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RESEEDING OF MUSSELS ON DENUDED ROCKY SHORES: PRELIMINARY STUDIES WITH THE BROWN MUSSEL *PERNA PERNA*

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A method is developed to establish clumps of mussels *Perna perna* in denuded areas on high-energy rocky shores on the south-east coast of South Africa. A total of 20 small (20–30 mm total length) mussels is placed under a 30 cm half-section of perforated PVC drainage pipe bolted to the rock surface. The pipe is left in position for one month before removal to allow the mussels to attach firmly to the substratum. A pilot study in a marine reserve indicated 76% survival of clumps and individuals over a period of a year. Mussels grew at a mean annual rate of 30.1 mm from an initial size of 31.8 mm. A subsequent study of survivorship and growth of three size-classes: 25–35, 50–60 and >70 mm, showed that greatest survivorship and growth were exhibited by the smallest size-class. Apart from the initial drilling of holes, the procedure is simple and inexpensive. Mussels could be harvested after about 12 months and the holes and PVC pipe re-used for repeats of the procedure. The method may be used as a research tool and as a way of rehabilitating areas denuded by other natural or anthropogenic agencies.

Key words: growth, mariculture, mussels, reseeding

The south-east coast of South Africa is characterized by its high-energy rocky shores, which have been utilized by local inhabitants for generations as a source of shellfish (Derricourt 1977). Increasing pressure on these resources in the latter part of the 20th century resulted in substantial reductions in the abundance of preferred species, such as the brown mussel *Perna perna* and various patellid limpets (Fielding *et al*. 1994). Extensive mussel beds have been replaced along much of the Transkei coast by a persistent mat of coralline algae that support only isolated clumps of mussels (Dye 1992). As mussel beds provide a complex three-dimensional habitat, important not only for their own recruitment but also for the recruitment of many other molluscs and echinoderms, their loss has a cascade effect that reduces the abundance of species dependent upon the habitat (Lasiak and Field 1995). Many of the species are potential food resources. The persistence of the algal mat is striking. Areas cleared of mussels experimentally in the period 1982–1983 were rapidly colonized by coralline algae and even 15 years later were largely devoid of mussels (Dye *et al*. 1997). This led to the conclusions that simply restricting mussel-harvesting would not ensure recovery of mussel beds within a reasonable period of time, and that the feasibility of rehabilitation should be investigated.

Although methods for growing mussels are well established in the mariculture industry, these could not be used as a starting point in the present case because the objective was rehabilitation of intertidal areas subject to heavy wave action. Mariculture techniques require relatively calm conditions and fairly elaborate structures, and are applicable only in subtidal areas. The aim of this study was to develop a technique for re-establishing mussels that is both cost-effective and sufficiently robust to be applicable on high-energy rocky shores.

MATERIAL AND METHODS

In September 1996, a pilot study was initiated in which 20 clumps of mussels were artificially established in the Dwesa Reserve (Fig. 1). A site (approx. 2×10 m parallel to the sea) was chosen at random in the infra-tidal zone at the southern end of the reserve where brown mussels *Perna perna* are most abundant. A total of 20 mussels in the size range 25–35 mm was placed under 30-cm long half-sections of perforated PVC drainage pipe, which was then attached to the rock surface by two alloy screws and plastic anchors (Fig. 2). The attachment was such that the mussels were held firmly but could still move their valves. The pipe was left in place for one month before being removed to expose the mussels, which by this time had attached firmly to the rock surface. The screws were replaced in the anchors to act as markers. After 12 months the surviving mussel clumps were

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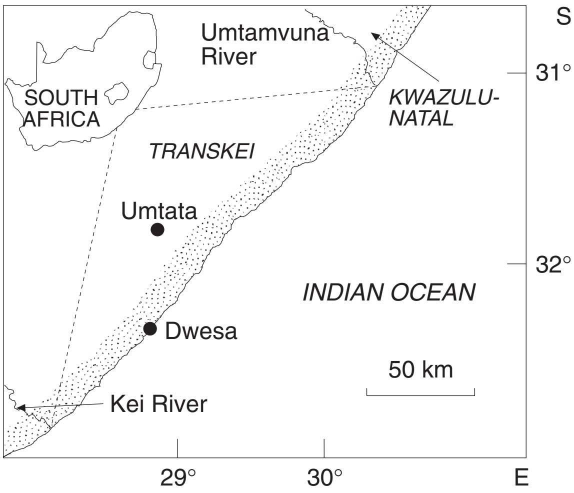

Fig. 1: Map of South Africa showing the location of the study area

removed and the total length (*TL*) of each individual was measured.

In December 1997, the technique was used at a site (approx. 2 × 15 m) 1 km north of the pilot site to assess survivorship and growth of mussels of three size-classes: 25–35, 50–60 and >70 mm. In all, 12 clumps of each size-class, containing 20 individuals, were established as described. In this case, however, each mussel was marked with a unique number using an engraving tool. In the case of the larger size-classes, it was necessary to modify the pipe by extending it 100 mm in the form of a 50-mm tongue at each end, which was used as a point of attachment. This allowed the half section of pipe to retain its normal shape while still being firmly attached to the rock. At three-monthly intervals for one year, three clumps of each size-class were removed and the surviving individuals measured. Increments in length, as measured by the shift in modal size, were plotted against the time interval. A differentiated Von Bertalanffy growth function was fitted to the data:

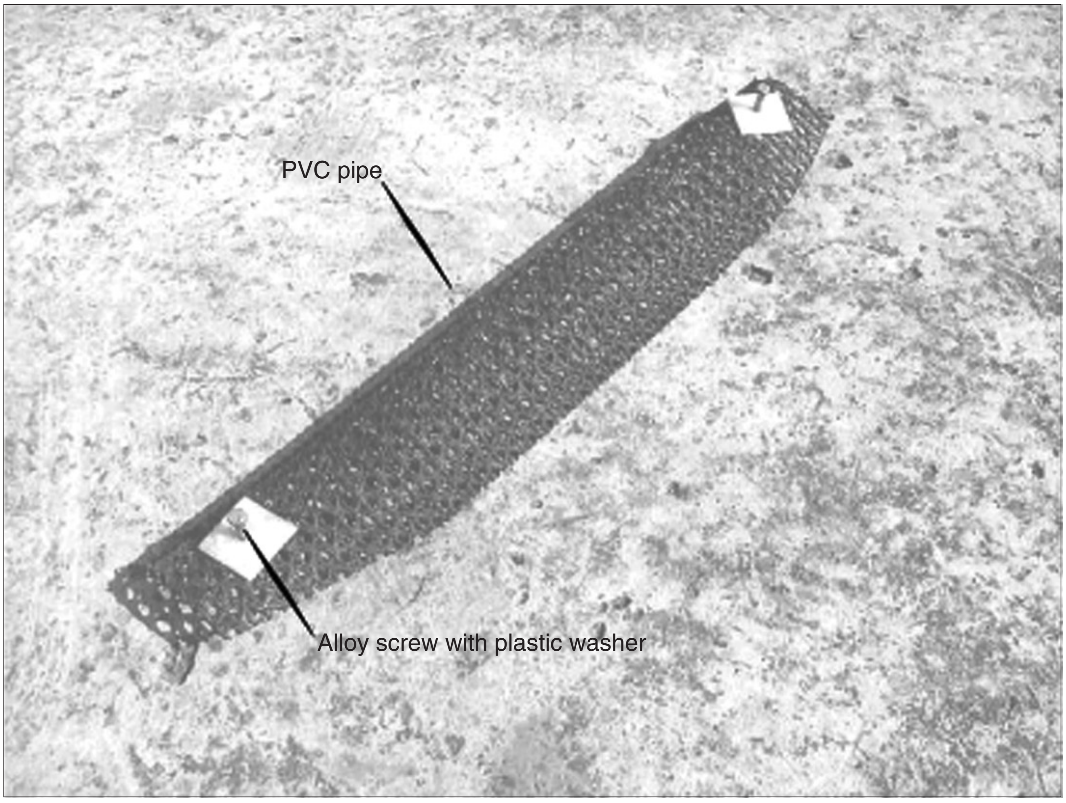

Fig. 2: Perforated PVC pipe structure used as an anchor for mussels clumps

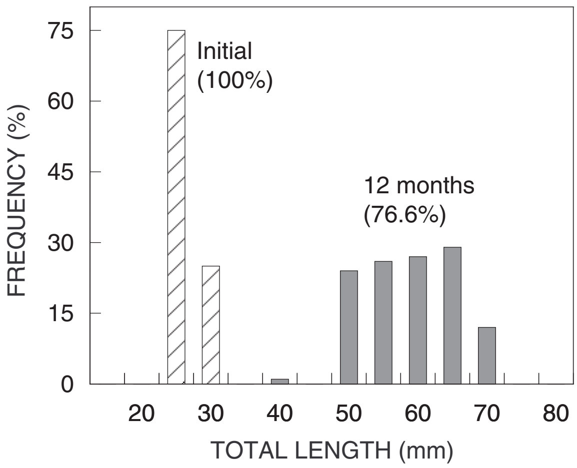

Fig. 3: Survivorship and growth of mussels after 12 months in the pilot study. Percentage survival is shown in parenthesis

$$dL = (L_\infty - L_1)\ [1 - \exp(-K\ dt - (L_{t1} + L_{t2})]\quad ,$$

where dL is the change in length over a given time period, L_∞ is the asymptotic length, K is the growth constant and L_t is the length at time t.

Survivorship was determined on the basis of the number of mussels remaining in each size-class at each sampling time. Any recruits (>3 mm) were also measured.

RESULTS

Pilot study

Mussel clumps established during the pilot study survived well, 80% remaining after 12 months. Individual survivorship was also high, 76.6% surviving overall (Fig. 3). The mussels grew from an initial mean total length of 31.8 ± 3.3 mm to a mean of 60.9 ± 6.3 mm, a growth rate of 30.1 mm year^{-1}. It was also noted that new mussel recruits (3–10 mm *TL*) had settled into the mussel clumps at an intensity equivalent to 5% of the original standing stock.

Survival and growth

Figure 4 shows the modal progression over 12 months of mussels in the size-classes 25–35 and 50–60 mm respectively. None of the largest mussels (>70 mm) survived beyond the first three months. Although all the clumps survived, individual survivorship in the smallest size-class declined rapidly in the first three months, but stabilized thereafter so that, by the end of the experiment, 54.5% of the original population remained. Similarly, all clumps in the 50–60 mm size-class survived, but individual survivorship was low, declining to 47.3% in the first three months. By the end of that experiment only 22.4% of the original mussels remained.

Mussels in the small size-class grew at a mean rate of 32.2 ± 5.3 mm year^{-1}, similar to that found in the pilot study, but individual growth rates were variable and ranged from 10.0 to 38.5 mm year^{-1}. Growth was minimal in the 50–60 mm size-class where mean total length increased by only 6.1 ± 2.1 mm year^{-1}. Again, individual growth was variable and ranged from 0 to 10.4 mm year^{-1}. Length frequency analysis of growth in the smallest size-class (Fig. 5) gave an L_∞ value of 150.5 mm, which would be attained at approximately 8 years.

DISCUSSION

New legislation in South Africa requires that utilization of marine resources, including for the first time subsistence resources, be conducted on a sustainable basis. Management of subsistence fisheries is usually focused on strategies aimed at reducing fishing effort, either by restricting access or by limiting catches (Dye *et al*. 1994a, b). Access may be restricted by introducing rotational cropping, which is often seen as a means to allow recovery of denuded stocks, or by establishing no-take reserves, thought to enhance recruitment of target species to adjacent areas. These strategies, however, assume that natural recruitment will ensure that denuded stocks will recover within a reasonably short period. While this may be so in many cases, the assumption does not hold in cases where recruitment is low or where stocks have been so depleted that recruitment failure is common. The assumption is also invalid in situations where exploitation has modified the habitat to such an extent that recruitment of targeted species is inhibited or prevented.

Long-term research on the south-east coast of South Africa has indicated that *P. perna* has low resilience to disturbance (Lambert and Steinke 1986, Lasiak and Dye 1989). Dye *et al*. (1997) reported that areas denuded of mussels were recolonized by coralline algae, which represents an alternative stable state, effectively preventing recovery or development of mussel beds. Brown mussels appear to require the

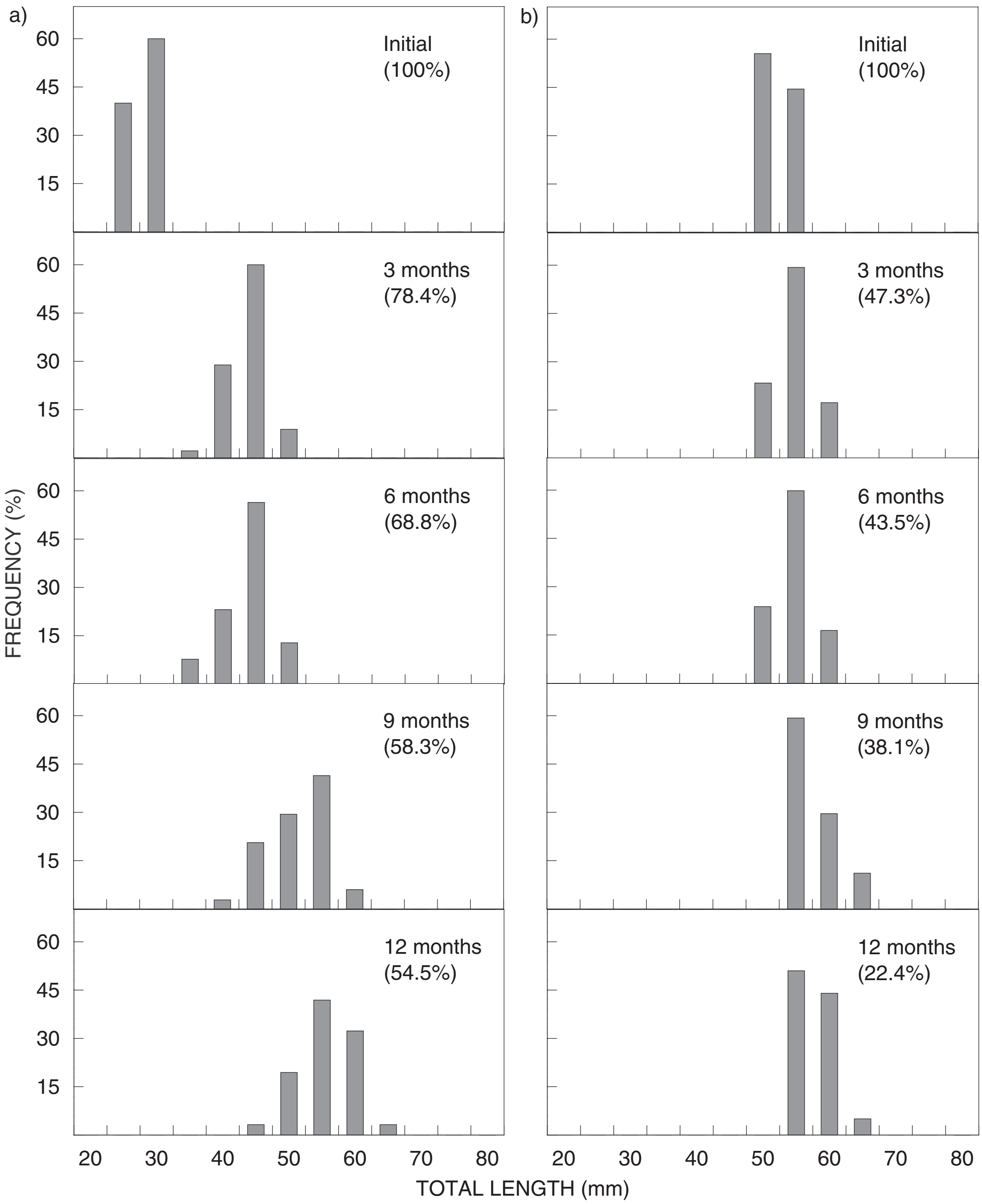

Fig. 4: Survivorship and growth of mussels in the (a) 25–35 mm and (b) 50–60 mm size-class during the main study. Percentage survival at each time interval is shown in parenthesis

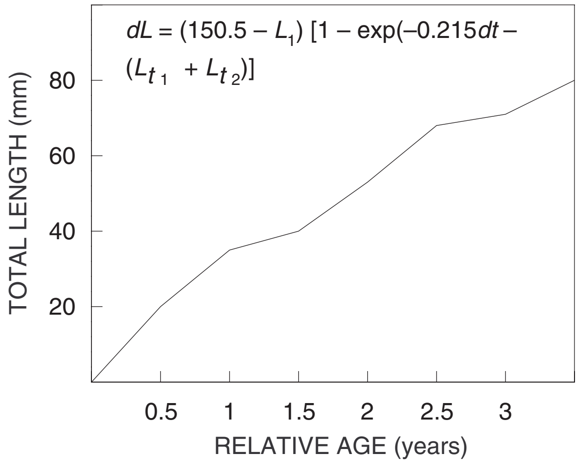

Fig. 5: Differentiated Von Bertalanffy growth curve for mussels in the 25–35 mm size-class during the main study (see text for details)

presence of adult beds or large clumps for successful recruitment (Lasiak and Barnard 1995). Although mussels settle onto algal mats, they are easily dislodged as they grow because they cannot attach to the rock substratum, which may be 2–3 cm below the surface of the mat. Even within marine protected areas, recovery of experimentally cleared mussel beds may require 8–10 years, with little or no recovery in exploited areas.

It is clear that, under such conditions, simply closing areas or reducing effort will have little or no effect on stocks in the short to medium term. What is required is a management strategy that embodies some measure of intervention in which recruitment is accelerated. Traditional mariculture techniques are generally designed to operate within sheltered waters or to utilize structures anchored to the seabed. Neither of these options is feasible in the present case, because there are no suitable sheltered areas on the South-East Coast and wave action is moderate to high. Furthermore, the cost of seabed structures is prohibitive and well beyond the means and expertise of rural communities. A technique for re-establishing mussels on high-energy rocky shores is required and the present study shows that it is technically feasible.

Although a number of studies have shown that growth in mussels is highly variable and dependent upon a number of factors, including position on the shore (Seed 1968, Jorgensen 1976, McQuaid and Lindsay in press) and wave action (Jones and Demetropoulos 1968), mussels transplanted in this study survived well and grew at a rate similar to that of *P. perna* in the area generally (Tomalin 1995, Kaehler and McQuaid 1999). Nevertheless, further trials are needed to establish the generality of the results.

The value of establishing mussel clumps in this way lies in the fact that it has the potential to enhance recruitment by providing a substratum for settlement and possibly reducing the dominance of algal turf on the low shore, which is thought to inhibit recovery of mussel beds (Dye *et al.* 1997). The technique is also valuable in that it offers the possibility of increasing the productivity of mussel stocks by re-using the bycatch of small mussels discarded by shellfish-gatherers.

Technical feasibility, however, is a necessary but insufficient condition for success, and at least two additional conditions must be met. First, to be attractive to cash-limited management authorities, the technique must be cost-effective with minimal maintenance. Second, the intervention must be acceptable to local communities who often hold strong beliefs about marine resources that may be at odds with scientific views. Apart from the initial set-up phase, which requires drilling equipment to establish the set of mussel pipes, material and maintenance costs are minimal. As the durable PVC pipe sections can be used several times, because they are exposed to the elements for only one month in each run, it is estimated that each deployment of a pipe unit, with screws and anchors, costs about 20 US cents. The only tool required is a 10-mm spanner for attaching and removing the pipe sections. Harvesting is possible after 12 months, when the mussels are about 50 mm *TL*. However, it may be more cost-effective to leave them for an additional six months, when the individual yield would be higher. As the highest mortality is in the first year, the increase in time should not incur excessive additional losses.

Following the promulgation of South Africa's new Marine Living Resources Act in September 1998, fisheries management in South Africa has been extended to include shellfish obtained for subsistence purposes. Because human resources for law enforcement are limited, and in keeping with international trends, authorities are promoting partnerships with local communities and seeking sustainable harvesting practices. The possibility of developing the reseeding procedure as a community-based activity, creating employment within a co-management system, should make it attractive to both management authorities and local communities. In addition, conservation authorities may find the method attractive for its utility both as a tool in rehabilitation projects and in research on the dynamics of mussel populations.

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