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Experimental harvesting of *Mytilus galloprovincialis*: Can an alien mussel support a small-scale fishery?

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Abstract

In an effort to stimulate new fisheries and address historic imbalances in access to fishing rights, there has been a recent focus on the development of small-scale fisheries in South Africa. To assess the biological viability of a fishery for the alien mussel *Mytilus galloprovincialis*, an experimental fishery operated by two impoverished coastal communities was initiated. Harvesting took place on a rotational basis at three sites, nested within four locations. At each of these 12 sites, 5 treatments were undertaken to span a spectrum of harvesting intensities ($F = 0$, 0.3, 0.6, 0.9 and a once-off total removal). A dynamic biomass-based fisheries model was developed to predict changes in exploited populations over time. Monthly maximum sustainable yield (MSY) estimates peaked at 1560 kg per 100 m of shore in March–April and September–October, but dropped by two orders of magnitude to 15 kg per 100 m of shore during the remainder of the year. The two peaks in MSY corresponded to the peak spawning periods of *M. galloprovincialis* along the South African west coast. Consequently, harvesting will only be viable if focused within two seasons spanning the peaks in MSY. Under these conditions, a range of harvesting intensities between $F = 0.1$ and 0.3 would permit long-term biological sustainability of a fishery. If implemented, this would represent the first instance of a marine invasive species being utilised to achieve socio-economic goals in South Africa.

Keywords: *Mytilus galloprovincialis*; Alien; Small-scale fishery; Socio-economic development; South Africa

1. Introduction

In many parts of the world, fisheries of near-shore and intertidal marine resources are well established. One of the most thoroughly researched systems subjected to such exploitation is the Chilean coast. There, harvesting of the intertidal predatory gastropod *Concholepas concholepas*, the key-hole limpet *Fissurella crassa* and the sea urchin *Loxechinus albus* is both common and economically important (Oliva and Castilla, 1986; Durán et al., 1987). By contrast, the exploitation of intertidal marine resources is almost entirely limited to subsistence utilisation in South Africa, where it is focused predominantly on the coasts of northern Kwazulu-Natal (Kyle et al., 1997; Harris et al., 2003) and the Eastern Cape (Hockey et al., 1988; Lasiak, 1992). The brown mussel *Perna perna* forms the major portion of catches in this region, but other organisms collected include a number of species of limpet, oyster and abalone (Siegfried et al., 1985). In comparison, the west coast is subjected to dramatically lower levels of exploitation (Griffiths and Branch, 1997), because of the low human population density there and the exclusion of the public from large areas by diamond-mining operations.

To date, 21 marine alien species are known from South African waters (Mead et al., in press). Of these the most significant is the Mediterranean mussel *Mytilus galloprovincialis*. First recorded along the South African west coast in 1979 (Branch and Steffani, 2004), this aggressive invader is currently the dominant intertidal species along the west coast and occupies over 2000 km of South African coastline (Robinson et al., 2005). As a principal space occupier the ecological impacts of *M. galloprovincialis* are wide ranging and include partial displacement of the indigenous mussels *Choromytilus meridionalis*

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and *Aulacomya ater* (Hockey and Van Erkom Schurink, 1992), competitive dominance of the limpets *Scutellastra granularis* and *Scutellastra argenvillei* (Griffiths et al., 1992; Steffani and Branch, 2003a; Steffani and Branch, 2005) as well as significant changes to overall community structure (Robinson et al., 2007a).

In an effort to stimulate new fisheries-based industries, and address historic imbalances in access to fishing rights, increasing attention has been paid to the development of small-scale commercial fisheries in South Africa in recent years (Levitt et al., 2002; Pulfrich and Branch, 2002). In line with such expansion, and in an effort to bring economic upliftment to impoverished coastal communities of the Northern Cape Province, the Sustainable Coastal Livelihoods Programme (SCLP) initiated a project in 2002 to determine the potential for exploitation of inshore marine resources in the region. In particular, *M. galloprovincialis* was identified as a possible target species, and a Northern Cape Mussel Project was established by the Fishing and Mariculture Development Association (FAMDA) through the SCLP. This project was charged with establishing an experimental intertidal mussel fishery based on *M. galloprovincialis* that would ensure both maximum economic benefit to the historically disadvantaged coastal communities in the region and the sustainability of the fishery. This represents the first project in South Africa to consider the utilisation of an alien marine species to generate economic benefits for local communities.

2. Methods

2.1. Experimental design and selection of harvesting sites

Several factors influenced the selection of harvesting sites. Firstly, by design the fishery needed to focus around the communities of Port Nolloth and Hondeklipbaai (Fig. 1), the only two communities in the region with direct access to the coast.

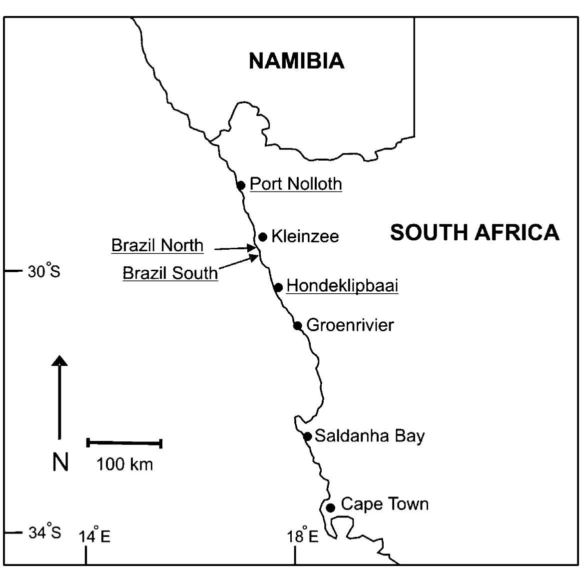

Fig. 1. Map of the west coast of South Africa showing the geographical position of the four harvesting locations (underlined) and other places mentioned in the text.

Secondly, due to diamond-mining activities, open access to the shore in this region is restricted. Thirdly, the remoteness of the region meant factoring in the logistics of transporting people to the sites and mussels from there to the market. In many areas not even freshwater is available. Lastly, the local people employed as harvesters had no history of utilising intertidal resources and very few could swim so it was vital that harvesting sites be as safe as possible with regards to wave-exposure. In an effort to combine the above constraints into a robust experimental setup, a nested design was chosen in which groups of three sites were nested within each of four locations, offering 12 harvesting sites in total. Port Nolloth, Brazil North, Brazil South and Hondeklipbaai were chosen as the four locations (Fig. 1). The sites within each location were separated by a minimum of 50 m and a maximum of 5 km. All harvesting sites were located on gently sloping rocky platforms bordered below by beds of the kelps *Laminaria pallida* and *Ecklonia maxima*. In the pre-harvested state, the mid-shore of most sites was covered by an open mussel-algal matrix dominated by *M. galloprovincialis* and the algae *Gigartina stiriata* and *Champia lumbricalis* and the low-shore zone was dominated by dense beds of *M. galloprovincialis*.

To track the effects of a spectrum of predetermined harvesting intensities on the *M. galloprovincialis* stocks, each site was subdivided into five areas: a control area with no harvesting ($F = 0$), a once-off total clearance area, and areas of $F = 0.3$, 0.6 and 0.9, respectively, referring to preset harvesting intensities where 30, 60 or 90% of the mussel biomass present in the pre-harvest state was harvested over the 6-month duration of the experiment. The order of these areas within each site was randomly allocated. During a pre-harvest survey the standing stock of *M. galloprovincialis* at each site was assessed (see below). As no significant difference between sites was detected in the biomass *M. galloprovincialis* (one-way ANOVA, data log transformed: $F_{11,24} = 2.173$, $p > 0.05$) or its densities (one-way ANOVA, data log transformed: $F_{11,24} = 5.876$, $p > 0.05$), the mean biomass of 246 kg m^{-1} (152 S.D.) was used to calculate harvest intensities that would maintain desired harvesting levels in each area. In an effort to make harvesting simple for the harvesters, the biomass to be harvested from each area was kept the same and the different intensities were achieved by varying the widths of the experimental areas (Table 1). On a practical level the harvest was controlled by allowing the removal of 14 milk crates of mussels (17.5 kg wet weight per crate) from each area. The boundaries of various areas were marked by permanent bolts drilled into the rock above the mean high water mark and near the low tide mark. Upon arrival at a site the harvesters were required attach

Table 1
The width of the various harvesting areas and the harvest of mussels (kg) removed from each

Harvesting intensity	Width of area (m)	Harvest (kg)
Control	10.0	0
$F = 0.3$	10.0	738
$F = 0.6$	5.0	738
$F = 0.9$	3.3	738
Total removal	3.0	738