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Direct estimation of natural mortality of the New Zealand abalone, *Haliotis iris* (Note)

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Abstract Rates of natural mortality (M) of *Haliotis iris* were estimated by monitoring enclosed populations, and from the frequency of empty marked shells recovered from natural populations. Annual instantaneous rates were ≤ 0.1 in all instances. The major source of mortality was predation by the starfish *Astrostele scabra*. Predation by fishes was evidently low. The low rates of natural mortality suggest that fisheries for *H. iris* may be less productive than those of other species of abalone.

Keywords abalone; *Haliotis iris*; natural mortality.

INTRODUCTION

Individuals from exploited marine populations are lost to removal during harvest, harvest-induced mortality, emigration, predation, and other natural causes. Separating natural losses (natural mortality) from other causes is often difficult, yet knowledge of natural mortality is important for an understanding of the demography of exploitable species. For abalone, the methodology and estimation of mortality was reviewed by Shepherd & Breen (1992). Rates of natural mortality vary inter- and intra-specifically. Estimates of instantaneous annual

rates for adult abalone vary over an order of magnitude, from 0.07 to 0.7 (Shepherd & Breen 1992). For the New Zealand abalone *Haliotis iris*, Sainsbury (1982) provided an estimate of 0.1 derived from analysis of the size composition of a South Island population. More often than not, natural mortality is estimated indirectly because of the difficulty of accurately censusing open populations.

In this paper we present the first direct estimates of natural mortality of *H. iris* by monitoring enclosed and unexploited assemblages from one locality. These estimates are compared with others indirectly derived by measuring the frequency of empty shells in marked and unfished populations.

MATERIALS AND METHODS

The study to estimate natural mortality in enclosed assemblages of *H. iris* was located at Reef Bay, Wellington, New Zealand (McShane & Naylor 1995a). Six enclosures (5×5 m) were randomly placed on the sea floor at a depth of 6–8 m. The enclosures consisted of a net of 25-mm square nylon mesh suspended c. 60 cm above the sea floor and were designed to retain abalone. Because the surface area in each enclosure was large (25 m^2) effects of the surrounding mesh on the availability of food (drift macroalgae), water flow, or light availability were considered minimal. The weighted base line of the enclosure followed the surface contours of the bottom and the enclosures were considered impenetrable to most mobile epifauna.

About 1000 individuals collected from surrounding habitat were marked with a numbered polyethylene disc glued to the shell immediately below the spire. The size range of individuals tagged (22–165 mm shell length) reflected that of the local population. Marked individuals were placed randomly in each enclosure during July 1992 (356, 336, and 328 individuals, respectively): tags were coded for individual enclosures. The maximum time of emersion for tagged individuals was 1 h.

Where possible, fortnightly censuses of marked individuals in the enclosures and within 20 m of each enclosure were done. Searches outside, but not inside, the enclosures included overturning boulders. Any marked individuals found outside the enclosures were replaced in the enclosures from which they came. A complete search of the enclosures was done after 12 months. All empty shells were included in the record.

Our study sites at D'Urville Island included three paired bays and exposed headlands with similar north-west facing aspects as described by McShane & Naylor (1995b). The topography was similar among bays and headlands and was solid basalt reef with smaller boulders (10 cm diam.). About 2000 individuals were taken from each of the three bays. These were tagged as above and about 1000 individuals carefully placed in either bay or headland habitat during July 1993 (Table 1). Small individuals (< 80 mm shell length) were replaced under boulders, and larger individuals were returned to open habitat (smooth rocky gutters). At each site, all were replaced within a radius of about 10 m. Tagged individuals were recaptured after about 9 months at liberty by careful searching at all sites.

Natural mortality was estimated from the frequency of marked empty shells (N_1) compared with that of tagged live individuals recaptured (N_0). It was assumed that the shells of animals that were eaten or died from other causes would remain in the enclosures or, at D'Urville Island, within the study area. The probability of finding a live or dead shell was therefore considered to be the same. The hard substratum at all localities meant that burial and subsequent lack of detection of empty shells was unlikely, particularly as at Reef Bay regular censuses outside the enclosures were done. Furthermore, recoveries of empty shells at various periods of liberty indicated that empty shells would

remain intact for at least 9 months (McShane & Naylor unpubl. data). The instantaneous rate of natural mortality (M) was estimated from each enclosure to be: $M = -(1/t) \ln [N_0 / (N_0 + N_1)]$, where t is time at liberty expressed in years.

RESULTS

Five *H. iris* were eaten by starfish (*Astrostele scabra*) soon after introduction to the experimental enclosures. Deaths within 120 h were assumed to have been caused by transfer and were not used in calculating M . Some *H. iris* escaped, particularly after a storm event 12 months after introduction to the enclosures. Mortality was therefore determined for the preceding 9 months for the marked individuals remaining in the enclosures before the storm: during this time < 10% of the marked individuals escaped from the enclosures. The recovery of empty shells, i.e., N_1 , found in the three enclosures were: 12, 5, and 18. Survivors, i.e., N_0 in the experimental enclosures numbered 316, 275, and 281, thus providing estimates of M of 0.05, 0.02, and 0.08.

Few empty shells were found off D'Urville Island (Table 1). Means of M varied between bays ($n = 3$, mean \pm SE = 0.032 ± 0.017) and headlands ($n = 3$, 0.070 ± 0.029) but not significantly (ANOVA $F_{1,5} = 1.27$, *n.s.*).

DISCUSSION

The direct estimation of the natural mortality of *H. iris* was possible because the major predators, the starfish *Astrostele scabra* and *Coscinoasterias calamaria*, leave the shell intact. The results from the enclosures were obtained by careful and regular monitoring of the experimental assemblages. Although some losses of individuals occurred from

Table 1 Summary data for estimates of natural mortality of *H. iris* off D'Urville Island.

Site	Exposure	Live individuals recaptured (N_0)	Dead individuals (empty shells) recaptured (N_1)	M
1	Bay	99	3	0.040
2	Headland	103	2	0.026
3	Bay	142	0	0.000
4	Headland	51	5	0.125
5	Bay	47	2	0.056
6	Headland	45	2	0.058

the enclosures, most were retained. Censuses of the enclosures revealed that up to 50% of the *H. iris* in the enclosures were lost after a storm event after 12 months. Such losses were evident in surveys at this time which revealed many marked individuals outside the enclosures. Before this, escapees were rarely found in the surveys conducted outside the enclosures. Although it is possible that some individuals which escaped from the enclosures died and were not recorded in mortality estimates, natural mortality was estimated before any evident escapement (after 9 months).

Predators such as starfish were not constrained by the enclosures: starfish were observed eating *H. iris* soon after the latter were introduced to the enclosures. Even though the densities within the enclosures were enhanced, the growth rate of *H. iris* within enclosures was the same as that from the natural population (McShane & Naylor 1995a). The enclosures were therefore considered to present no unnatural sources of mortality to the experimental abalone.

Although it is possible that some shells were lost by burial as shown by Hines & Pearse (1982), the habitat surveyed off D'Urville Island comprised flat reef with small boulders. Relatively little sediment was present in which shells could be buried and most of the habitat could be searched for empty shells. Moreover, the rate of natural dissolution or breakage of abalone shells is evidently low (Shepherd 1990): loss over a 9-month period was considered to be negligible. However, rates of recapture of *H. iris* from D'Urville Island were relatively low and the associated estimates for natural mortality should be treated as minima. Nonetheless, the estimates of M from D'Urville Island were similar to direct estimates from Reef Bay.

The estimates of natural mortality from this study are consistent with estimates for another population of *H. iris* (Sainsbury 1982). Rates of natural mortality for *H. iris* are low ($M < 0.1$ per year) compared with estimates for other species of abalone (Shepherd & Breen 1992). One explanation for the comparatively low rate of natural mortality of *H. iris* is that elasmobranchs and other fish, important as predators of other species of abalone (Shepherd & Breen 1992), are evidently unimportant predators of *H. iris* (Schiel 1992). Other predators known to eat abalone, such as

octopuses, were never observed at either locality. Low rates of natural mortality suggest that fisheries for *H. iris* may not be as productive as those based on other species of abalone.

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REFERENCES

- Hines, A. H.; Pearse, J. S. 1982: Abalones, shells, and sea otters: dynamics of prey populations in central California. *Ecology* 63: 1547–1560.
- McShane, P. E.; Smith, M. G. 1992: Shell growth checks are unreliable indicators of age of the abalone *Haliotis rubra* (Mollusca: Gastropoda). *Australian journal of marine and freshwater research* 43: 1215–1219.
- McShane, P. E.; Naylor, J. R. 1995a: Density independent growth in *Haliotis iris* (Mollusca: Gastropoda). *Journal of experimental marine biology and ecology* 190: 51–60.
- McShane, P. E.; Naylor, J. R. 1995b: Small-scale spatial variation in growth, size at maturity, and yield-and egg-per-recruit relations in the New Zealand abalone *Haliotis iris*. *New Zealand journal of marine and freshwater research* 29: 603–612.
- Sainsbury, K. J. 1982: Population dynamics and fishery management of the paua, *Haliotis iris*. 1. Population structure, growth, reproduction and mortality. *New Zealand journal of marine and freshwater research* 16: 147–161.
- Schiel, D. R. 1992: The enhancement of paua (*Haliotis iris* Martyn) populations in New Zealand. In: Shepherd, S. A.; Tegner, M. J.; Guzmán del Prío, S. A. ed. Abalone of the world: biology, fisheries and culture, pp. 474–484. Fishing News Books, Oxford.
- Shepherd, S. A. 1990: Studies on southern Australian abalone (genus *Haliotis*) XII. Long-term recruitment and mortality dynamics of an unfished population. *Australian journal of marine and freshwater research* 41: 475–492.
- Shepherd, S. A.; Breen, P. A. 1992: Mortality in abalone: its estimation and causes. In: Shepherd, S. A.; Tegner, M. J.; Guzmán del Prío, S. A. ed. Abalone of the world: biology, fisheries and culture, pp. 276–304. Fishing News Books, Oxford.