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Reproductive Cycle of the Pacific Bonito, *Sarda chilensis* (Scombridae), from Northern Chile[1]

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ABSTRACT: The Pacific bonito, *Sarda chilensis*, spawns from spring to late summer off northern Chile. The smallest female in spawning condition was 410 mm standard length (SL); the smallest spermiogenic male, 390 mm SL. Females spawn more than one batch of eggs per season.

THE PACIFIC BONITO, *Sarda chilensis*, occurs in the Pacific from Chile to the Gulf of Alaska (Miller and Lea 1976). Previous studies have given the spawning time for *S. chilensis* in Chile (Barrett 1971, Serra et al. 1980) and Peru (Chirinos de Vildoso 1966) as October–November and ending before April. However, as these observations were based on gonosomatic indices or microscopic examinations of unstained gonads, it was felt that a histological analysis of monthly samples (as presented herein) would give a more precise description of the reproductive cycle of this species.

MATERIALS AND METHODS

A total of 129 females and 169 males were obtained from local fishermen at Iquique (20°18′ S, 70°08′ W), region I, Chile from November 1981 to December 1982. Fish were collected with nets. Gonads were preserved in 10 percent formalin. Histological sections of 85 females and 102 males were cut at 8 μm and stained with Harris' hematoxylin followed by eosin counterstain. Fresh fish and gonads were weighed to the nearest gram using a torsion balance. Seasonal gonosomatic indices (GSI) (gonad wt/fish wt × 100) were calculated. Fish weight in these calculations included the gonads.

Ovaries were histologically classified into four stages (sizes are mean diameters) (Table 1): regressed or regressing (contain primary oocytes [56 μm] or mature oocytes undergoing atresia); previtellogenic (contain enlarging [161 μm] oocytes with a ring of vacuoles around the inner periphery); vitellogenic (enlarging oocytes [315 μm] in the process of accumulating yolk); spawning (mature, yolk-filled oocytes [545 μm] and/or hydrated eggs [798 μm]).

Testes (Table 2) were histologically classified into four stages: spermiogenesis (lumina occluded with sperm, germinal cysts line lumina); late spermiogenesis (lumina occluded with sperm, reduced quantities of germinal cysts); regression (germinal cysts exhausted); and recrudescence (proliferation of germinal cysts).

RESULTS

Gonosomatic indices increased (Figure 1) during spring (September in southern hemisphere) and reached a maximum in early summer (December). The smallest female in spawning condition measured 410 mm standard length (SL). The earliest postovulatory follicles were observed in September 1982. These structures are remnants of the granulosa layer of the spawned eggs which hypertrophy. In *Sarda chilensis* they are highly convoluted structures consisting of a layer of columnar epithelium and an underlying supportive connective tissue theca. From spawning the northern anchovy, *Engraulis mordax*, in captivity (Leong 1971) and from subsequent

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TABLE 1

MONTHLY DISTRIBUTION OF BODY SIZES (SL) AND STAGES IN *Sarda chilensis* SPAWNING CYCLE, NOVEMBER 1981–DECEMBER 1982

MONTH	*N*	RANGE (mm)	REGRESSED OR REGRESSING (%)	PREVITELLOGENIC (%)	VITELLOGENIC (%)	SPAWNING (%)
November	2	430–480	0	0	0	100
December	5	410–510	0	0	0	100
January	5	410–430	20	0	0	80
February	4	410–480	0	25	0	75
March	11	425–550	55	9	0	36
April	7	425–550	100	0	0	0
May	5	415–460	100	0	0	0
June	9	420–455	100	0	0	0
July	7	425–530	100	0	0	0
August	6	420–450	100	0	0	0
September	6	420–570	33	0	0	67
October	10	425–580	0	20	20	60
November	6	415–490	0	0	0	100
December	2	460–480	0	0	0	100

TABLE 2

MONTHLY DISTRIBUTION OF BODY SIZES (SL) AND STAGES IN *Sarda chilensis* TESTICULAR CYCLE, NOVEMBER 1981–DECEMBER 1982

MONTH	*N*	RANGE (mm)	REGRESSION (%)	RECRUDESCENCE (%)	SPERMIOGENESIS (%)	LATE SPERMIOGENESIS (%)
November	8	385–455	0	0	100	0
December	6	415–495	0	0	83	17
January	15	390–460	0	0	80	20
February	12	400–465	0	0	67	33
March	10	425–455	30	0	70	0
April	7	425–550	100	0	0	0
May	4	425–560	100	0	0	0
June	6	425–445	100	0	0	0
July	7	420–445	100	0	0	0
August	4	430–480	25	50	25	0
September	7	440–525	0	14	86	0
October	8	420–515	0	0	100	0
November	5	410–465	0	0	100	0
December	3	485–600	0	0	100	0

histological analysis of material obtained in this manner (Hunter and Goldberg 1980), it was determined that the postovulatory follicle has a brief existence and is indistinguishable from atretic follicles after 48 hrs. They were noted in 61 percent of 1981–1982 females that were classified as being in spawning condition. The presence of postovulatory follicles from a recent spawning alongside mature follicles for a subsequent spawning indicated *S. chilensis* spawns more than once during a reproductive season. In some cases hydrated eggs were also noted. Hydration occurs just prior to spawning when the mature oocyte grows to as much as four times its original volume (Wallace and Selman 1981).

At the end of summer (1981–1982) gonosomatic indices decreased (Figure 1). During

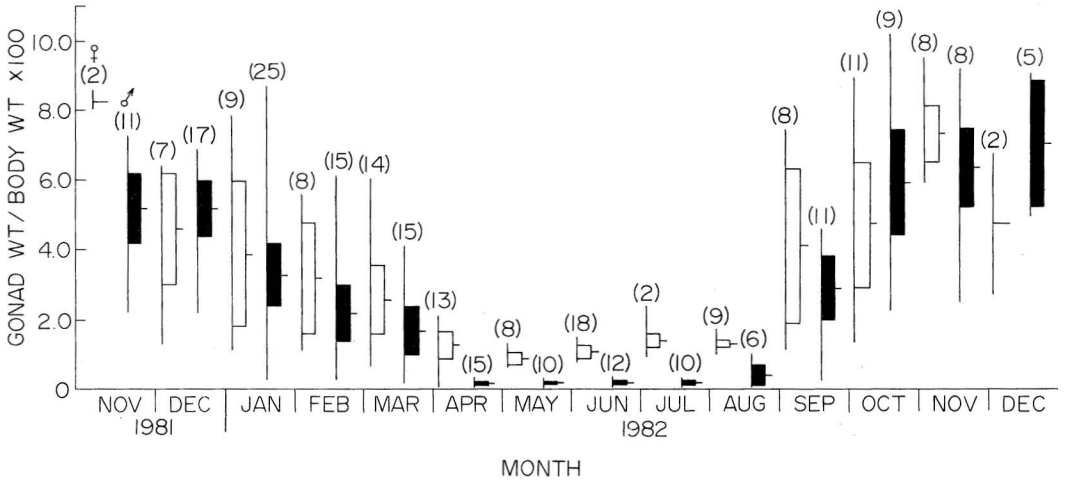

FIGURE 1. Seasonal gonosomatic indices for *Sarda chilensis*. Vertical line = range; horizontal line = mean; rectangle = 95 percent confidence interval; white rectangle female, black rectangle male; sample size in parentheses.

March, females undergoing atresia comprised 27 percent of our sample. This is commonly seen toward the end of the spawning cycle when follicles that initiated but did not complete yolk deposition degenerate. All ovaries from April–August were regressed (Table 1). The data for September–December 1982 were similar to those from 1981. In 1982, the absence of previtellogenic and vitellogenic stages (which normally precede spawning) can probably be explained by our small August sample size.

The gonosomatic indice data for males (Figure 1) was similar to that for females as was the seasonal pattern of testes stages (Table 2). Testes sizes were largest during late spring–early summer, followed by a size decrease through summer. Testes began to enlarge in late winter (August). The smallest reproductively active male (spermiogenesis in progress) measured 390 mm SL.

DISCUSSION

In northern Chile, *Sarda chilensis* undergoes a seasonal reproductive cycle typical of temperate zone fishes, as spawning occurs during half of the year with no reproductive activity in the other half. This type of cycle is timed so that larvae appear when food is abundant. It differs from the prolonged spawning cycles typical of tropical and subtropical species (Nikolsky 1963) in which there is no clear seasonal abundance in the plankton on which larvae feed.

Previous work in Chile (Barrett 1971, Serra et al. 1980) based on analyses of gonosomatic indices indicated that spawning begins in September and ends before April. Our work histologically confirms their observations. Barrett (1971) found that female *Sarda chilensis* of approximately 51 cm (fork length) were mature. Our smallest mature female (410 mm SL) had a total length of 485 mm, making it somewhat smaller than Barrett's (1971) estimate.

Klawe (1961) summarized the dates of *Sarda chilensis* spawning observations from other areas of the world. In all cases, spawning occurred during summer. The only exception came from Dakar, Senegal, where spawning was recorded during February–March.

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