the winter migration was found. Females were more frequent in the samples of all size and age groups in both the fishing season (57.8%; $n = 867$) and off-season (54.3%; $n = 256$), but differences were not statistically significant ($P > 0.05$).

Total lengths in the landings varied with the fishing gears used. Purse-seiners landed the smaller fishes, followed by coastal gill-nets, and the largest fishes were caught with hand-lines and bottom gill-nets on the outer shelf. The widest length range was found in the landings of bottom-fishing trawlers, which included small quantities of both small and large enchovas (Fig. 5).

Monthly size compositions during the fishing season show two distinct groups from June to September: the first group consists of pre-adult enchovas of < 350 mm TL in their second year of life, and the second group includes older fishes mainly aged 2 to 4 years (Fig. 6a). By the end of the season the young fishes are no longer caught, suggesting that younger enchovas migrate northward earlier in late autumn and winter.

The purse-seine fishery was largely sustained by enchovas aged 1 to 3 years (Fig. 6b). Fish aged 1 year represented 53.2% of the total number and 35.2% of the total weight (Table 3). The coastal gill-net fishery caught enchovas mostly of ages 2 and 3 years and the outer-shelf fishery caught enchovas aged 4 years and older. Between 1976 and 1983, over 99% of the catches were of enchovas aged 1 to 4 years (Table 3).

Discussion

Do Pomatomus saltatrix populations off Argentina and southern Brazil belong to the same stock?

Several similarities were observed between stocks of *Pomatomus saltatrix* from different regions of the Atlantic Ocean, such as fast growth of juveniles, sexual maturation

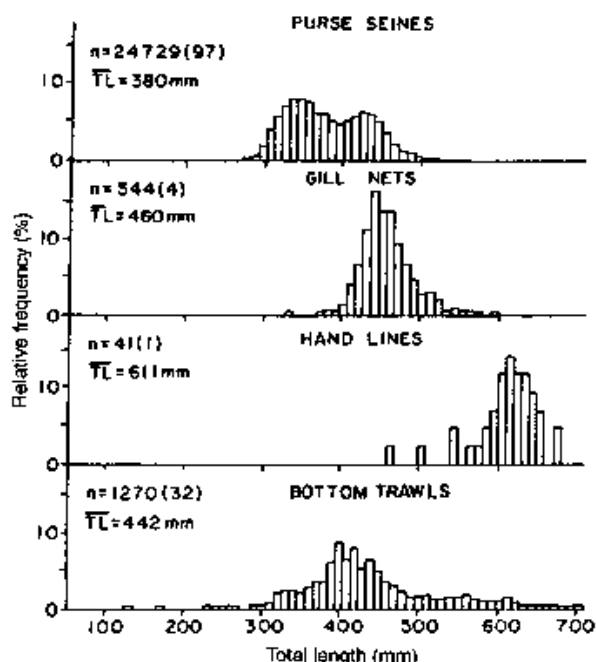


Fig. 5. Length frequency distributions of enchovas (*Pomatomus saltatrix*) landed in Rio Grande (1976-83) and fished with different gears (TL, mean total length; n, number of specimens measured, with the number of samples in parentheses).

beginning in the second year of life, and all individuals becoming mature by the third year (Conand 1975; van der Elst 1976; Wilk 1977). Off southern Brazil, individuals are smaller than those along the eastern coast of the United States and off north-eastern Africa but are larger than those off south-eastern Africa and in the Mediterranean Sea (Turgan 1959; van der Elst 1976; Wilk 1977; Champagnat 1983). Sexual maturation for both sexes was attained at

Table 3. Total landings of enchova (*Pomatomus saltatrix*) in Rio Grande from 1976 to 1983 by number and weight, with estimated percentages of each age class in coastal gill-nets, purse-seines and all fishing, including trawling and hook-and-line catches. Source: Krug and Haimovici (1991)

Gear	Catch	Age class				
		1	2	3	4	5+
	No. (trillions)	percent in numbers				
Coastal gill-nets	4.6	3.5	39.2	44.6	9.8	2.9
Purse-seiners	31.9	53.2	23.1	18.7	4.8	0.3
All fishing	36.5	46.9	25.1	22	5.5	0.5
	Weight (t)	percent in weight				
Coast gill-nets	4296	2.4	35.6	46	12	4
Purse-seiners	17185	35.2	29.9	26.9	7.9	0.2
All fishing	21444	28.6	31	30.7	8.7	1

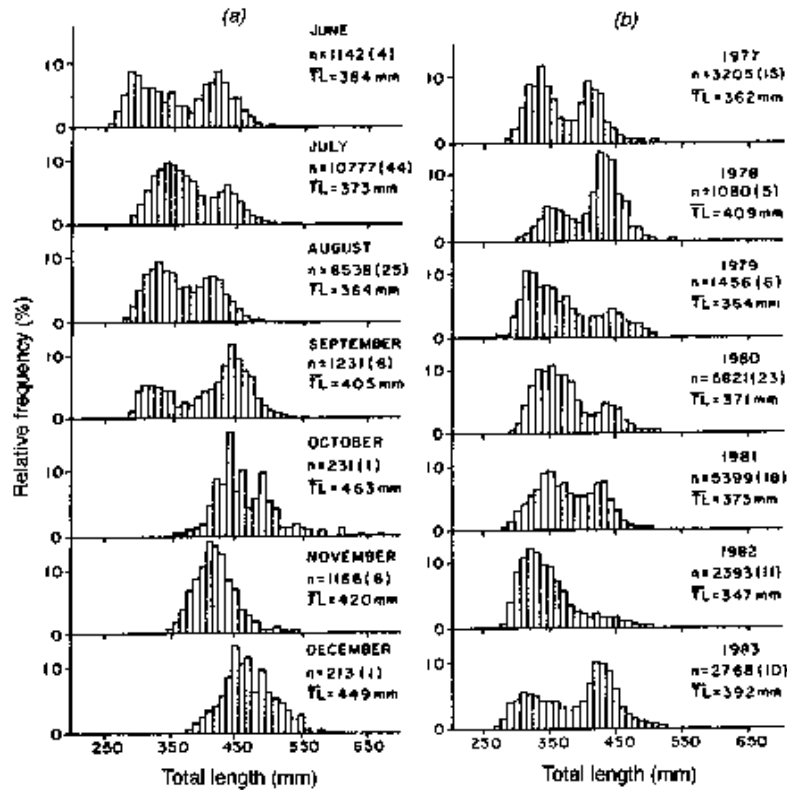


Fig. 6. Length-frequency distributions of anchovy (*Pomatomus saltatrix*) fished (a) by purse-seiners and landed in Rio Grande in different months of the fishing season (pooled 1977-83) and (b) by purse-seiners during the entire fishing season in different years between 1977 and 1983 (TL, mean total length; n, number of specimens measured, with the number of samples in parentheses).

larger sizes in faster-growing stocks—250 mm off South Africa (van del Elst 1976), 350 mm off Brazil (Haimovici and Krug 1992) and 430 mm off Dakar in Senegal (Conand 1975; Champagnat 1983)—but the relation L_{95}/L_{50} was relatively constant in different stocks.

Despite the lack of direct evidence from marking experiments, several observations listed below lead to the conclusion that anchovy from northern Argentina to Santa Catarina in southern Brazil are part of a single stock.

(1) Mean monthly landings in Mar del Plata, Rio Grande and Santa Catarina by the artisanal or coastal fisheries (Fig. 2) show a seasonal displacement of the fishery. Large, sexually mature specimens are caught off Argentina in summer at sea surface temperatures over 20°C. In autumn, when temperatures decrease, smaller anchovy aged 1 to 4 years begin migrating from the south and are fished off Rio Grande from June to September at surface temperatures between 15°C and 17°C. Off Santa Catarina, larger catches are in winter and spring (July to December) at sea surface temperatures of 20°C to 22°C.

(2) Sexually mature females were recorded from November to March off Rio Grande, where spawning schools have been observed over the Parcel do Carpinteiro (Fig. 2), and mature large specimens have been recorded off Mar del Plata in summer (R. Roa, personal communication). No data are available from Santa Catarina.

(3) Larvae, in small quantities, were mostly found in summer in association with warm (>20°C) and saline (>34) waters of the inner shelf (Muelbert and Sinque 1996).

(4) Off Rio Grande, juveniles were found in mid-water trawl surveys in the estuary of Los Patos Lagoon in small numbers from autumn to spring but not in summer (Chao *et al.* 1982). In coastal waters of northern Argentina, adult anchovy are common in summer, arriving from the north, and juveniles are frequent in the Rio de la Plata estuary and front (Cousseau 1985).

The cyclic migration seems to follow the western boundary of the subtropical convergence between the Brazil and Malvinas Currents, remaining always in surface waters over 14–15°C. The anchovy (younger first and in more

coastal waters) move northward in autumn and winter, favoured by the northward-moving water masses along the coast. Enchovas do not seem to feed intensely during the migration, but their passage along the coast of Rio Grande do Sul coincides with higher biomasses of *Engraulis anchoita* (Lima and Castello 1995). Southward movements of adults in late spring and summer appear to follow the southward movement of warm waters of the Brazil Current, as large enchovas (550–750 mm TL) were caught in September and October along the outer shelf and upper slope and spawning concentrations were found inshore off Rio Grande in November. Available information is insufficient to assess the relative importance of the spawning and nursery grounds. Along the coast, from Santa Catarina to Buenos Aires Province, there are no major sources of freshwater runoff other than the Rio de la Plata and the Lagoa dos Patos. Thus, these are probably the main nursery grounds. Owing to favourable southerly currents, spawning off Rio Grande may contribute to the recruitment to the nursery grounds in the estuary and front of the Rio de la Plata.

Little is known about the stock of *Pomatomus saltatrix* fished off Rio de Janeiro. These fish probably belong to a separate group associated with the upwelling off Cabo Frio, but there are no studies on their life cycle for that region.

Migration patterns observed off southern Brazil and Argentina have similarities to those in other regions: *P. saltatrix* adults migrate in spring towards higher latitudes with advancing warmer waters, with larger fishes being further from the coast (Lund and Maltezos 1970; Champagnat 1983). Multiple spawning beginning in spring in lower latitudes and summer spawning in higher latitudes are also cited for different stocks (Conand 1975; van der Elst 1976; Wilk 1977).

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