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ABALONE, SEA URCHINS AND ROCK LOBSTER: A POSSIBLE ECOLOGICAL SHIFT THAT MAY AFFECT TRADITIONAL FISHERIES

R. J. Q. TARR, P. V. G. WILLIAMS* and A. J. MACKENZIE**

A possible association between sea urchins *Parechinus angulosus* and juvenile abalone *Haliotis midae* has been monitored since 1989 during diving surveys at three sites on the South-Western Cape, South Africa. In 1994, numbers of sea urchins declined dramatically at two sites (Betty's Bay and Mudge Point), with a simultaneous decline in juvenile abalone. This decrease coincided with an apparent influx of rock lobster *Jasus lalandii* into the kelp beds of these regions. The hypothesis is proposed that predation by rock lobsters caused the previously large population of sea urchins to collapse, resulting in high mortality of juvenile abalone.

Sea urchins are recognized as important organisms in the ecology of certain temperate kelp forests because of their grazing impact on the benthos. Urchin abundance is usually controlled by predators such as crabs (Muntz *et al.* 1965, Bernstein *et al.* 1983), sea otters (McLean 1962, Ebert 1968, Lowry and Pearse 1973, Estes and Palmisano 1974), lobsters (Breen and Mann 1976a, Mann 1982, Tegner and Levin 1983, Andrew and MacDiarmid 1991) and fish (Bernstein *et al.* 1981, Tegner and Dayton 1981). When not regulated by predation, urchin populations may spread, leading to denudation of the kelp forests and the creation of "urchin barrens" which are covered with crustose coralline algae (Leighton 1971, Breen and Mann 1976b). Conversely, when urchin populations decline as a result of disease (Pearse and Hines 1979) or fishing pressure (Tegner and Dayton 1991), the density or extent of the kelp beds may increase. Studies of such interactions have elicited some critical discussions (Miller 1985, 1987, Breen 1987, Elner and Vadas 1990).

Interactions between abalone and sea urchins are less common, because populations of these species tend to be inversely related to each other as a result of competition for food (Lowry and Pearse 1973, Shepherd 1973, Tegner and Levin 1982). Juvenile abalone, however, have been observed under the spines of sea urchins (Kojima 1981). A relationship between sea urchins *Parechinus angulosus* and juvenile abalone *Haliotis midae* that appears to have a beneficial effect on the survival of the latter is described in this paper. Increased predation by rock lobster *Jasus lalandii* on the urchin population in recent years is hypothesized to have had negative consequences for abalone survival in certain areas of the South-Western Cape.

METHODS AND RESULTS

A close relationship between sea urchins and juvenile abalone in the South-Western Cape was first noted in 1985 during extensive abalone-tagging dives. This relationship has since been substantiated in other South-Western Cape abalone areas, in inshore waters (< 5 m) within the kelp *Ecklonia maxima* forests. Juvenile abalone were consistently found under urchins, particularly when the latter were aggregated in crevices and sheltered hollows on reefs, but also under the spines of urchins on exposed flat rocks. The size range of such abalone varied during the year as a result of cohort growth, but most were between 3 and 18 mm shell length (*SL*, Fig. 1), after which size they tended to occupy crevices for shelter.

The smallest recruitment stages visible to the naked eye measure 1–2 mm *SL*, are white in colour and have been observed by the current authors on crustose coralline algae only. An abalone recruitment programme was established in 1989 to monitor and quantify the annual changes in abundance of recruiting abalone over the size range 1–45 mm *SL*. Results from this survey demonstrated successful annual settlement at three study sites east of Cape Hangklip (Betty's Bay, Mudge Point and Danger Point), within the main abalone fishery region (Fig. 2), whereas at one West Coast site (Robben Island) recruitment was intermittent (Tarr 1994). Sea urchins were also monitored by placing five 0,25-m^2 quadrats selectively over urchin aggregations. The abalone underneath the urchins were removed and measured. The disappearance of urchins was first observed at the Betty's Bay and Mudge Point sites in

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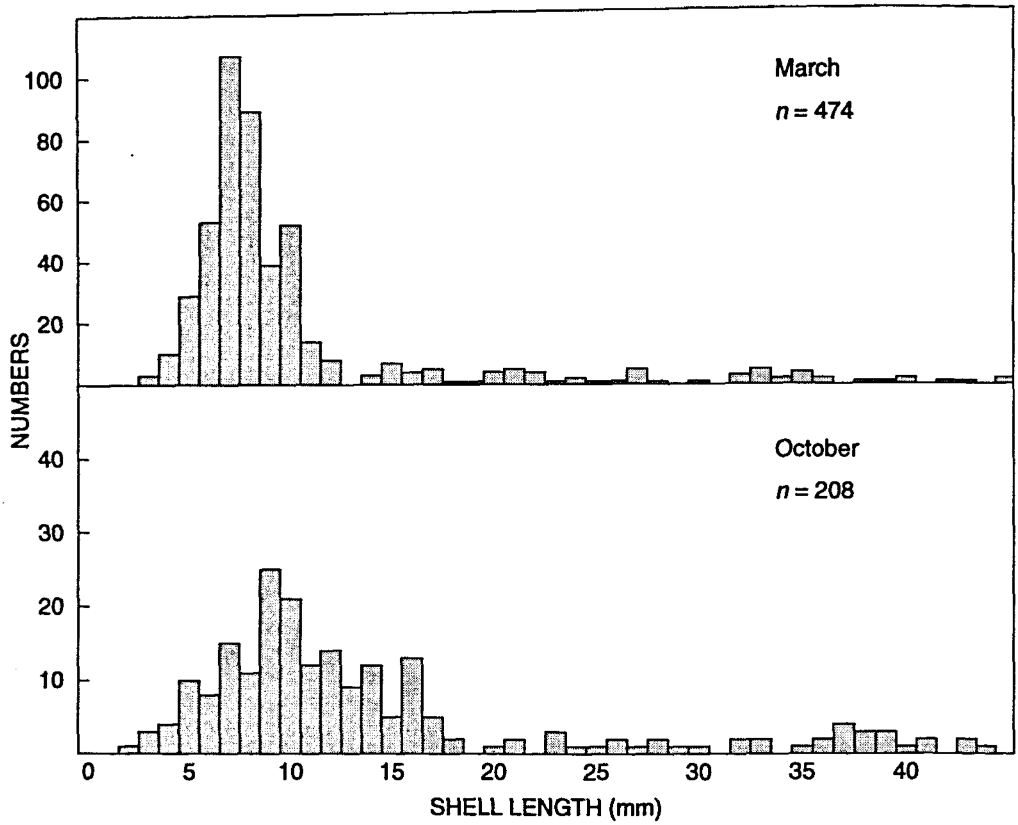

Fig. 1: Length distribution of abalone found under sea urchins at Betty's Bay in March and October, 1989–1992

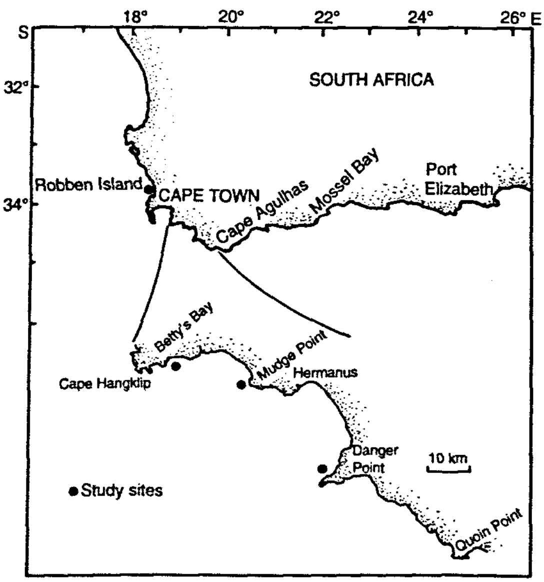

Fig. 2: Abalone recruitment study sites

1994 (Fig. 3). There was also a marked decline in abalone recruits at these two sites. Unfortunately, this phenomenon occurred when sampling had been scaled down to once per year. Only a few shallow sites (away from the research area), which were exposed to heavy swell conditions, supported sea urchins, albeit in low densities.

For approximately two years prior to the decline in urchin abundance at Betty's Bay and Mudge Point, diving surveys showed increases in the number of large rock lobsters *Jasus lalandii* in those areas. This is supported by the increased proportion of recreational rock lobster landings since 1991 in the region east of Cape Hangklip (Fig. 4). As rock lobsters are known to prey on urchins (Tegner and Levin 1983, Zoutendyk 1988, Andrew and MacDiarmid 1991), it is suggested that predation by rock lobsters caused the collapse of the urchin population at Betty's Bay and Mudge Point after February 1994.

Observations during a diving survey at Mudge Point in March 1995, when fewer than 20 urchins were counted during a two-hour survey, strongly support this hypothesis. The urchins were hidden deep in crevices or, in the case of juveniles, beneath boulders. During

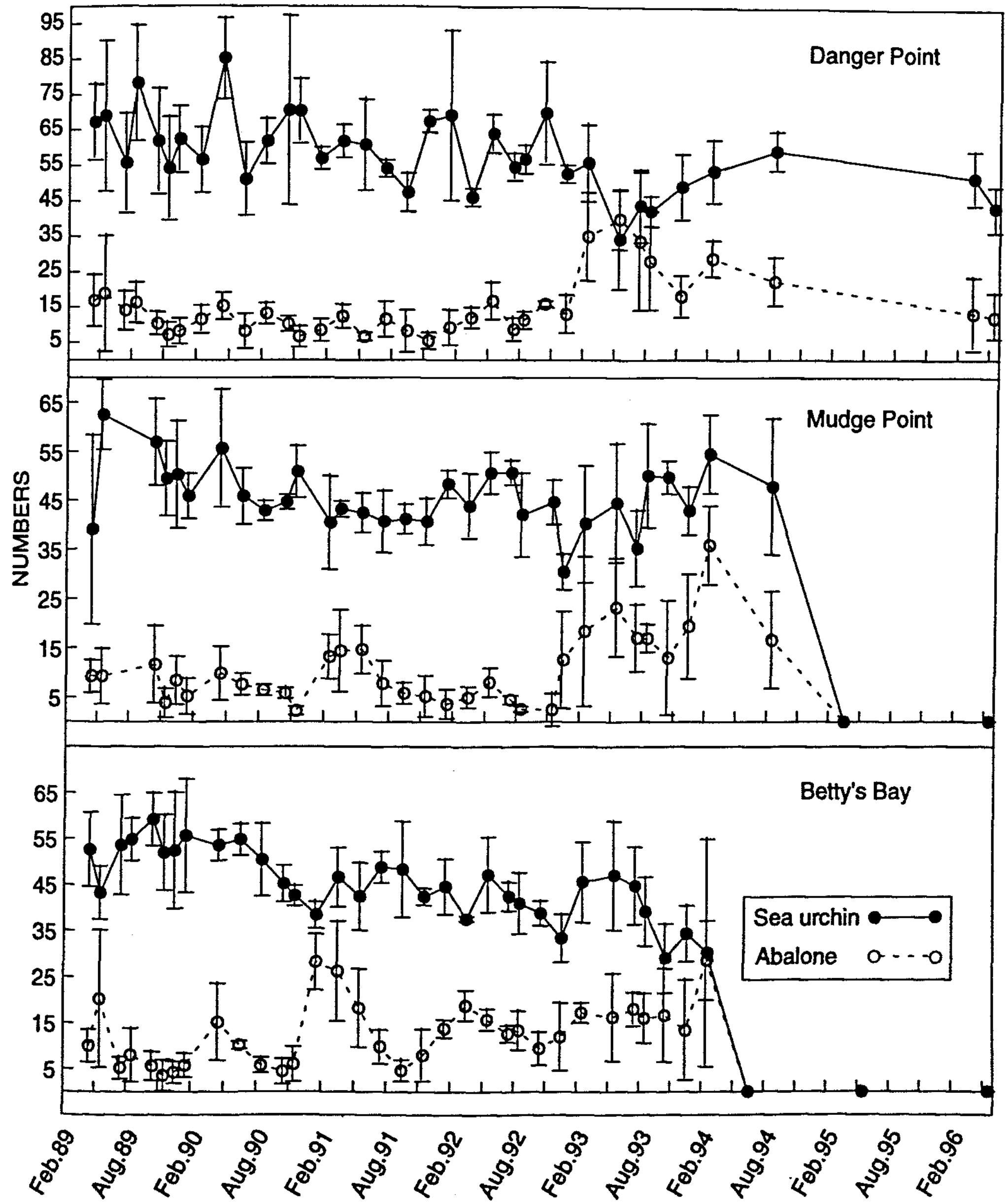

Fig. 3: Mean (± *SE*) number of sea urchins and abalone counted per 0,25 m^2 quadrat at three sites east of Cape Hangklip

that survey, only 13 juvenile abalone were observed, all of them under sea urchins and in crevices. A similar survey in previous years would have yielded many hundreds of small abalone. In contrast, a high abundance and a wide size range of rock lobsters were noted in the area, many more than was found in previous years. Also, they appeared to be moving freely over the reef, apparently foraging. Approximately 10 rock lobsters had captured prey, consisting entirely of urchins. Given the scarcity of urchins at the site, it appears that the lobsters preyed preferentially on urchins. Previous studies have shown that *J. lalandii* commonly feed on the mussels *Choromytilus meridionalis* and *Aulacomya ater* (Zoutendyk 1988, Pollock 1979); however, such prey is

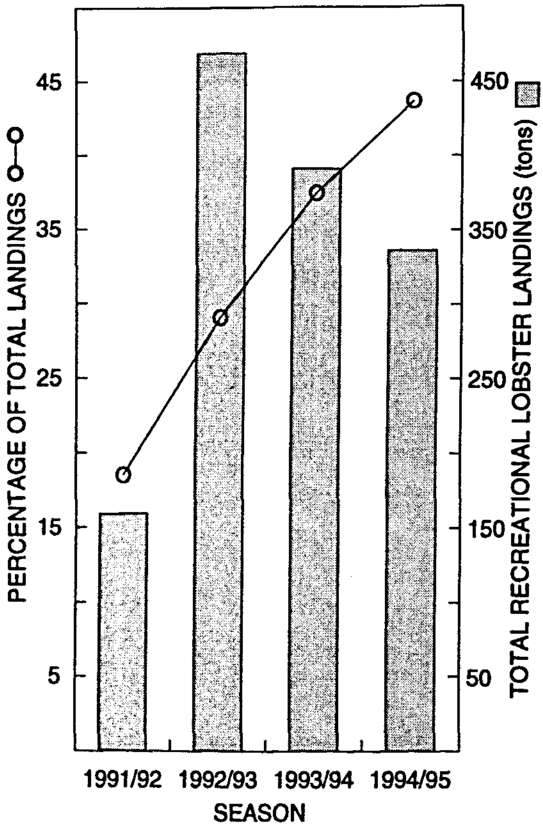

Fig. 4: Recreational lobster landings east of Cape Hangklip, expressed as a percentage of the total recreational landings. Note that the marked increase in landings in 1992/93 was partially influenced by a reduced size limit as well as increased season length (A. C. Cockcroft, Sea Fisheries Research Institute, pers. comm. and unpublished data)

not common within the kelp beds of the study site (Field *et al.* 1980b).

Diving observations in 1996 substantiated the existence of large numbers of rock lobsters, the absence of urchins and the scarcity of abalone recruits at Mudge Point and Betty's Bay. It is noteworthy that, on the basis of a series of diving surveys carried out 20 years previously, Field *et al.* (1980a, p. 172) commented that "The shallow and nearshore part of the transect, as far as 300 m out, is populated mainly by the grazer *Haliotis midae* and the debris-feeder *Parechinus angulosus*", and "... *Jasus lalandii* is not abundant at Betty's Bay ...".

DISCUSSION AND CONCLUSION

It appears that a large-scale invasion by rock lobsters of the kelp beds east of Cape Hangklip (Betty's Bay to Hermanus) has taken place in recent years. Foraging by these animals seems to have removed virtually the entire *P. angulosus* population from the kelp forests. As this species of sea urchin is relatively small (attaining a maximum shell diameter of 60 mm), it has no refuge in size from *J. lalandii*. The rapid rate of decline in urchin and abalone numbers could be an artifact of the survey method, which targeted urchin aggregations. It is possible that increasing predation was causing the number or size of urchin aggregations to decline over a year or more, which would not have been reflected in our samples. Only when there were no more urchin aggregations to sample was this apparent.

Juvenile abalone are vulnerable to predation because they do not possess the strong adhesive powers or shell strength that protect adults. For this reason they are found only in cryptic habitats. The immediate, high-speed movements exhibited in juvenile abalone after the removal of urchins (L. Reynolds, University of Cape Town, pers. comm.) suggest that the protection provided by the urchins may be an important survival strategy for young abalone. Mortality of abalone recruits, of the sizes normally found under urchins, is likely to be the result of increased predation by rock lobsters because of the lack of shelter, as well as possible predation by rock lobsters. Therefore, if rock lobsters are present for an extended period of time, there are probably detrimental implications for the future sustainability of abalone harvests in the region from Betty's Bay to Hermanus.

A previous study found that two contrasting ecosystems can be maintained within the same physical and topographic conditions, dictated primarily by the presence or absence of predation by *J. lalandii* (Barkai and Branch 1988b). In the present study areas it may be assumed that, if *J. lalandii* moved into the area in large numbers, they may later move out, or simply not survive once the available food (e.g. urchins) is exhausted. However, Barkai and Branch (1988a) showed that rock lobsters are able to exploit unorthodox food supplies such as barnacle recruits, thereby maintaining high predator densities in areas of low food abundance. Therefore, it is possible that *J. lalandii* may persist in densities high enough to prevent the re-establishment of significant numbers of urchins in certain areas permanently.

A study is now underway to investigate the extent to which rock lobsters feed on urchins, and whether they also prey upon juvenile abalone. Further research is needed to understand what other effects are likely as a result of the removal of the sea urchins; whether the increase in rock lobster abundance in certain areas warrants the initiation of a new inshore commercial fishery and, if so, could this indirectly benefit the abalone resource; whether there is continued movement of rock lobster into abalone areas further east than Mudge Point. At present urchins and juvenile abalone are still abundant at Danger Point, but this area should be monitored closely to establish if the distribution of lobster is shifting eastwards.

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