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Age and Growth of the Narrow-barred Spanish Mackerel (*Scomberomorus commerson* Lacépède, 1800) in North-eastern Queensland Waters

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Abstract

Whole otoliths were used to age *Scomberomorus commerson* in tropical Australian waters. Age estimates were validated by marginal-increment analysis of the first three otolith annuli. Confirmation of age estimates was provided by otolith daily growth increments and tag returns of known age. Differential growth in length, weight and longevity was evident between the sexes. The oldest male was 10 years old (127 cm FL, 19·0 kg). The oldest female was 14 years old (155 cm FL, 35 kg). The von Bertalanffy growth parameters L_∞ and K were 127·5 cm and 0·25 for males and 155·0 cm and 0·17 for females.

Introduction

The narrow-barred spanish mackerel, *Scomberomorus commerson* (Lacépède, 1800), is an epipelagic continental-shelf species rarely found in waters deeper than 100 m. The species is distributed around the northern Australian coastline south to approximately 30°S latitude on the eastern and western coasts. Its habitat extends from the edge of the continental slope inshore to shallow coastal waters often of low salinity and with high turbidity (Munro 1943).

Total commercial and recreational annual landings throughout the Australian east-coast distribution of the species were estimated in 1988 to be approximately 2500 t (McPherson, unpublished). The gear used in the commercial and recreational fisheries is described by McPherson (1987, 1988).

S. commerson is considered to be migratory throughout its Indo-Pacific range (Kishinouye 1923) and, more specifically, within its Australian distribution (Munro 1943; McPherson 1981). This migratory behaviour leads to progressively northward-moving peaks in seasonal abundance within the Queensland east-coast commercial fishery, culminating in the peak season between September and November in northern Great Barrier Reef waters (Munro 1943; McPherson 1981). Shaklee *et al.* (1990) reported that two genetic stocks of *S. commerson* occur within Queensland waters. Fish to the south-east of Torres Strait form an Australian east-coast stock, whereas fish in Torres Strait and the Gulf of Carpentaria are part of a northern Australian stock that extends from southern Papua New Guinea to the western coast of the continent.

It was the aim of the present study to examine the age and growth rate of east-coast and northern Australian stocks of *S. commerson*.

Materials and Methods

Fork length (FL, in cm), total weight (to the nearest 0·1 kg) and sex were recorded and otoliths sampled at sea from catches by commercial troll-fishing vessels during the period January 1977 to February 1979 from northern-stock fish at Bramble Cay in Torres Strait and east-coast-stock fish from reefs between Lizard Island and Townsville (Fig. 1). Whenever possible, otoliths were samples from

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fish as they were caught. During periods of high catch rates, 25 fish were sampled at random from 'landing/killing boxes' at the conclusion of the fishing period. When these fish were sampled, any fish not processed from the total catch were measured and sexed. Small *S. commerson* individuals less than 45 cm were collected from incidental catches in inshore bait-nets and prawn-trawls in east-coast waters.

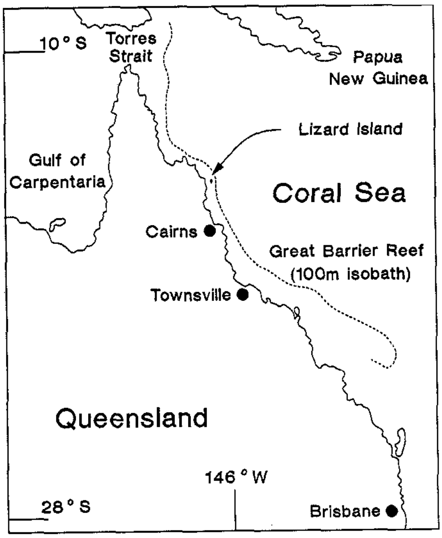

Fig. 1. Queensland coastal waters sampled for *S. commerson*.

The length distributions of 2587 males and females of *S. commerson* sampled from the commercial catch and of a sample of 1634 fish from which otoliths were obtained are given in Fig. 2. The length distribution of the 1429 fish successfully aged in this study is also given. The maximum size of an *S. commerson* male observed in the commercial fishery was 132 cm, and the largest male sampled for age determination and subsequently successfully aged was only slightly less at 127 cm. The largest female fish successfully aged was, at 155 cm, also the largest observed in commercial catches during this study.

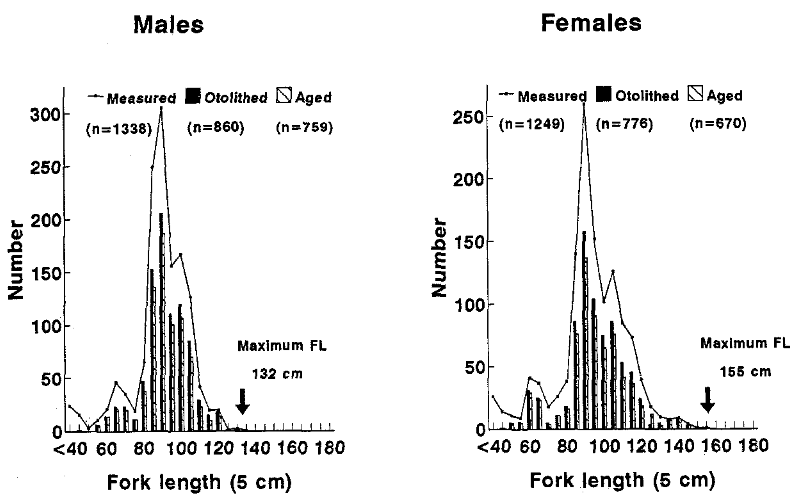

Fig. 2. Length distributions (5-cm intervals) of males and females of *S. commerson* as measured from the commercial east-coast fishery (solid lines), sampled for otoliths (solid bars), and successfully aged (hatched bars).

Otoliths (sagittae) were immersed in aniseed soil and examined three times under reflected light against a black background at a ×10 magnification. Otolith radius and annulus measurements were taken on the concave proximal face from the focus to the posterior margin along an axis approximating the sulcus acousticus on the distal face (Fig. 3).

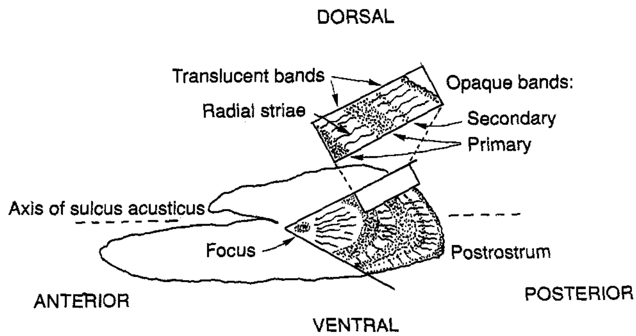

Fig. 3. Schematic diagram of the proximal (internal) surface of an *S. commerson* otolith.

In all, 205 otoliths were rejected for age determination because they were totally opaque (20·3%) and annuli could not be adequately defined or because they were totally translucent (79·7%). Rejections for the latter reason were usually associated with the effects of salt or fresh water on the otoliths during on-deck sampling procedures.

Loubens (1978) noted that otoliths were translucent when sampled, then lost their overall translucency and developed visible growth bands over several days. Laboratory trials indicated that water could permanently maintain translucence in *S. commerson* otoliths, making interpretation of opaque structures difficult. The effect has also been observed in otoliths from coral trout (*Plectropomus leopardus*) and other serranids (McPherson, unpublished data).

Dr E. Brothers of EFS Consultants (3 Sunset West, Ithaca, New York 14850, USA) examined the otoliths from seven specimens (21·6–72·0 cm) of *S. commerson* from the Australian east coast for daily growth increments, using the technique described by Brothers and MacFarland (1981). Otoliths were ground on their ventral surface to nearly half of their depth, polished, cleaned, and viewed in oil.

Growth estimates for *S. commerson* were obtained from a tag-and-release programme carried out on east-coast fish between Lizard Island and southern Queensland (latitude 28°S) and on northern-stock fish between Torres Strait and the Gulf of Carpentaria (Fig. 1). Capture techniques were adapted from commercial trolling methods using heavy hand-lines with baited hooks or lures, and from sportfishing rod-and-reel methods. Tagging activities were conducted in association with, or from, chartered commercial vessels. Fish were landed into a padded cradle capable of restraining the sizes of *S. commerson* (1·5–30·0 kg) normally encountered in the northern Queensland commercial fishery. The capture method, fork length, and condition of fish at release were recorded for each fish.

In all, 1871 *S. commerson* individuals were tagged and released in east-coast waters, most within the period from August to November in 1979 and 1980. Fish were recaptured by commercial and recreational fishers. Tagging of fish from the northern stock was conducted between August and October 1983, when 610 individuals were measured and released. The length distributions of fish from both tagging periods are given in Fig. 4. The maximum size recorded from tagging operations was 178 cm. However, this fish was considered to be exceptionally large by the commercial fishermen engaged in the fishery at that time.

Estimates of parameters for the von Bertalanffy growth curve were obtained with a nonlinear least-squares algorithm (Saila *et al.* 1988) from otolith length-at-age data.

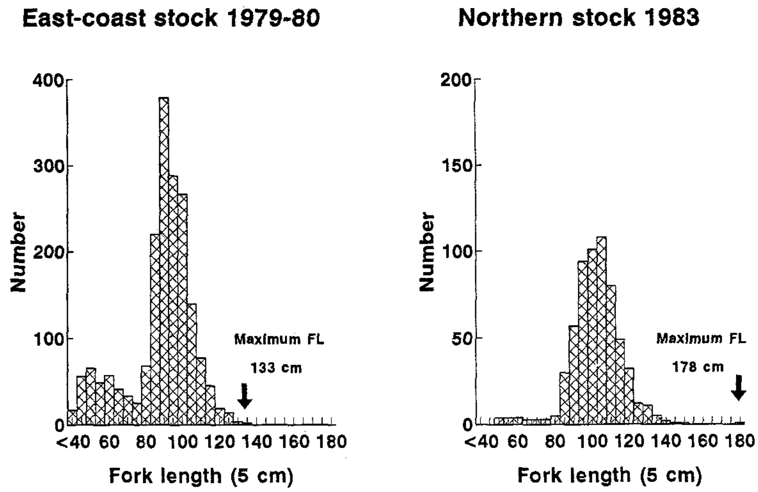

Fig. 4. Length distributions (5-cm intervals) of tagged and released *S. commerson* from east-coast and northern stocks.

Results

Otolith Description and Reading

Translucent and opaque bands were apparent in *S. commerson* otoliths. The translucent bands were characterized by light-refracting radial striae on the surface of the otolith (Fig. 3). Radial striae on the surface of otoliths of New Caledonian reef fish are described by Loubens (1978). These striae (the structural aragonite needles of Panella 1974) are prominent on the distal otolith surface throughout the first to third translucent zones, thereafter being progressively restricted to the raised ridge that develops from near the focus to the postrostrum on the distal face.

Primary and secondary opaque zones were recognized in the otoliths of *S. commerson*. Opaque zones appeared as milky or cloudy under reflected light. Higher-power magnification of most opaque zones suggested that they were in turn composed of many smaller opaque bands that may have some periodic cycle. Loubens (1978) observed this type of otolith growth pattern for New Caledonian reef fish. Primary zones were broader than secondary zones and were distinguished from the latter in that they interrupted the outward radiation of the striae from the focus (Fig. 3).

The formation of primary opaque bands was the most abrupt and consistently detectable change observed in the otoliths of *S. commerson* with the limited-numerical-aperture microscope used in this study, and this was interpreted as the annulus (Wilson *et al.* 1983) for age interpretation. The formation of an opaque band was the annulus of Beaumariage (1973) and Johnson *et al.* (1983) for *S. cavalla*.

Otoliths rejected on the first or second reading were excluded from further examination. The first, second and third readings rejected 12·3, 0·1 and 0·1% of otoliths for age determination, respectively. The index of average percentage of error (Beamish and Fournier 1981) for successfully aged otoliths was 0·9% for all three readings.

June, July and August appeared to be the peak months for formation of primary opaque bands on otolith margins of the first three year classes (Fig. 5). The percentage of opaque margins decreased markedly after September. The formation of primary opaque bands over such a short time validated their use for age-determination purposes.

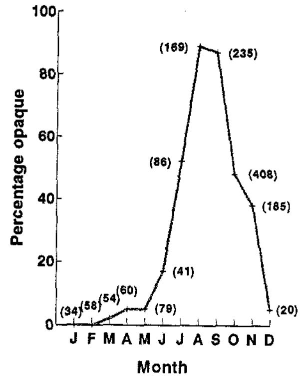

Fig. 5. Percentage of opaque otolith margins for *S. commerson* age groups 1, 2 and 3 (numbers in parentheses are sample sizes).

The formation of annuli was validated for 1-, 2- and 3-year-old east-coast fish by examination of otolith marginal increments (Fig. 6). Marginal increments generally reached a maximum for the three year classes in late autumn (May) and were at a minimum between late winter (August) and early spring (October). Analysis of variance (ANOVA) indicated highly significant differences ($P<0 \cdot 01$) between monthly means for all three year classes. October and November were identified as the peak spawning months for *S. commerson* in Barrier Reef waters between Townsville and Cairns (Munro 1942; McPherson 1981). The appearance of a translucent band was coincident with the maturation of gonads and spawning.

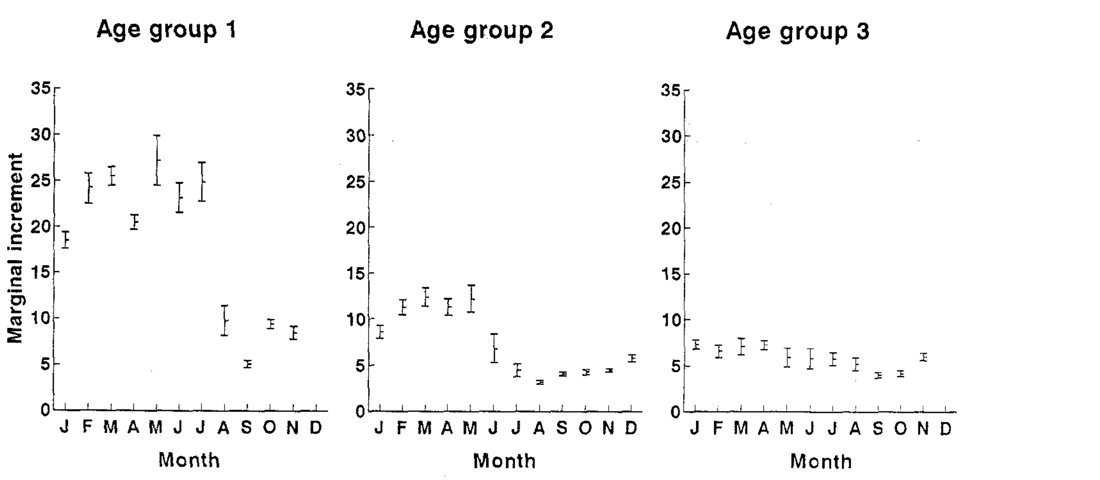

Fig. 6. Mean otolith marginal increments (in ocular-micrometer units) for *S. commerson* age groups 1, 2 and 3 (bars indicate standard errors).

Otoliths from mature females of *S. commerson* often displayed a narrow secondary opaque band between January and May. When observed with the primary opaque bands, these secondary bands appeared to be comparable to the doublets described by Johnson (1983) for *Euthynnus alletteratus*.

A linear regression model of the relationship between fish length (L, cm) and otolith radius (R, in ocular-micrometer units) for east-coast and Torres Strait fish showed that sex had no influence on the relationship in the form $R=a+bL$. A common slope of $0 \cdot 84$ (standard error $0 \cdot 01$) was adequate for both sexes and both areas, although there were significant differences ($P<0 \cdot 01$) between intercepts for the east-coast and Torres Strait fish of $17 \cdot 56$ (standard error $0 \cdot 96$) and $19 \cdot 86$ (standard error $1 \cdot 08$), respectively.

Because a linear fork length–otolith radius relationship ($r^2 = 0 \cdot 85$) was demonstrated, lengths-at-age were determined by the proportional back-calculation method of Gutreuter (1987). Lengths-at-age for males and females were back-calculated to the last annulus to reduce the effects of size selective mortality (Gutreuter 1987) and unequal sample sizes from a highly seasonal fishery (Davis and Kirkwood 1984). Mean back-calculated length-at-age estimates and observed length-at-age data for east-coast males and females are shown in Table 1. Two-way ANOVA demonstrated that there was a significant interaction ($P < 0 \cdot 01$) between length-at-age and sex. Except in age group 1, which is not fully recruited into the commercial fishery, males were smaller than females within corresponding age groups.

Table 1. Mean back-calculated (B) and mean observed (Obs.) lengths-at-age (cm) for east-coast males and females of *S. commerson*

FL, fork length; s.e., standard error; **, differences between male and female mean back-calculated lengths-at-age significant at $P < 0 \cdot 01$

Age class		Males			Females			Significance level
		FL	(s.e.)	*n*	FL	(s.e.)	*n*	
1	B	60·0	(0·4)	118	59·6	(0·5)	110	
	Obs.	72·2	(1·0)		74·0	(1·1)		
2	B	81·6	(0·3)	355	84·0	(0·3)	269	**
	Obs.	85·9	(0·2)		88·2	(0·3)		
3	B	91·0	(0·5)	126	96·0	(0·5)	121	**
	Obs.	94·7	(0·4)		100·6	(0·5)		
4	B	97·5	(0·3)	87	101·0	(0·7)	61	**
	Obs.	100·3	(0·4)		105·0	(0·7)		
5	B	102·0	(0·8)	40	109·2	(1·0)	31	**
	Obs.	104·3	(0·9)		112·9	(0·9)		
6	B	107·8	(1·3)	13	113·8	(1·4)	13	**
	Obs.	110·8	(1·5)		116·1	(1·4)		
7	B	112·7	(1·5)	6	127·6	(2·1)	13	**
	Obs.	113·5	(1·8)		123·5	(2·0)		
8	B	113·7	(2·9)	3	127·6	(2·1)	6	**
	Obs.	116·7	(0·9)		129·2	(3·7)		
9	B	118·0		1	128·5	(2·9)	4	
	Obs.	118·4			133·5	(4·2)		
10	B	124·8	(0·6)	2	136·5		1	
	Obs.	126·0	(1·0)		139·0			
11	B	–			135·6	(2·1)	6	
	Obs.	–			137·3	(2·2)		
13	B	–			145·6	(3·6)	2	
	Obs.	–			147·5	(4·5)		
14	B	–			147·6	(3·6)	2	
	Obs.	–			148·5	(6·5)		

The oldest male captured and successfully aged from the east-coast stock was 10 years old, measured 127 cm FL, and weighed 19·0 kg. The largest and oldest female successfully aged was 14 years old, measured 155 cm, and weighed 35·0 kg.

Observed lengths-at-age for fish from the east-coast and northern (Torres Strait) stocks suggested that Torres Strait fish attained larger lengths-at-age than did east-coast fish (Table 2). Three-way ANOVA of observed lengths of four age groups of males and females of *S. commerson* taken in Torres Strait during the second week of October 1978 and in east-coast waters during the two weeks on either side of this time showed significant ($P<0\cdot01$) interactions between localities, sex and length-at-age. Fish in Torres Strait were larger than east-coast fish sampled at the same time.

Table 2. Mean observed lengths-at-age (cm) for males and females of *S. commerson* from east-coast and northern stocks (October 1978)

Age group	East-coast stock						Northern stock					
	Males			Females			Males			Females		
	Mean	(s.e.)	*n*	Mean	(s.e.)	*n*	Mean	(s.e.)	*n*	Mean	(s.e.)	*n*
2	84·5	(0·5)	59	89·3	(0·6)	41	87·8	(0·5)	66	89·7	(0·7)	36
3	95·2	(2·1)	6	94·0	(–)	1	95·4	(1·0)	27	101·3	(0·9)	33
4	96·0	(3·4)	2	107·5	(1·4)	12	107·5	(1·4)	12	107·5	(1·4)	12
5	104·0	(–)	1	113·0	(3·1)	3	109·0	(3·8)	2	116·3	(2·2)	6

Ageing from Daily Otolith Increments

Counts of presumed daily growth increments in *S. commerson* otoliths are plotted against FL in Fig. 7. The smallest fish examined (21·6 cm) displayed 74 daily growth increments. There were two samples with counts of 380 daily growth increments and assumed to be approximately 1 year of age, from a male of 62·0 cm and an unsexed fish of 57·0 cm. The first opaque band was present on the margin of the 57·0 cm fish and had been completed on the 62·0 cm fish.

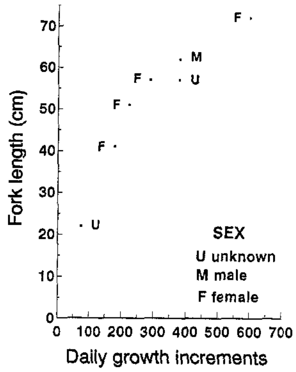

Fig. 7. Daily growth increments for *S. commerson*.

The results of the daily-increment ageing by Brothers suggested an inflection in the early growth rate of juveniles of *S. commerson*. Although the sample was limited ($n=7$), Fig. 7 indicates a decline from an initial rapid growth rate between 250 and 400 days. To attain a fork length of 60 cm at age 1 year, an average daily growth increment of $1\cdot64$ mm day^{-1} would be required. The growth rate up to the time of the inflection in growth exceeded $2\cdot0$ mm day^{-1}.

The date of spawning for these fish was back-calculated from the number of growth increments and the date of capture. On the assumption that all fish were spawned in the same season, the back-calculations indicated that spawning occurred between October and January inclusive (Fig. 8), which agrees with the spawning season reported by Munro (1942) and McPherson (1981).

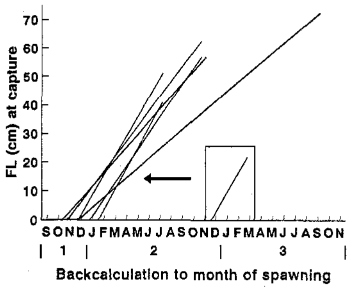

Fig. 8. Back-calculation of daily growth increments and fork length to month of spawning for *S. commerson*. In the box, a single short-term growth increment is offset by 12 months.

Growth Increments from the Tagging Programme

Recapture FL measurements provided by nonresearch staff occasionally resulted in negative growth increments over periods of less than 2 months. This result was not unexpected, and fish at liberty for less than 4 months were not considered for growth-rate determination.

Details of 32 fish recaptured from east-coast waters are given in Table 3. The largest growth increment was 27 cm, and the longest time at liberty was 5·98 years. The length range of these recaptured fish at tagging was 55–120 cm. Ten male and five female fish were recaptured, measured, and successfully aged. No length or sex details were reported for the single recapture from northern-stock waters.

Growth Curves

von Bertalanffy growth curves were fitted to the mean back-calculated lengths-at-age given in Table 1 (where $n \geqslant 2$). Least-squares estimates of the von Bertalanffy growth-curve

Table 3. Details of fork length (cm) at release (FL_1) and recapture (FL_2), time at liberty (greater than 4 months), and otolith age for tagged males and females of *S. commerson* from east-coast waters

Males				Females			
FL_1	FL_2	Time at liberty (years)	Otolith age (years)	FL_1	FL_2	Time at liberty (years)	Otolith age (years)
96	121	5·98	10	95	103	1·92	–
110	117	1·85	–	85	98	1·02	–
88	102	3·29	–	76	88	1·00	–
86	95	1·74	3	99	103	0·94	4
84	93	1·49	3	90	100	2·10	–
81	95	1·74	4	86	98	1·55	–
96	102	0·76	–	96	106	1·38	–
80	91	0·92	3	95	106	0·96	4
92	97	0·72	–	84	95	1·00	–
78	87	0·43	–	55	97	2·00	–
55	91	1·62	–	120	126	0·98	8
56	83	1·13	2	88	92	0·37	2
86	92	0·95	3	80	93	0·92	3
57	80	0·82	2	67	85	1·18	–
82	91	0·78	3	91	102	0·99	–
90	98	1·24	4				
88	93	1·13	–				

parameters and the 95% confidence intervals are given in Table 4. The growth model fits well the data obtained from the commercial fishery, with regression coefficients of $r^2 = 0 \cdot 98$ for males and females.

Table 4. Estimates, standard errors and 95% confidence intervals for the parameters of the von Bertalanffy growth curve fitted to back-calculated length-at-age (cm) data for east-coast males and females of *S. commerson*

Parameter	Males	Females
L_∞	127·5	155·0
(s.e.)	(5·7)	(5·8)
(95% C.I.)	(114, 141)	(142, 168)
K	0·25	0·17
(s.e.)	(0·05)	(0·03)
(95% C.I.)	(0·07, 0·43)	(0·10, 0·24)
t_0	−1·72	−2·22
(s.e.)	(0·54)	(0·50)
(95% C.I.)	(−3·0, −0·5)	(−3·3, −1·1)
r^2	0·98	0·98

There was close agreement between the mean observed length-at-age data, the von Bertalanffy curve, and the growth increments from captured fish of known age (from otoliths) for male and female fish (Figs 9 and 10, respectively). The growth increments from tagging commence in both figures at the known FL and age at recapture and extend back to the FL at release. The horizontal component of each increment indicates the time at liberty in years.

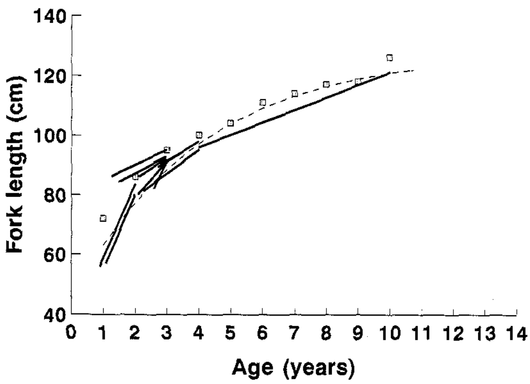

Fig. 9. Growth increments from tagging (solid lines) for known-age males of *S. commerson*, compared with the von Bertalanffy growth curve (dashed line) and mean observed length-at-age data (squares).

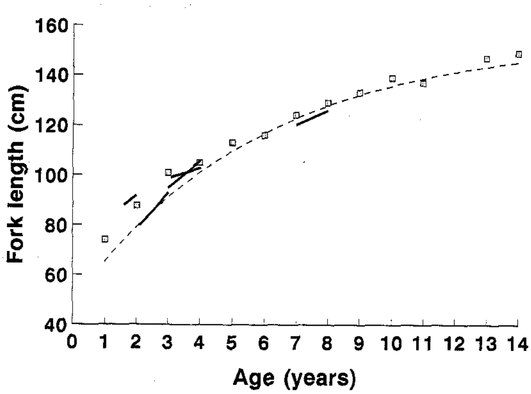

Fig. 10. Growth increments from tagging (solid lines) for known-age females of *S. commerson*, compared with the von Bertalanffy growth curve (dashed line) and mean observed length-at-age data (squares).

Length–Weight Relationships

Fish fork length–total weight (W) relationships for males and females of *S. commerson* from east-coast and northern stocks were fitted by least squares to a $\log_e$ linear model in the form $\ln W = a + b \times \ln L$. The values of the parameters a and b, and standard errors for b, are shown in Table 5. The effect of location and sex were significant (F-tests, $P < 0 \cdot 05$). For a given length, fish from the northern stock were heavier than those from the east-coast stock and females were heavier than males.

Table 5. Estimates of the parameters of the $\log_e$ linear fork length (L, cm)—total weight (W, kg) regression $\ln W = a + b \times \ln L$, expressed in the form $W = a \times L^b$, for males (M) and females (F) of *S. commerson* from the east-coast (EC) and northern (N) stocks

Sex	Stock	Regression parameters a	b (s.e.)	Sample range Fork length (cm)	Weight (kg)	Sample size
M	EC	$1 \cdot 32 \times 10^{-5}$	2·89 (0·02)	42–127	0·9–17·2	658
F	EC	$0 \cdot 99 \times 10^{-5}$	2·95 (0·02)	47–155	0·9–35·0	579
M	N	$0 \cdot 79 \times 10^{-5}$	3·00 (0·03)	63–122	2·3–15·1	337
F	N	$0 \cdot 59 \times 10^{-5}$	3·07 (0·03)	60–145	1·8–29·5	462

Discussion

Whole otoliths were used to age *S. commerson* in tropical Australian waters. The precision of otolith readings from this study (index of average percentage of error = 0·9%) compared favourably with the results obtained by other authors for scombrids. An index of 6·3% was obtained for Atlantic bluefin tuna (*Thunnus thynnus*; Prince *et al.* 1985), and 10·3% was obtained for little tuna (*Euthynnus alletteratus*; Cayré and Diouf 1983).

The age of the first year group was confirmed by daily growth increments (assuming a constant relationship between increments and days). The back-calculation of daily growth increments to time of spawning coincides with the months of the spawning season reported by Munro (1942) and McPherson (1981), peaking in October and November and extending to December. Tagged and recaptured fish aged by otoliths provided additional confirmation of the validity of the whole otolith technique to predict growth for males up to 10 years of age and females up to 8 years of age.

The first three annuli were validated as annual marks by marginal-increment analysis. These results differ from those of Deveraj (1981), who determined that two hyaline zones were formed each year in *S. commerson* from Indian waters.

Differential growth in length, weight and longevity was observed for *S. commerson* in Queensland waters. Differences in growth between sexes has also been observed in other *Scomberomorus* species. Johnson *et al.* (1983) demonstrated unequal growth and longevity between sexes for *S. cavalla* from south-eastern United States waters and showed that females grew larger than males at all ages. Fable *et al.* (1987) demonstrated that *S. maculatus* females grew significantly faster than did males from the same area.

Differences in length-at-age and in the length–weight relationship were detected between east-coast and northern stocks of *S. commerson*. These differences support the assertions of Anon. (1978) and Shaklee *et al.* (1990) that two stocks occur in north-eastern Australian waters.

The back-calculated lengths at the first year for males and females of *S. commerson* in Queensland waters of 60·3 and 59·6 cm, respectively, and the length-at-age estimates from daily increments suggest an extremely rapid growth for the species in the first year. The otolith-microstructure observations of Brothers and Mathews (1987) suggested that *S. commerson* in Kuwaiti waters grew to between 44·5 and 52·0 cm in the first 5 months. A rapid growth phase also occurs in Omani waters, with fish achieving 50–60 cm in the first 6 months and about 80 cm in the first year (R. G. Dudley and E. Brothers, personal communication; Anon. 1988). Length at age 1·04 years in Saudi Arabian waters was established for modal progression analysis to be 74·3 cm (Kedidi and Abushusha 1987).

All *S. commerson* 1-year-olds aged by the whole-otolith technique were taken by commercial hook-and-line gear. Trent *et al.* (1983) indicated that gear selectivity was operating for commercial hook-and-line gear (directly comparable to that used in the Queensland fishery) against small *S. cavalla*. Therefore, it is possible that the average size of *S. commerson* 1-year-olds was overestimated.

The von Bertalanffy growth equation may not be appropriate to describe the early growth of *S. commerson*. The results of the daily-increment ageing of Brothers suggested an inflection in the early growth rate of juveniles sometime between 250 and 400 days. However, the length range over which the von Bertalanffy growth curve does not predict growth well is below the size at full recruitment to the commercial hook-and-line fishery.

Growth models other than that of von Bertalanffy may be more appropriate for a number of scombrid fishes during early growth stages. Kearney (1978) suggested the possibility of linear growth increments occurring during the first 2 years of growth of skipjack tuna (*Katsuwonus pelamis*). Uchiyama and Struhsaker (1981), Wild (1986) and Yamanaka (1988) identified inflection points in the early growth stages of skipjack and yellowfin (*Thunnus albacares*). More recently, R. G. Dudley and E. Brothers (personal communication) have suggested an inflection in the early growth of *S. commerson* in Omani waters.

Landings of individual fish in excess of the L_∞ value of 155 cm FL (the average maximum size for very old fish in the exploited population, corresponding to an estimated weight of 35 kg) estimated for females from the commercial fishery were reported from the fishery prior to, during and following the period of this study. The author tagged and released a 178 cm fish during tagging operations at Bramble Cay, the northernmost reef on the Great Barrier Reef and adjacent to the continental slope. Marshall (1964) noted a 59·0 kg fish from the Townsville region. The largest *S. commerson* reported from Queensland waters was 240 cm and 70 kg (verified by the author from the purchase docket and a photograph). The FL of the latter fish fell well outside the L_∞ upper 95% confidence limit of 168 cm. This fish was captured north of Lizard Island along the outer Great Barrier Reef (Fig. 1) in deep continental-slope waters during the early 1960s.

Despite the occasional catches of large fish in excess of 155 cm FL and approximately 35 kg, most landings of fish above this length or weight are not only rare but are taken from outside the boundaries of the commercial fishing areas defined by McPherson (1981). Therefore, the von Bertalanffy growth model may be appropriate for the size classes that are fully recruited to the commercial fishery. Josse *et al.* (1979) noted that the von Bertalanffy model may be appropriate to describe skipjack growth provided that the interpretations of the model are made within the limits of the observations.

The von Bertalanffy parameters for *S. commerson* from the eastern Australian coast and other Indo-Pacific areas are given in Table 6. The parameter estimates of Deveraj (1981) are from otoliths and length–frequency samples, whereas the other estimates from outside Australian waters were obtained from length–frequency samples. If differential growth occurs between the sexes in these Indo-Pacific waters, which is likely, then the stock-assessment conclusions based on combined sex data may need to be re-evaluated.

Table 6. Review of the estimated parameters of the von Bertalanffy growth equation for *S. commerson*

Sex	L_∞ (FL, cm)	K (year^{-1})	t_0 (years)	Locality	Reference
Females	155·0	0·17	−2·22	Queensland	Present study
Males	127·5	0·25	−1·72	Queensland	Present study
Combined	187·1[A]	0·18	−0·16	India	Deveraj (1981)
Combined	110·0	0·10	–	Thailand	Cheunpan (1986)
Combined	162·0	0·50	−0·12	Saudi Arabia	Kedidi and Abushusha (1987)
Combined	135·7[A]	0·21	–	Djibouti	Bouhlel (1986)
Combined	177·5	0·38	−0·23	India	Thiagarajan (1989)

[A] Total-length-to-fork-length conversions of Thiagarajan (1989).

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B. J. 'Snowy' Whittaker launched my longtime interest in this species. Tony Lewis, Bob Kearney, Lindsay Chapman and David Die helped me to keep that interest.

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