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Reproduction of Three Dominant *Lutjanus* Species of the Great Barrier Reef Inter-Reef Fishery

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Abstract

Spawning activity of *Lutjanus sebae*, *L. malabaricus* and *L. erythropterus* occurs during the spring and summer months in the Great Barrier Reef waters of Australia. The duration of the spawning period for the three species was 7, 5 and 8 months, respectively. There was no apparent relationship between spawning activity and lunar cycle. The fork lengths at 50% maturity of females of the three species were estimated as 54.2, 57.6 and 48.6 cm, respectively.

Introduction

The Great Barrier Reef (GBR) demersal fishery is a diverse multispecies fishery which varies in its methods of operation and species composition throughout 14° of latitude adjacent to the Queensland east coast (McPherson 1989). One of the component fisheries is the relatively deepwater (25-100 m) commercial and recreational line fishery conducted during the night in the inter-reef areas off north Queensland.

Three large species of lutjanids dominate this fishery, the red emperor (*Lutjanus sebae*), scarlet sea perch (*L. malabaricus*) and saddletail sea perch (*L. erythropterus*). All are locally referred to as 'redfish' (McPherson 1989). Commercial landings of 'redfish' from the GBR are about 50 t·year^{-1} (Queensland Fish Management Authority catch and effort database). Recreational landings of reef fish on the GBR are considered to substantially exceed those of commercial fishers (Hundloe 1985).

The reproductive biology of lutjanids has been reviewed by Grimes (1987). The seasonality of reproductive activity and the size at maturity of lutjanids were considered to vary according to whether the population was from a continental or insular reef habitat.

Most assessments of reproductive maturity or seasonality of tropical species have been conducted by macroscopic or gonad index assessments. However these assessments lack the precision of histological reproductive assessments (Hunter and Macewicz 1985). This paper primarily used histological assessment to identify the seasonality of spawning activity and size at maturity of females for the dominant *Lutjanus* species on the GBR.

Materials and Methods

Sampling was conducted in northern GBR waters between latitudes 15° and 18° (Fig. 1). Specimens of *L. sebae*, *L. malabaricus* and *L. erythropterus*, usually >35 cm in fork length (FL), were obtained from handline catches of research, commercial and recreational vessels between 1981 and 1983. Mixed schools of the three species were fished around low relief coral and rubble substrate from reef edge to inter-reef waters 20-160 m deep. Additional samples from recreational catches were examined for state of reproductive development in 1989-90. Juveniles <35 cm were sampled during 1981-83 from commercial shrimp trawl catches from inshore waters <20 m.

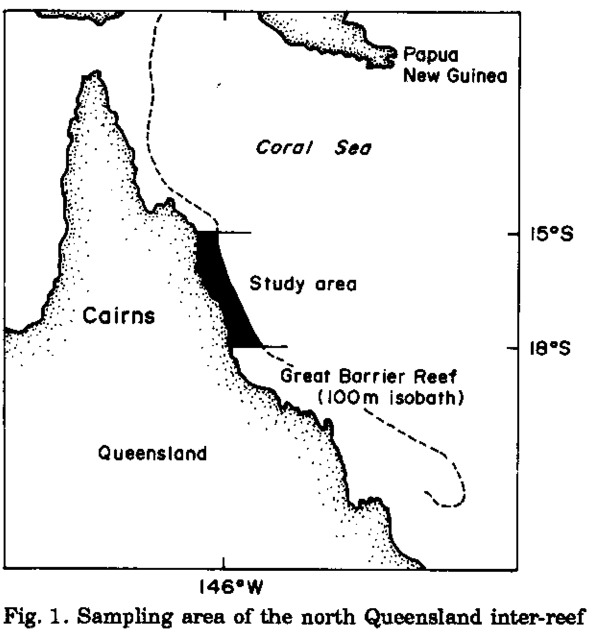

Fig. 1. Sampling area of the north Queensland inter-reef fishery.

Whole fish were obtained from research vessel catches and filleted frames from commercial and recreational catches. Fish were measured to the nearest 0.5 cm FL and whole fish weighed to the nearest 0.025 kg on laboratory scales at the Northern Fisheries Centre in Cairns or to the nearest 0.1 kg on spring scales at sea. The relationship between total weight (TWt) and FL was examined as log transformed functional regressions (Kendall and Stuart 1973).

Gonads were weighed to the nearest 0.1 g on laboratory scales or 1.0 g in the field, and preserved in Bouins solution or neutral buffered formalin. Gonads sampled during 1981-83 were embedded in paraffin, sectioned at 6-10 μm, and stained with hematoxylin and eosin. Gonads examined macroscopically were classified using the macroscopic-histological categories of Schaefer (1987). Ovaries were classified as being sexually mature when vitellogenic, hydrated or atretic oocytes were histologically apparent, or when categorized macroscopically as mature or spent. The logistic curve relationships between FL and the probability of individual ovaries being mature was estimated using the logit model (NAG 1985).

Mean monthly gonadosomatic indices (GSIs) were calculated as the ratio of ovary or testis weight to total weight multiplied by 10. Estimates of total weight were calculated from the total weight: FL relationships derived from 'redfish' in Table 1. Gonads less than 1.0 g were excluded from GSI calculations. GSIs, including those for male *L. sebae*, were corrected for the effect of fish length as

Table 1. Functional regression parameters for the total weight-fork length relationships of the 'redfish' species in the form ln(TWt) = a + b · ln(FL). Asymmetric 95% confidence intervals are given for b.

Species	n	a	b	(95% CI)
		Regression parameters		
L. sebae	459	-11.18	3.10	(3.09 -3.11)
L. malabaricus	173	-10.50	2.83	(2.79 -2.87)
L. erythropterus	255	-10.62	2.87	(2.80 -2.95)

recommended by Hunter and Macewicz (1985). Mean monthly GSIs (transformed to log (GSI)) for each species and sex were adjusted to the mean sample FL by ANCOVA.

Spawning activity of 'redfish' ovaries was assessed as either imminent (that is, within 12 hours), indicated by the presence of hydrated oocytes (Hunter and Macewicz 1985) from macroscopic and histological examination, or recent (that is, within 24 hours), indicated by the presence of postovulatory follicles (Hunter and Macewicz 1985; Hunter et al. 1986) from histological examination. The spawning fraction was estimated as the ratio of ovaries with postovulatory follicles to the number of mature ovaries (Hunter and Macewicz 1985).

Results

The total numbers of *L. sebae*, *L. malabaricus* and *L. erythropterus* of known sex examined from handline catches in 1981-83 were 526, 641 and 459, respectively; and in 1989-90 were 73, 98 and 103, respectively. Trawl catches provided sample sizes of 145, 331 and 47 fish in 1981-83 for the above species, respectively. The size compositions of 'redfish' sampled by handline and trawl during 1981-83 and 1989-90 are shown in Fig. 2.

Length and Weight Relationships

The total weight (TWt): FL regressions for males and females of the three species were not significantly different. The parameters of the regressions for combined sexes and for the three species in the form ln(TWt) = a + b ln(FL), are given in Table 1.

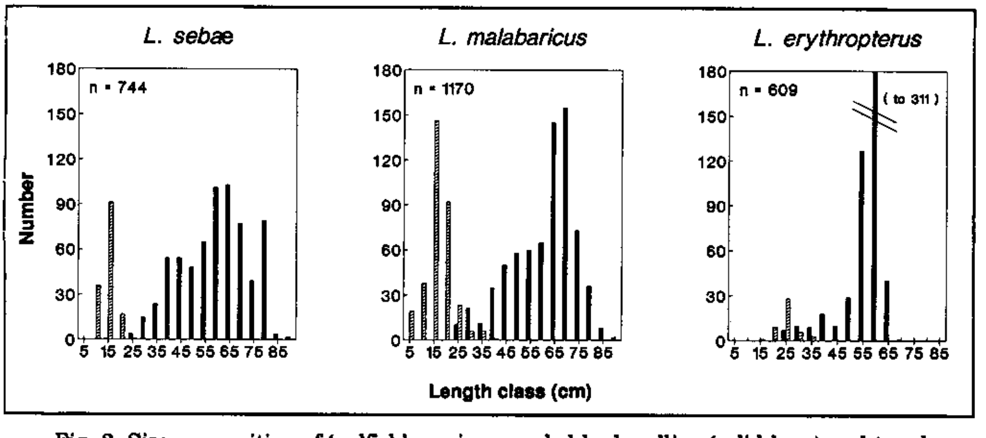

Fig. 2. Size composition of 'redfish' species sampled by handline (solid bars) and trawl (hatched bars).

Gonadosomatic Indices (GSIs) and Spawning Activity

A significant positive relationship ($P<0.01$) was evident from ANCOVA between GSI and FL for both sexes of the 'redfish' species, with the exception of male *L. sebae*. Smaller fish had lower GSIs. Differences between monthly GSI means of ovaries and testes were highly significant ($P<0.01$) for all 'redfish' species. The untransformed but length-corrected ovary and testis GSIs are given in Fig. 3.

Ovary GSIs for *L. sebae* and *L. malabaricus* reached a peak during the late spring and early summer months of October through December, declined during late summer to autumn and reached a minimum during the winter months. GSIs of *L. erythropterus* ovaries reached a similar late spring and early summer peak, although they appeared to remain higher in late summer than the other two species.

Seasonal variation in testis GSIs was readily apparent for all 'redfish' species (Fig. 3). Testis GSIs were higher in spring and early summer with peaks in monthly means corresponding to peaks of ovary GSIs.

The months in which spawning activity was detected in ovaries are also indicated in Fig. 3. Spawning activity extended for 8 months for *L. erythropterus*, 7 months for *L. sebae* and 5 months for *L. malabaricus*. Spawning activity could not be readily determined from male 'redfish' as spermatozoa were histologically identified from all 'redfish' males >20 cm in all months of the year.

Length corrected ovary GSIs did not appear to be a reliable indicator of the duration of spawning activity. For *L. sebae* and *L. malabaricus*, the monthly GSIs in late summer when spawning activity was detected, were less than those of late winter and early spring prior to spawning activity commencing. However, ovary GSIs did appear to indicate peaks in spawning activity. The spawning fraction of ovaries suggested that spawning peaks occurred for *L. sebae* and *L. malabaricus* during November-January and for *L. erythropterus* during October-November (Table 2).

The depth ranges at which females in an imminent spawning or recent spawning condition occur are given in Fig. 4. Evidence of spawning activity occurred throughout the monthly sampled depth range, extending to 160, 70 and 70 m for *L. sebae, L. malabaricus* and *L. erythropterus*, respectively.

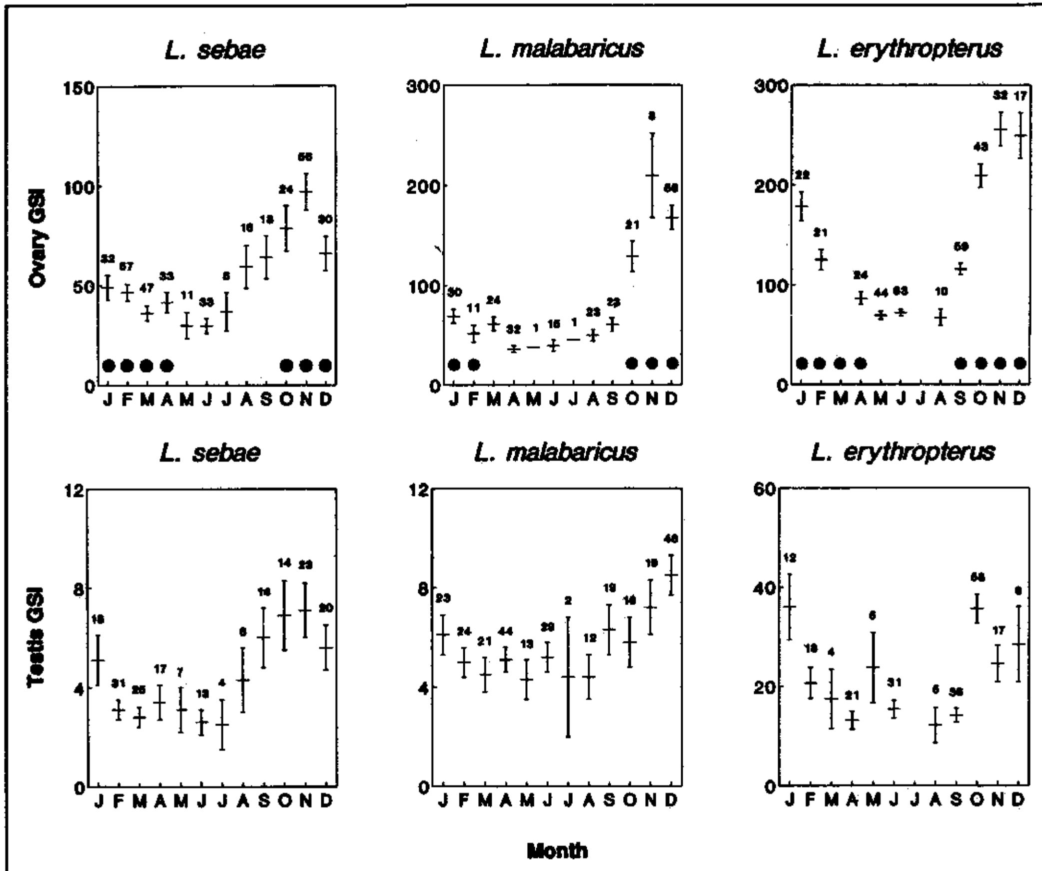

Fig. 3. Ovary and testis GSIs of 'redfish' species (means and standard errors indicated, numbers indicate sample sizes). Months of spawning activity indicated by solid circles.

Table 2. Spawning fraction of mature ovaries of 'redfish' from histological analysis (sample size in parentheses). Months in which spawning activity was identified only by macroscropic assessment are indicated by asterisk.

Species	Jan	Feb	Mar	Apr	Sep	Oct	Nov	Dec
			Month of mature sample					
L. sebae	0.29 (14)	0.07 (27)	*	*		0.12 (12)	0.17 (24)	0.80 (22)
L. malabaricus	0.23 (30)	0.06 (16)				0.17 (23)	0.38 (8)	0.30 (53)
L. erythropterus	0.21 (14)	0.14 (7)	*	0.20 (5)	0.23 (31)	0.51 (43)	0.57 (7)	0.25 (12)

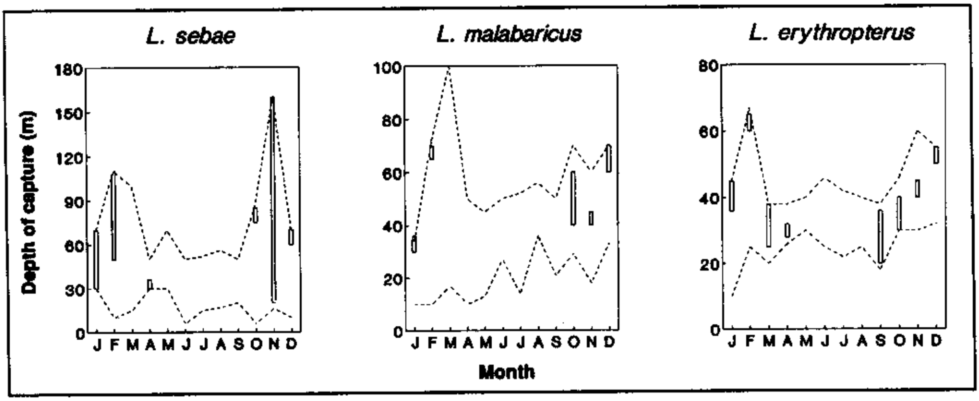

Fig. 4. Depth range of spawning 'redfish'. Dotted lines join maximum and minimum sampling depths for each month.

Days on which spawning activity was recorded were distributed throughout the full lunar cycle. Spawning events occurred over both spring and neap tide periods (Fig. 5). Recent postovulatory follicles comparable to those estimated by Hunter et al. (1986) to be 0-2 hours old for skipjack tuna (*Katsuwonus pelamis*) were observed in ovaries sampled between dusk and midnight.

Length at Sexual Maturity of Females

The sex and the level of reproductive development of individual fish was determined primarily through histological assessment for 73% of fish sampled. No evidence of hermaphroditism was detected in the 2,508 gonads of these fish.

The percentages of mature fish within 5-cm length classes during the months of spawning activity for each species are shown

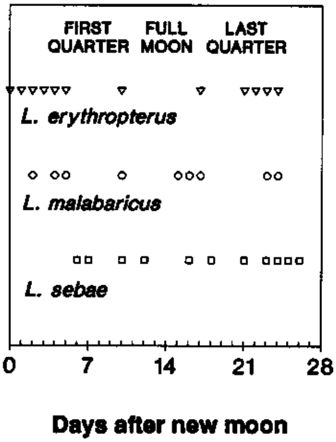

Fig. 5. Spawning activity of 'redfish' species by day of moon phase.

in Fig. 6. The logistic curve relationships between FL and the probability of individual ovaries being mature are also shown. The lengths at which 50% of ovaries were mature (l_m) using the logit model, and the smallest observed length at first maturity during the months of spawning activity are given in Table 3. The l_m for *L. sebae*, *L. malabaricus* and *L. erythropterus* was estimated as 54.8, 57.6 and 48.6 cm, respectively. The minimum lengths observed for mature individuals of these species were 48.5, 54.0 and 50 cm, respectively.

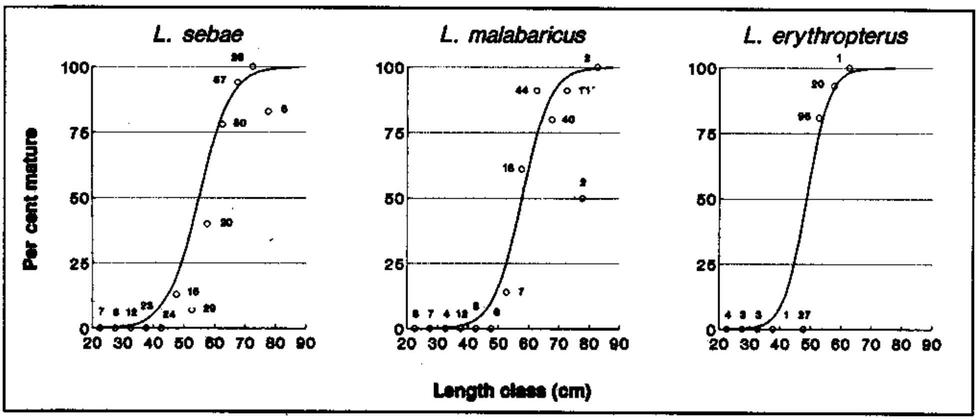

Fig. 6. Percentage of mature females with 5-cm length classes and logistic curve relationships between length and the probability of individual ovaries being mature (numbers indicate sample sizes).

Table 3. Length at 50% maturity (l_m) and minimum observed length at first maturity for 'redfish' species.

Species	l_m FL (cm)	(s.e.)	Minimum mature size FL (cm)	n
L. sebae	54.8	(0.8)	48.5	283
L. malabaricus	57.6	(1.0)	54.0	209
L. erythropterus	48.5	(1.7)	50.0	215

Discussion

The reproductive data indicate that spawning activity occurs during the spring and summer for all three 'redfish' species. The spawning period of *L. erythropterus* was the most prolonged. Peaks in spawning activity were inferred from the pronounced peak in ovary GSIs of the 'redfish' species, and supported by shorter duration periods of higher spawning fractions of mature ovaries. These results confirm the general observations of other authors (reviewed by Grimes 1987) that continental lutjanids exhibit extended summer spawning.

Tarbit (1980) proposed that the main spawning period of *L. sebae* extended to 5 months between December and April in the Seychelles (4°S latitude). Lablache and Carrara (1988) suggested two spawning peaks over an 8-month period for *L. sebae* from the Seychelles in September-October and February-April.

Brouard and Grandperrin (1985) found that ovary GSIs of *L. malabaricus* were at a peak during the spring and summer months. Spawning activity as evident from hydrated and spent macroscopic stages was also considered to occur during the winter months. However, as spent ovaries are only indicative of mature, not postovulatory ovaries (Hunter and Macewicz 1985), the period of spawning activity could well have been overestimated.

The presence of postovulatory follicles approximately two hours old from fish sampled during the late evening suggested that spawning could occur between dusk and midnight. Grimes (1987) considered that spawning of lutjanids occurred at night and also suggested that spawning sometimes coincided with spring tides at new or full moon. There was no indication from the present data that spawning of 'redfish' coincided with a lunar/tidal cycle in GBR waters.

The l_m of 54.8 cm and observed minimum length at maturity of 48.5 cm estimated for *L. sebae* females corresponded with the length range of 50-60 cm for attainment of maturity in the Seychelles (Tarbit 1980), and 49.0 cm in east African waters (Talbot 1960).

The l_m of 57.6 cm and observed minimum length at maturity of 54.0 cm estimated for *L. malabaricus* from GBR waters are substantially greater than the l_m of 35 cm in Vanuatu waters (Brouard and Grandperrin 1985). These observations differ from the conclusion of Grimes (1987) that lutjanids in continental and shallow habitats mature at smaller lengths than those species and populations from insular and deep habitats. No comparative data are available for *L. erythropterus*.

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