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ASPECTS OF THE POPULATION BIOLOGY OF *OCTOPUS VULGARIS* IN FALSE BAY, SOUTH AFRICA

C. D. SMITH and C. L. GRIFFITHS†*

The population biology of the octopus *Octopus vulgaris* was studied from specimens collected by SCUBA in False Bay, South Africa, between 1997 and 1998. In all, 83% of the specimens collected were found in shelter. Small octopuses were more active than large individuals during the day, 37% of the former and 8% of the latter being found outside of shelters. All males >170 g were mature, the smallest male being 136 g. No mature females were found in the study area, and maturing females spanned a broad size range caught (275–3 600 g). Average size at spawning is probably between 1 500 and 2 500 g. Although there were no significant overall differences in mass between sexes ($p > 0.05$), the average mass of octopus in winter (766 g) was significantly smaller than in summer (1 161 g) and spring (964 g). Fluctuations in the average size of octopus tracked subsurface water temperature. The overall sex ratio was significantly biased towards males (0.6F:1.0M, $p < 0.01$), largely because fewer females were caught during spring and summer. Spawning likely occurs throughout the year. However, significantly higher ($p < 0.01$) female gonadal somatic indices of 0.52 and 0.46 found in spring and summer respectively (periods of warmer water in False Bay) may indicate peak spawning during those seasons.

Key words: maturation. morphometrics, *Octopus vulgaris,* population biology, sex ratio, spawning season

With the worldwide decline in conventional finfish stocks, fishers are redirecting their attention to alternative stocks, in particular invertebrates (Perry *et al*. 1999). Initiatives towards developing small-scale commercial fisheries, aimed at supporting previously disadvantaged fishers and targeting previously underexploited species, have become important in South Africa. Octopuses appear to be particularly suitable candidates for exploitation, because of their short lifespan, rapid growth, firm texture and high meat recovery (Paust 1985 cited by Paust 1988). Because of the extensive depth and geographic distribution of *Octopus vulgaris* (South African Museum, unpublished records) and its high commodity value (Anon. 1981), only this species was considered suitable for exploitation by a small-scale fishery in South Africa (Smith 1999). The biology of *O. vulgaris* has been studied elsewhere (Hatanaka 1979, Ambrose and Nelson 1983, Mangold 1983, Whitaker *et al*. 1991, Sánchez and Obarti 1993, Quetglas *et al*. 1998). However, despite its potential as an exploitable species, its biology has not been studied in depth in South Africa (Buchan and Smale 1981).

Given that a local small-scale potfishery for *O. vulgaris* is imminent, basic information on its population biology is required. The aims of this study were to describe aspects such as size, activity patterns, morphometrics, maturation, sex ratios and spawning cycle.

MATERIAL AND METHODS

Study sites and sampling techniques

O. vulgaris were collected using SCUBA during the day in the kelp beds of three sites (Windmill Beach, Miller's Point and Buffels Bay) on the west coast of False Bay (Fig. 1). Species were collected at depths up to 10 m between February 1997 and January 1998. Additional specimens were collected from Glencairn and Cape Hangklip (Fig. 1). An attempt was made to capture all octopuses observed during the dive, using the technique described by Smale and Buchan (1981). The depth of capture and whether the octopus was in or out of shelter were noted. Water temperatures were obtained hourly using a thermoscript placed at Boordjiesdrift (Fig. 1.)

Biological analysis

O. vulgaris were returned to the laboratory and frozen at -20°C. Prior to analysis, individuals were thawed and the following data were collected: total length (*TL*, to the nearest 10 mm), mantle length (*ML*, to the nearest 5 mm), body mass (*BM*), sex, gonad mass (*GM*, to the

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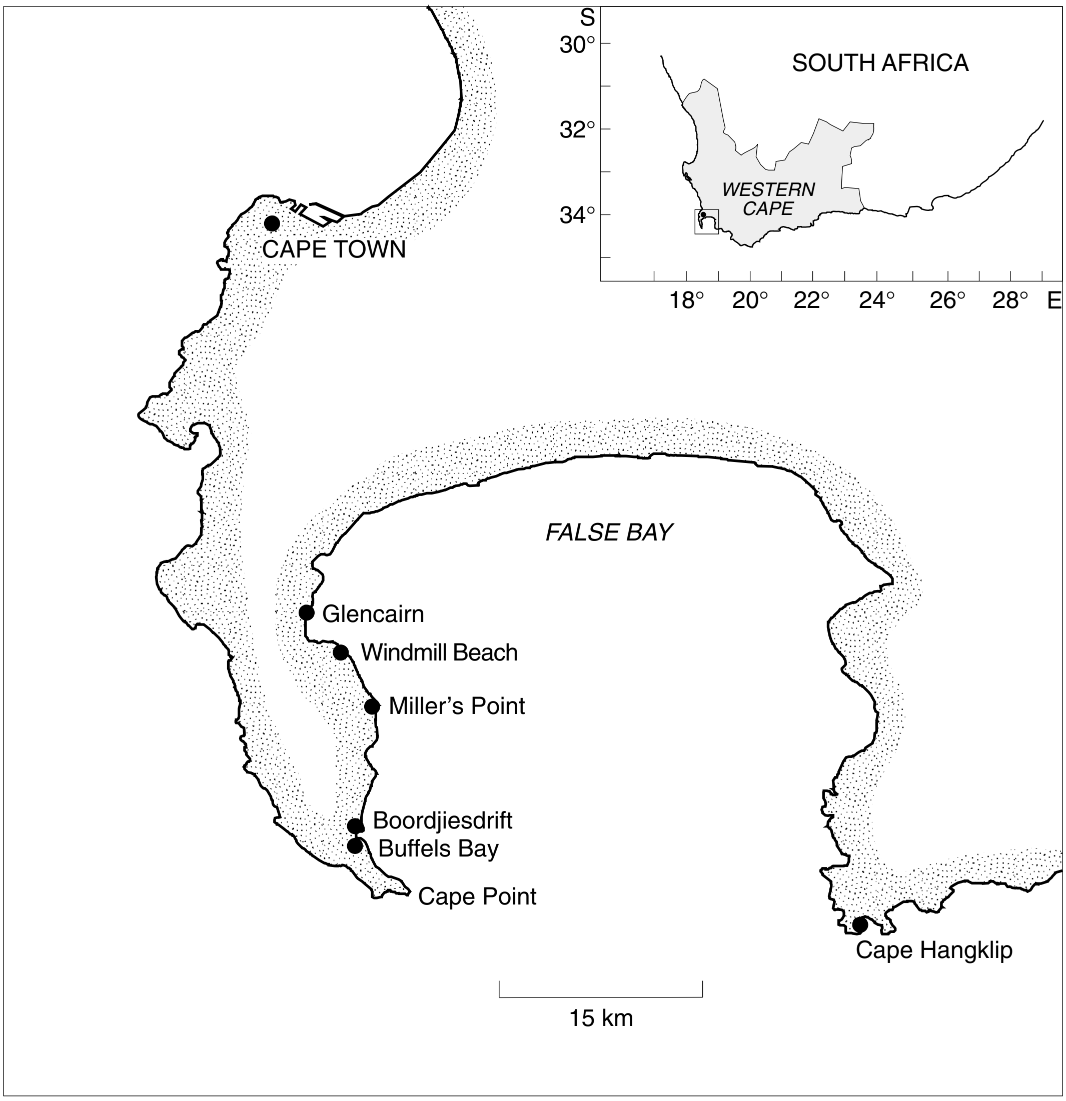

Fig. 1: Map of South Africa and False Bay showing the localities of sampling sites and other places mentioned in the text

nearest 0.01g) and lower beak mass (*LBM*, to the nearest 0.01g), according to Smale and Buchan (1981) and Mangold (1983). Specimens >200 g were weighed to the nearest 25 g and smaller specimens were weighed to the nearest 2 g. *GM* was related to *BM* to calculate the gonadosomatic index (*GSI*). Males were classified as sexually mature by the presence of spermatophores in the Needham's sac. Female maturity was categorized according to Mangold (1987): Stage 1 (immature), where the ovary is small and white; Stage 2 (maturing), where the ovary is larger and the eggs are off-white; Stage 3 (mature), where loose eggs are present in the ovisac; and Stage 4 (spent), where the ovisac is flaccid and containing few loose eggs present.

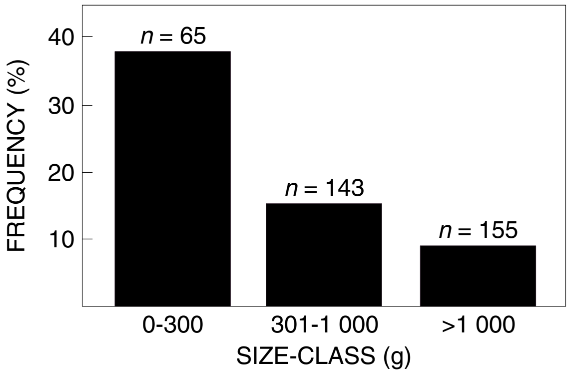

Fig. 2: Proportion of small, medium and large *O. vulgaris* collected outside shelter during the day in False Bay in 0–10 m depth

Statistical analysis

A χ^2 contingency table was used to test for significant differences between the proportions of octopuses found outside or inside shelters for small (0–300 g), medium (301–1 000 g) and large (>1 000 g) specimens, based on the null hypothesis that small octopuses should be more active than larger octopuses during the day. Morphometric relationships were analysed by least square regression, using the line or curve of best fit. A two-way ANOVA was used to identify differences in mass between season or sex. Mass data were log-transformed to improve normality and homoscedasticity (Zar 1994), because some samples displayed unequal variances. *Post hoc* multiple comparisons were performed using a Tukey HSD test for unequal sample size (Zar 1994). The relationship between mean monthly octopus mass and water temperature was analysed by linear regression. A χ^2 test was used to test whether the overall sex ratios differed. Because of unequal variances between seasons, a Kruskal-Wallis ANOVA by ranks was used to test for significant seasonal differences in *GSI*.

RESULTS

A total of 353 *O. vulgaris* was collected over the 12-month sampling period. The mean mass was 1 019 g, ranging between 58 and 4 625 g. In all, 83% were found in shelters. The proportion of small ($0 \leq 300$ g), medium (301–1 000 g) and large (>1 000 g) octopuses found outside shelters differed significantly (χ^2 = 29.67, $p < 0.01$), with 37% of small, 15% of medium and 8% large octopuses found outside shelters (Fig. 2).

The relationship between *ML* and *TL* was linear, and the relationships between *ML* and *BM* and between *ML* and *LBM* were described by power curves (Fig. 3). *GM* increased linearly with *BM* for males and followed a weak power curve for females (Fig. 4).

All males >170 g were mature; the smallest mature male being 136 g. No mature females were found; however, one spent female was collected in November. Some 63% (n = 19) of females >2 000 g were in the second maturation phase (Fig. 5), the smallest maturing female being 275 g.

There were no significant differences ($p > 0.05$) in mass between males (976.9 g) and females (1 114 g) over all seasons. However, the combined mean mass in winter (766 g) was significantly lower than in summer (1 161.2 g) and spring (964.3 g). Although the mean mass was highest in autumn (1 193 g), it did not differ significantly from that of winter, probably because of the high sample variance. Also, the proportion of small (<300 g) octopuses caught in spring (8.4%) was lower than in summer (18.5%), winter (20.2%) and spring (16.3%; Fig. 6). Monthly mean mass fluctuations of the inshore population of *O. vulgaris* tracked subsurface water temperature (n = 12, r^2 = 0.22, $p < 0.01$; Fig. 7).

Overall, the sex ratio of *O. vulgaris* was significantly biased towards males (0.6F:1.0M, χ^2 = 22.4, n = 353, $p < 0.01$). This could be attributed to females being under-represented in the spring and summer samples. *GSI* was significantly higher in spring and summer, when the water is warmer in False Bay, than in autumn and winter (χ^2 = 15.9, df = 3, $p < 0.01$; Fig. 8).

DISCUSSION

Adult *O. vulgaris* in False Bay are probably more active at night, as reported elsewhere for the species (Kayes 1974, Mangold 1983, Wells *et al.* 1983). The higher proportion of small octopuses found outside their shelters during the day than at night concurs with observations by Mather and O'Dor (1991), who found juvenile *O. vulgaris* to be more active during the day. These differences in activity between juvenile and adult may be a strategy by juveniles to avoid predation by large octopuses, which are cannibalistic (Smale and Buchan 1981, Villanueva 1993). Predator avoidance could explain the distributional differences between juvenile and adult *O. vulgaris*, *O. dofleini*

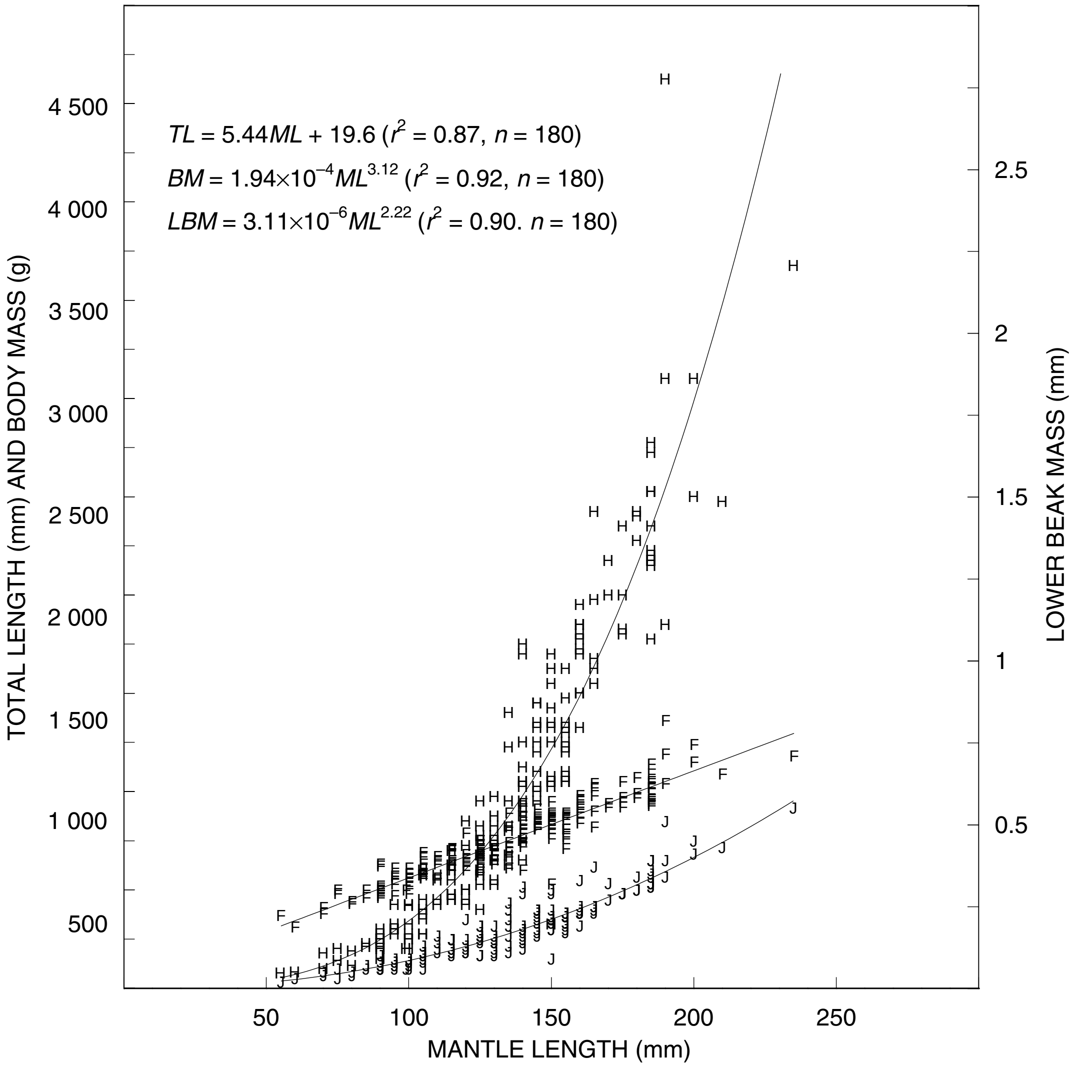

Fig. 3: Morphometric relationships for *O. vulgaris*. *ML* = mantle length, *TL* = total length, *LBM* = lower beak mass, *BM* = body mass

and *O. tetricus* found by Mather (1994), Hartwick *et al*. (1988) and Anderson (1997) respectively. Although the average depth at which small octopuses were collected (2.9 m) was shallower than that of large specimens (3.8 m) in this study, the differences in depth distribution could not be verified because tidal fluctuations were not considered.

The morphometric relationships for *O. vulgaris* in False Bay were similar to those reported for the species by Hatanaka (1979) off the north-west coast of Africa, by Smale and Buchan (1981) on the east coast of South Africa and by Sánchez and Obarti (1993) on the Spanish Mediterranean coast. This finding lends support to the suggestion by Mangold (1997) that the species referred to as *O. vulgaris* from the eastern Atlantic and the neotype of *O. vulgaris* from the

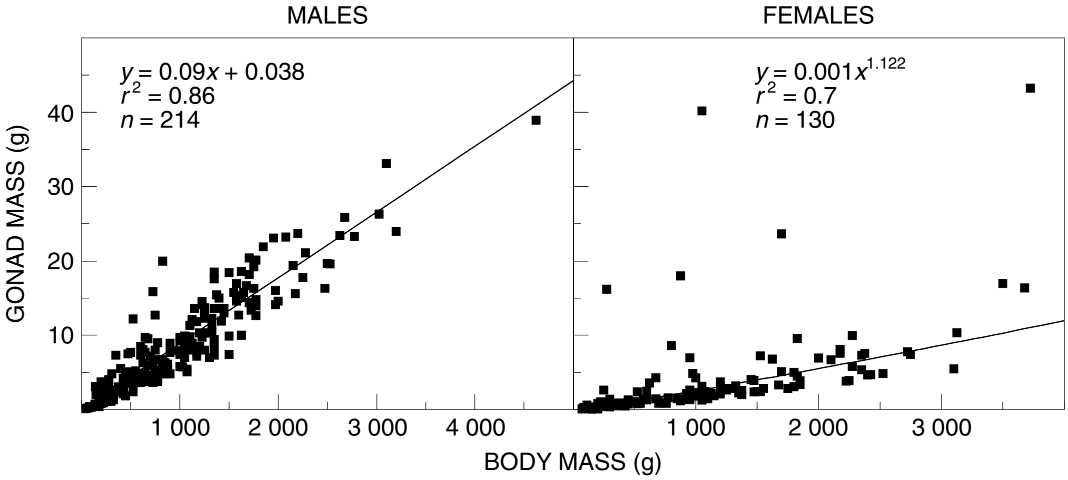

Fig. 4: Relationship between gonad mass and body mass for male and female *O. vulgaris* from False Bay

Mediterranean Sea are the same species.

Male *O. vulgaris* matured at a smaller size than females, consistent with most other cephalopods (see review by Mangold 1987). However, male maturation was largely determined by octopus size, and all octopuses >170 g were mature. This size at maturity is comparable to that of *O. vulgaris* in the Mediterranean (Mangold 1983), but larger than that reported for the species off the east coast of South Africa (Smale and Buchan 1981). Although maturing females were found across a broad size range of 275–3 600 g, the average mass for spawning females is likely to be 1 500–2 500 g, higher than that reported by Mangold (1983), but lower than that reported by Smale and Buchan (1981). In contrast to males, female maturation may depend on additional factors such as light intensity (Wells and Wells 1959), water temperature (Richard 1966, cited in Mangold 1987, Robinson and Hartwick 1986) and food availability (van Heukelem 1976 cited in Mangold 1987, Robinson and Hartwick 1986). The absence of mature females in this study may be attributable to them being overlooked, because of their spawning behaviour and egg brooding in caves. Alternatively, spawning may have taken place outside the study area, i.e. in depths >10 m. Smale and Buchan (1981) advanced a similar hypothesis for a shallow-water population of *O. vulgaris* off South Africa's east coast. In support of this, Whitaker *et al.* (1991) and Sánchez and Obarti (1993) found a high proportion of mature *O. vulgaris* females between 10 and 30 m deep along the South Carolina and Spanish Mediterranean coasts respectively.

The low mean mass of octopus in winter could be attributable to fewer large males and females being caught. This may be the result of natural male and female mortality during that period. Alternatively, large octopus may migrate offshore during winter to avoid unsuitable sea conditions, as suggested by Man-

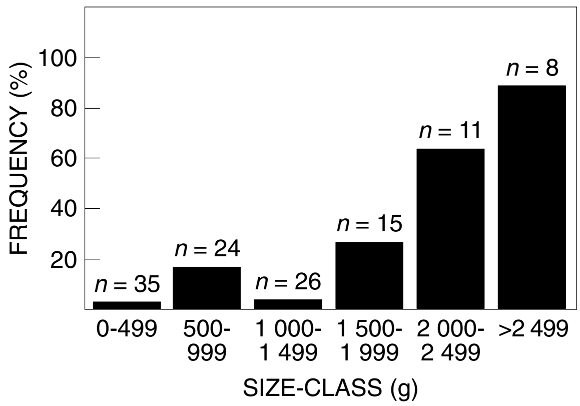

Fig. 5: Porportion of maturing female *O. vulgaris* from False Bay per 500 g size-class. Sample numbers (*n*) are provided

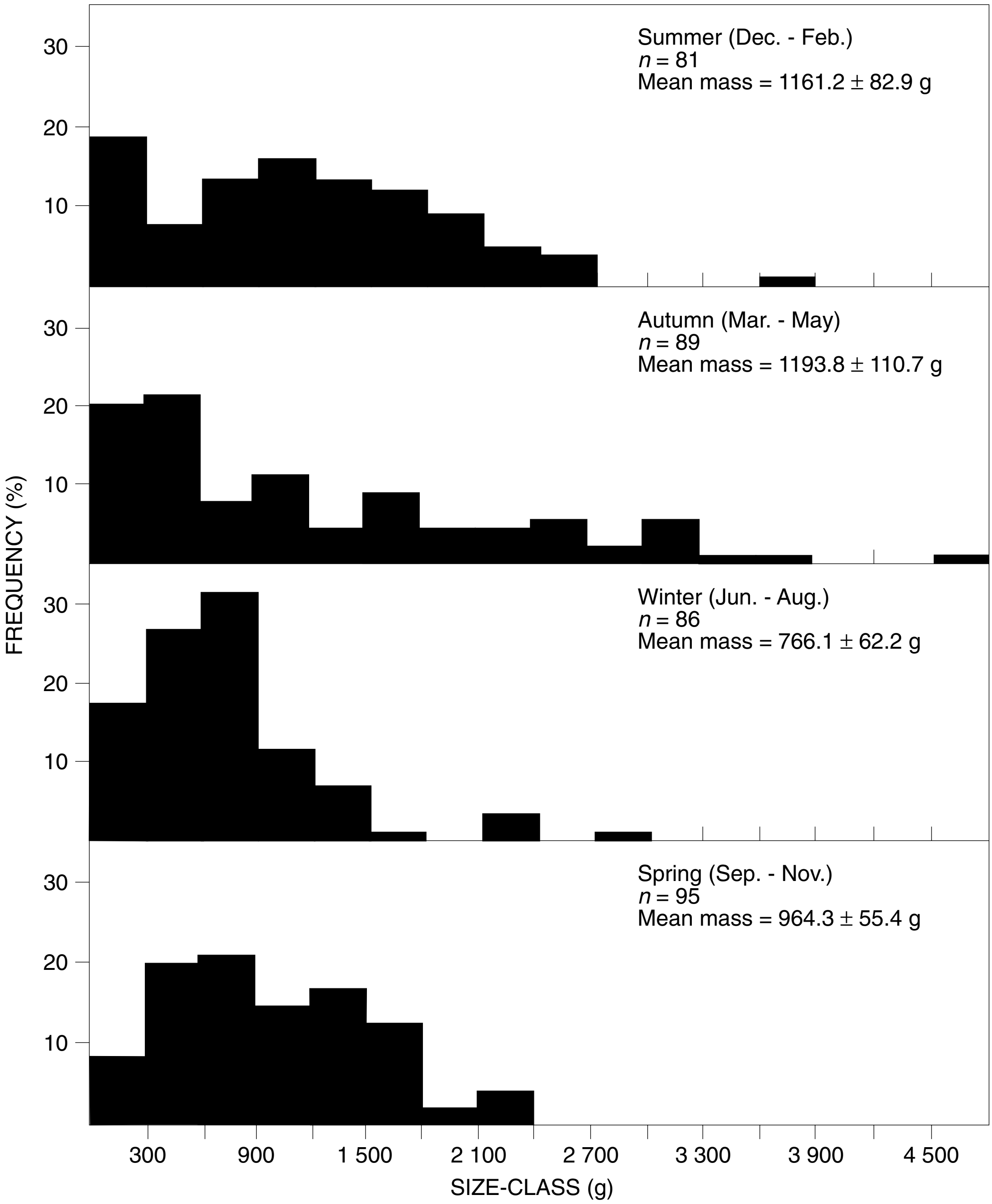

Fig. 6: Size frequency of *O. vulgaris* per season in False Bay, February 1997–January 1998. Seasonal mean mass and associated *SE* are also given

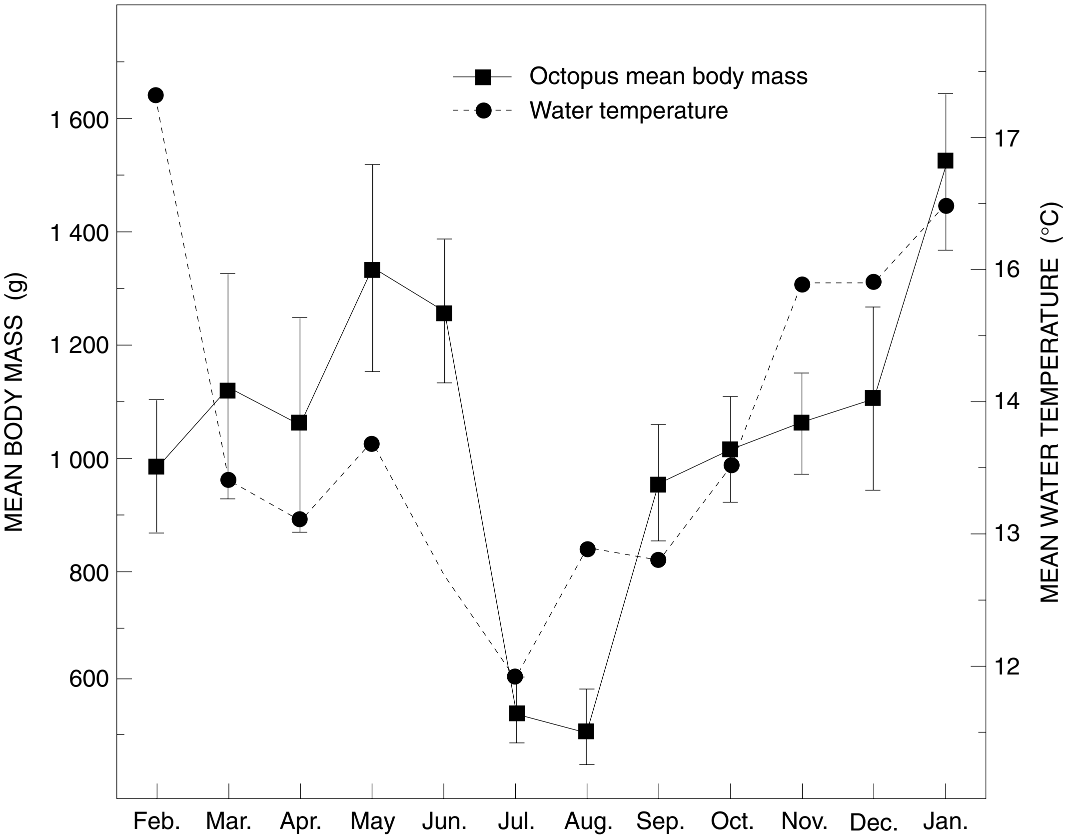

Fig. 7: Monthly variation in mean (± *SE*) body mass of *O. vulgaris* collected in False Bay and mean subsurface water temperature, February 1997–January 1998

gold (1983) to explain the greater abundance of *O. vulgaris* in coastal waters during spring and summer than in winter. Offshore-onshore migrations of octopus have been shown elsewhere; *O. vulgaris* (Hatanaka 1979, Guerra 1981, Whitaker *et al.* 1991), *O. dofleini* (Hartwick *et al.* 1984) and *O. tetricus* (Anderson 1997).

O. vulgaris likely spawns throughout the year in False Bay, with possible peaks in spring and summer when the water is warmer. However, this suggestion cannot be confirmed here, because spawning octopuses were not caught in those seasons, maybe as a result of mature females moving offshore or retreating into crevices to spawn. Spawning peaks in *O. vulgaris* have been reported for other temperate regions, but they vary seasonally, e.g. in spring off South Carolina (Whitaker *et al*. 1991), in autumn off North-West Africa (Hatanaka 1979) and in summer, autumn and

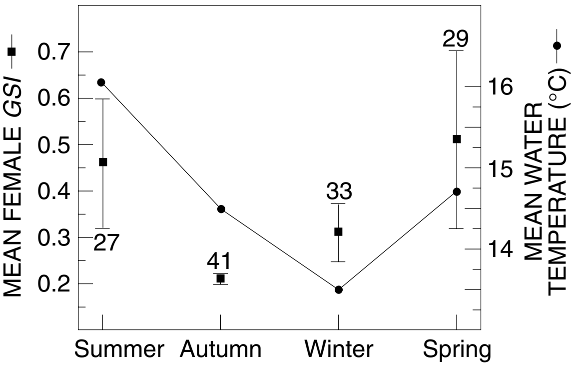

Fig. 8: Seasonal variation in mean (± *SE*) female *GSI* of *O. vulgaris* and mean water temperatures, February 1997–January 1998. Numbers of females examined per season are provided

winter in the Mediterranean (Mangold 1983). Spawning peaks most likely are associated with increasing water temperatures, as shown for False Bay and elsewhere (e.g. Whitaker *et al*. 1991). In contrast, no spawning peaks have been reported for subtropical and tropical populations of *O. vulgaris* (Wodinsky 1972, Smale and Buchan 1981).

This study provides some basic biological information for *O. vulgaris* in False Bay. However, because only the kelp beds were sampled, it is difficult to infer specific management recommendations for a future small-scale octopus fishery, which is intended to operate offshore. Offshore studies are crucial for a better understanding of the population dynamics of *O. vulgaris,* thereby enabling sound management recommendations to be made.

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