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Original Article

Testing site selection for seeding trials using hatchery reared juvenile *Haliotis mariae* Wood, 1828 along the western Dhofar coast, Arabian Sea, Sultanate of Oman

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Abstract

In order to test site selection and seeding methodology hatchery reared juvenile *Haliotis mariae* with an average shell-length 30-52 mm were seeded along the Dhofar coast during the winter months of the NE monsoon. 18 sites (10 juveniles per site) were sampled after 30, 60, and 90 days. Approximately 70% of the total area seeded comprised habitat that has the potential to shelter and protect juveniles (boulders <50 cm Ø). In total 93% of the juveniles recovered utilized this type of habitat. 86% of the juveniles moved <1m over the experimental period. Growth rates ranged from 1.39 to 3.57 mm month^{-2}. A significant negative relationship was found between time and recovery rates (p=0.04). Site selection and seeding methodology was shown to be consistent and reliable, paving the way for larger scale long-term seeding experiments.

Keywords: *Haliotis mariae*, restocking, seeding, habitat selection, seed densities

1. Introduction

The wild abalone (*Haliotis mariae*, Wood 1828) fishery along the Dhofar coast forms an integral and important part of Omani fishing culture. Fishermen from communities between Ras Mirbat in the west, through Sadah, Hadbin, Hassik and Ras Sharbithat in the east, utilize this seasonal resource as part of a multi species fishery (Figure 1, Al-Hafidh, 2006; Sanders, 1982). Like many other commercial abalone species worldwide, this abalone species has drastically declined in abundance over the last decade (Guzmán del Próo *et al.*, 2004; Al-Rashdi and Iwao, 2008; Raemaekers *et al.*, 2011). The Ministry of Agriculture and Fisheries in Oman has implemented strategies aimed at protecting the abalone fishery, one of these was closing the fishery from 2008 until 2010. The recovery from this closure was short-lived and average abalone densities throughout most of the fishery have declined from 2012 to 2013 (unpublished data), and abalone stocks are still considered overexploited (Balkhair *et al.*, 2013). The development of stock enhancement or restocking technology (Bell *et al.*, 2006, 2008; de Waal *et al.*, 2013; Hart *et al.*, 2013a) is an additional management strategy now under consideration by authorities.

Seeding research using hatchery reared juveniles has been undertaken in a number of countries, including Japan, South Africa, Australia, New Zealand, and China (de Waal, 2002; Gallardo *et al.*, 2003; Guzmán del Próo *et al.*, 2004; Simizu and Uchino, 2004; Hutchette *et al.*, 2005; Dixon *et al.*, 2006; Hart *et al.*, 2007; Heasman *et al.*, 2007; James *et al.*, 2007; Roberts *et al.*, 2007; Roodt-Wilding, 2007; Prince and Peeters, 2010; Hart *et al.*, 2013a). Oman now has the capability to produce hatchery-reared abalone (Al-Rashdi and Iwao, 2008; Balkhair *et al.*, 2013). Once seeding methodologies have been developed to optimize survival over both short and long term, large scale restocking strategies can be developed for *H. mariae*. Small-scale experiments can

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produce the required data to develop seeding methodology without doing large-scale extensive mass seeding experiments (de Waal, 2005; Read *et al.*, 2013; Hansen and Gosselin, 2013; de Waal *et al.*, 2013). The goal of this study is to further develop and test the knowledge and methodology established in a prior seeding experiment conducted with translocated wild juveniles described by de Waal *et al.* (2013).

The availability of seed of a suitable size and suitable diving conditions determined the timing of the experiment. During the summer months (July to September) the SW monsoon winds drive a strong surface ocean current (Somali Current) across the Arabian Sea inducing ocean and coastal upwelling (Tudhope *et al.*, 1996). This period is also associated with rough seas that make scientific diving very difficult. From the beginning of the SW monsoon (June, July) until late October/November there is an abundance of food available for abalone resulting in significant increases in growth rates in juveniles (de Waal *et al.*, 2013), but the masses of algae make searching for juvenile abalone very difficult. From December until May/June, growth rates decline (de Waal *et al.*, 2013) but there is little macroalgae, making sampling very effective. As a result seeding took place when food availability declines and by the end of the experimental period growth rates were at a relative seasonal minimum. The combination of open and macro-algae free habitats and small seeding densities increase searching efficiency by the divers. While we did not use any statistical manipulation to estimate accuracy (Hart *et al.*, 2007), recovery rates are direct counts of abalone found. Underestimation of survival due to abalone not being found is definitely possible.

2. Methods

2.1 Seed size

In this study, we have investigated the effects of seeding juvenile abalone ranging in SL (shell length) from 30 mm to 52 mm (SL). In seeding experiments in a number of countries, South Africa, New Zealand, Australia, and Canada juveniles in this size range have been used (Schiel, 1993; de Waal, 2002; Roberts *et al.*, 2007; Hart *et al.*, 2007; Read *et al.*, 2013).

2.2 Selecting suitable seeding sites

Seeding site selection, comprising largely of habitat specifically suited for juveniles, under-boulder habitat, cracks and crevices, has been shown to be vital to the survival of seeded juveniles (Hutchette *et al.*, 2005; de Waal, 2005; Dixon *et al.*, 2006; Hart *et al.*, 2007; Heasman *et al.*, 2007; Roberts *et al.*, 2007; Hart *et al.*, 2013a). In some abalone species, both recruits and juveniles are found predominantly under sea urchins (Day and Branch, 2002; 2000; de Waal, 2005; Goodsell *et al.*, 2006). However, studies in Oman have shown that under specific conditions urchins do play a significant role in supporting a large proportion (H"38%) of the wild juvenile abalone population in the fishery areas of the Dhofar coast (de Waal *et al.*, 2012). As a result, the presence of urchins is not considered crucial in site selection here.

Seeding sites were selected that comprised habitat similar to that which supported wild juveniles (de Waal *et al.*, 2013). Six experimental seeding sites were selected in each of three areas stretching over a distance of approximately 80 km of coast (Figure 1). Raha, the most westerly, Haat, approximately 40 km north east of Raha, and the most easterly, Hassila just outside Hadbin. In each of these three areas, each seeding site was separated from the next by a distance of between 10 and 20 m. Each site was marked with a lead weight and a colored piece of rope tagged with a number. All abalone were individually tagged and numbered.

Selection of seeding sites was done visually, based on physical characteristics of habitat supporting wild juveniles (de Waal *et al.*, 2013). An attempt was made to maximize the proportional cover of small boulders in comparison to larger boulders and to minimize exposed area (reef, bedrock or sand offering no shelter to juvenile abalone). Physical and biological habitat characteristics were quantified for each of the sites. Seeding was done at the beginning of December when macro-algae abundance was declining rapidly.

2.3 Seeding methodology

2 to 4 days prior to seeding the juvenile abalone were individually tagged using superglue and numbered plastic tape. Shell length (SL) was measured for each individual used in this series of experiments. One day prior to seeding the loose juveniles were placed in small net bags, 10 at a time, the bags were kept in tanks at the Mirbat facility. On the day of seeding, the net bags containing the juvenile abalone were placed in plastic cooler boxes and transported to the seeding sites by vehicle. On site the bags with the abalone were immediately placed in the water, once the divers had transported them to the preselected stations the abalone were seeded by the divers (de Waal *et al.*, 2013).

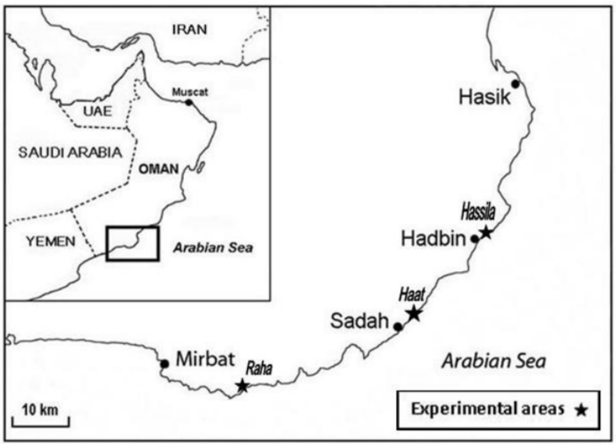

Figure 1. Experimental seeding areas along the Dhofar coast of Oman (Map supplied by Mikhail V. Chesalin).

All juvenile abalone were seeded by hand, placed directly into cracks and crevices and under boulders. Normally the juveniles clump together in the net bags in which they are transported and so a number, two or more, will usually be seeded together (Schiel, 1993; Hart *et al.*, 2007; de Waal *et al.*, 2013). Abalone are held against the surface of the rock or crack until they attach securely. Observations are made until the abalone are obviously stable. The seeding experiments comprised six sites in each of the three areas. Each of the three experimental areas were seeded on separate days, Hassila on the 4th, Haat on the 5th, and Raha on December 6, 2012. Seeding took less than one hour on each day. Ten abalone, average size 40.22 mm SL (SD 4.1), were seeded in each of the six sites. All 10 abalone were released within a couple of centimeters from each other so that survival could be compared on the smallest microhabitat scale possible within the context of these experiments. The same two divers (authors) did all site selection, seeding and sampling. Sampling was destructive and exhaustive; with the same searching methods employed throughout.

2.4 Description of each site.

Each site comprised a circle 6 m in diameter (Ø). Sites were described in the following basic substratum categories (estimates were made by the same person throughout the series of experiments):

1. % area exposed, sand, reef or big boulders surface that cannot provide shelter for juvenile abalone.
2. % area comprising boulders with a diameter (Ø) greater (>) than 50 cm.
3. % area comprising boulders with a diameter (Ø) between (-) 30 and 50 cm.
4. % area comprising boulders with a diameter (Ø) less (<) than 30 cm.
5. % area covered by crustose coralline algae.
6. Number of urchins.
7. Number of wild juvenile abalone.
8. Depth.

Statistical analyses were conducted using StatistiXL Software. Non-parametric analyses were used because data sets were limited in size. Variability in habitat categories (listed above) was tested between the three areas using KruskalWallis Tests.

2.5 Sampling regime

Within the context that physical, environmental and ecological characteristics are not constant between sites, site selection, seeding and sampling was standardized as far as possible in all three areas (de Waal *et al.*, 2013). In each area, the two sites sampled at the end of the specific sampling period were replicates of one treatment. Sampling was conducted in each area on separate days, in the same order that seeding took place. In total six sites were sampled after each experimental period. In each area, two sites were sampled after a period of 30 days, two after 60 days and the last two after 90 days. (In Raha 7 sites were seeded. After the first 30 days, one site was found to be completely covered by sand. Only one juvenile was found buried under the sand. This site was therefore discarded as an outlier and the additional site was sampled after 90 days. Raha therefore has three sites sampled after the 90-day period. This is reflected in the analyses). This study yielded data from 18 sites sampled over a period of 90 days.

2.6 Recovery rates and the effect of sampling period and area.

After each sampling period recovery rates from each of the sites were recorded as minimum number surviving. A Spearman Rank Correlation (1 tailed negative correlation) analysis was conducted to test for a relationship between time and recovery for all the sites sampled over the 90 day experimental period Mann-Whitney tests were applied to data from each time to test variability between areas.

2.7 Relationships between juvenile abalone recovery rates, habitat categories, urchin and wild juvenile numbers per site, and habitat utilization by recovered juveniles.

Spearman Rank Correlation Tests were conducted to test for relationships between recovery rates and the different site attributes for each of the 18 sites. The number of recovered juveniles utilizing each habitat category, including urchins, for shelter was recorded for each site, the data was then pooled. Mann Whitney tests were then conducted to test for significant variability in utilization by juvenile abalone between individual habitat categories. A Kruskal-Wallis Test was conducted to test for variability in habitat utilization between areas.

2.8 Dispersal and growth

Dispersal from the actual point of release was measured for all abalone recovered in a circle of diameter (Ø) 6 m. Frequencies of dispersal were calculated within 1 m distance classes from the point of release. Because the data sets were limited in size, dispersal frequencies in distance categories for all 18 sites were pooled. Mann-Whitney Tests were conducted to test for differences between individual distance categories. A Spearman Rank Correlation was conducted to test for a relationship between time and distance moved for all sites pooled.

Firstly growth rates from each individual abalone sampled where grouped by sample period and then by area. Variability between specific areas were compared using Mann-Whitney Tests for each of the sample periods, 30, 60, and 90 days. Secondly, growth rates from all sites in each area were pooled and variability between areas was tested using a Mann-Whitney Tests.

3. Results

3.1 General relative characteristics of each experimental area

Although the seeding sites were selected visually with respect to physical characteristics such as the prevalence of small boulders and less exposed area, be it bedrock or sand, detail results show that this was not always the case (Table 1). The Raha sites were generally deeper than both Hassila and Haat, depth differences tested significant (p=0.01, see Table 1). Raha also had the most urchins, the other two sites had between 35 and 45% less. Hassila had the least wild juveniles, almost 50% less than Haat and 25% of those found at Raha, the deeper area. The proportional cover of crustose coralline algae on the rock and boulder surfaces was similar in Raha and Haat, and approximately 40% lower at Hassila, one of the two shallower areas. Both Hassila and Haat comprised less exposed habitat, 10-20%, while Raha comprised 53%. Hassila had almost double the amount of boulders >50 cm Ø (46.7%) than the other two sites, Raha had the smallest proportion of boulders 30-50 cm Ø, and Haat the highest (Table 1). Raha had the least amount of the smallest boulders, 6.6%, Hassila 15% and Haat the most, 35.4%. The differences in exposed habitat tested significant between areas (p = 0.01).

Keeping in mind the complexity in shape of natural boulders and the degree to which that affects estimates of true boulder diameter the proportional cover of small boulders varied between sites. Haat had the most available under-boulder (the inverse of exposed) habitat (89%), Hassila slightly less (79%), and Raha the least (47%) (Table 1).

3.2 Recovery rates

Recovery rates between areas varied throughout the sampling period (Table 1). By the end of the 90 day-experiment the average recovery rates for all three areas was approximately equal at 60%. The recovery rates varied between sites and times with no consistent pattern (Table 1). However when average recovery rates are pooled from all sites sampled over each sampling period and plotted against

Table 1. General habitat characteristics for each experimental area. p values are for variability in physical characteristics between sites using the Kruskal-Wallis Test (* denotes significance at 95% confidence limits).

Area	Sampling period (days)	% Recovered	Depth (m)	Area exposed	Boulders >50cm Ø	Boulders 30-50cm Ø	Boulders <30cm Ø	% Area CCA	No Urchins	No Wild juveniles
Hassila	30	80	0.5	30	20	30	20	30	36	1
Hassila	30	90	0.5	15	60	5	20	5	12	0
Hassila	60	90	0.5	10	60	20	10	30	77	2
Hassila	60	30	1.5	20	60	10	10	50	57	1
Hassila	90	40	2.5	35	30	20	15	30	0	2
Hassila	90	30	3	15	50	20	15	20	83	23
Ave.		60	1.42	20.83	46.67	17.50	15.00	27.50	44.17	4.83
SD		29.66	1.11	9.70	17.51	8.80	4.47	14.75	34.07	8.93
Haat	30	70	0.5	15	0	42.5	42.5	30	1	4
Haat	30	80	0.5	0	0	30	70	30	16	14
Haat	60	30	0.5	0	20	10	70	30	37	15.0
Haat	60	60	0.5	0	60	20	20	60	80	5.0
Haat	90	50	1.5	0	20	70	10	70	144	15
Haat	90	70	2	50	25	25	0	50	35	7
Ave.		60	0.92	10.83	20.83	32.92	35.42	45.00	52.17	10.00
SD		17.89	0.66	20.10	22.00	21.12	30.27	17.61	52.27	5.22
Raha	30	40	2.5	80	10	0	10	80	80	35
Raha	60	90	4	40	30	20	10	20	8	23
Raha	60	90	5.5	30	40	20	10	40	4	11
Raha	90	30	2	30	60	10	0	45	180	11
Raha	90	60	2.5	80	0	10	10	60	130	2
Raha	90	40	2.8	60	20	20	0	40	85	16
Ave.		58.33	3.22	53.33	26.67	13.33	6.67	47.50	81.17	16.33
SD		26.39	1.30	23.38	21.60	8.16	5.16	20.43	68.52	11.45
p			0.01*	0.01*	0.12	0.08	0.05	0.14	0.54	0.05

time a downward trend is clearly visible decreasing from 72 % (±8.6 SE), to 65 % (±12 SE) and then to a minimum of 45.7% (±12 SE) over 30, 60, and 90 days respectively. A Spearman Rank Correlation 1-tailed test for negative correlation did show a significant negative relationship between time and recovery rates (p=0.04). The Mann Whitney tests applied on recovery rates between areas for each time period tested insignificant.

3.3 Recovery rates and habitat utilization

Mann-Whitney Tests showed the differences to be significant between the utilization of urchins and all categories of boulders (p=0.04, 0.04, and 0.001 for the largest to the smallest boulders respectively). Tests between the utilization of the different boulder classes were not significant. Because only four abalone were recovered from exposed habitat analyses testing the utilization of this type of habitat is considered redundant. The habitat most frequently utilized by seeded juveniles was small boulders (<30 cm Ø) and then the larger boulders (>50 cm Ø). Urchins were very rarely utilized (Table 2, Figure 2). A KruskalWallis Test revealed that the pattern of habitat utilization did not vary significantly between areas.

3.4 Dispersal and recovery

More than 85% of all seeded juveniles recovered were found within 1m from the point of release. Differences tested significant between the 1st and both the 2nd and 3rd m distance categories (Table 3, p=<0.001 for both). A Spearman Rank Correlation for all the data pooled tested not significant for any relationship between distance moved and time.

The sites with the highest recovery rates showed the least dispersal (Table 3). In all three areas lower recovery rates were associated with evidence of dispersal. At the sites with the lowest recovery rates, 35 and 40%, seed were recovered in both the 2nd and 3rd m interval from the seeding point. This was also found for one of the 60% recovery sites. Without ongoing (24 hrs) monitoring, which was not done in this study, detailed dispersal patterns or evidence of dispersal is difficult to interpret.

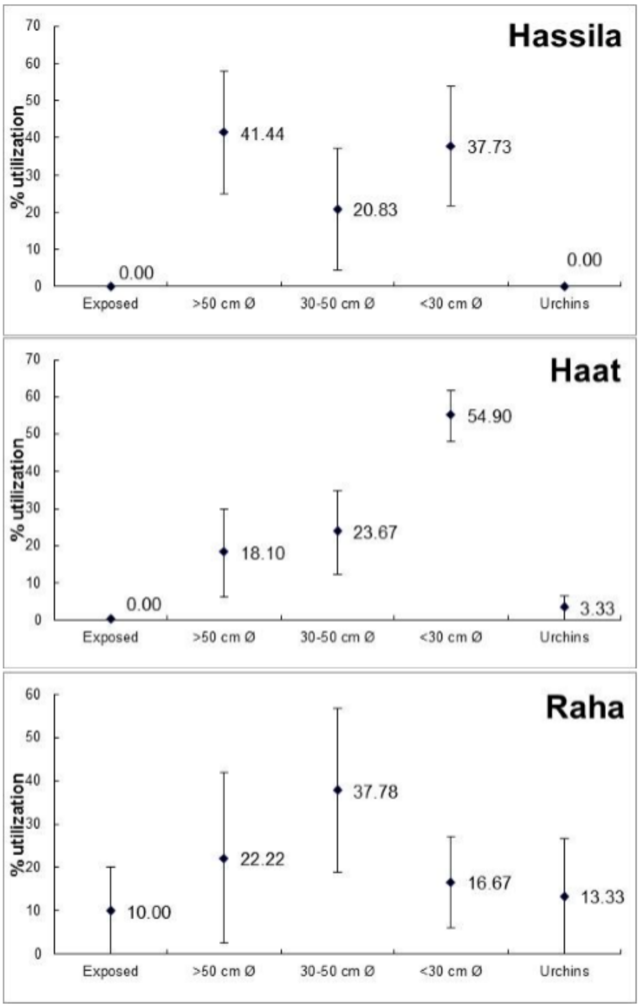

Figure 2. Proportional utilization of each habitat category by juvenile abalone in each area (Mean ± S. E.).

Table 2. *p* values from Mann Whitney tests show variability in the utilization between specific habitat categories by juvenile abalone. (* denotes significance at 95% confidence limits). Bottom row shows average % utilization of habitat categories by juvenile abalone.

Categories	> 50 cm Ø	30 -50 cm Ø	< 30 cm Ø	Urchins
Exposed area	0.04*	0.034*	0.001*	1
> 50 cm Ø		0.99	0.192	0.04*
30 -50 cm Ø			0.252	0.04*
< 30 cm Ø				0.001*
% utilization by juvenile abalone				
Exposed area	> 50 cm Ø	30 -50 cm Ø	< 30 cm Ø	Urchins
3.74	28.97	24.30	41.12	1.87

Table 3. Percentage frequency dispersal in 1-m distance categories for all abalone recovered. Mann-Whitney tests showed the significant variance to be between the first distance category and the two other categories, not between the second two (in both cases p=< 0.001* at 95% confidence limits).

	Period (days)	Distance categories (m) 1-1.9 m	2-2.9 m	3-3.9 m
Hassila	30 days	100	0	0
	60 days	100	0	0
	90 days	71.43	14.29	14.29
Haat	30 days	100	0	0
	60 days	77.78	22.22	0
	90 days	75.00	16.67	8.33
Raha	30 days	60.00	20.00	20.00
	60 days	100	0	0
	90 days	92.31	7.69	0
	Average	86.28	8.99	4.74

3.5 Growth rates

Seeded occurred during December, winter, when water temperatures average around 25°C. The 18 sites sampled in this series of experiments ranged in depth from less than 1 meter to approximately 5.5 m. The highest average growth rate was measured at Hassila 3.2 (SD 1.3) mm, next at Haat 2.7 (SD 1.4) mm, and the lowest at Raha 2.1 (SD 1.1) mm. The shallowest area was Haat, with an average depth of 0.92 m, and the deepest Raha, at 3.2 m (Table 1). Average growth rates appeared to vary between sites, with the shallower sites generally showing higher growth rates than the deeper ones. When the average growth rates for each period were pooled within each area and compared, using the Mann-Whitney Test, the difference in growth tested significant in each case between one of the two areas with shallower sites and the area with the deeper sites, Raha. Over the 30 day-period the difference tested significant between Raha and Hassila (p = 0.11), over the 60 day period it was between Haat and Raha (p=0.027), and over the 90-day period there was a significant difference between the two shallower areas Hassila and Haat (p=0.017) and Hassila and Raha (p=0.006). As in the previous analysis, Hassila yielded the highest average growth rate compared to Haat, the area with shallowest average site depth, and Raha, the area with deepest average site depths.

4. Discussion

4.1 Recovery rates

The primary goal behind this study was to test the strength of site selection and seeding methodology developed in an earlier experiment using wild juveniles (de Waal *et al.*, 2013). Short-term recovery rates have been used as the primary indicator of success. In contrast to the experimental design followed by Hart *et al.* (2013), which allowed for long term monitoring of the same sites, our method of destructive sampling (which optimizes finding juveniles) did not allow this. Their study showed that over an extended period both juveniles and adults can move both in and out of an experimental area, affecting recovery and therefore expected potential survival rates over time. In our study the relationship between time and recovery was considered weak and therefore not a good indicator of success either way. Similar overall recovery rates did however indicate that the quality of site selection was reasonably consistent throughout. While we do not know what happened to the juveniles we did not recover (Prince and Peeters, 2010), we do know that those that have survived and grown over the 30 to 90 day periods survived through the period that food was severely limited, reflected in low growth rates (de Waal *et al.*, 2013). It is possible that seeding in times that food is abundant will affect survival beneficially. The recovery rates found in this study are comparable to those found in studies conducted on other abalone species in similar size classes and over similar time scales (Hutchette *et al.*, 2005; Goodsell *et al.*, 2006; Hart *et al.*, 2007; James *et al.*, 2007; Roberts *et al.*, 2007; de Waal *et al.*, 2013). What this research has also shown clearly is that regardless of seeding methodology and the selection of sites with similar characteristics, recovery rates are variable between sites. Comparisons between sites, geographic areas, and species should be done with caution (de Waal *et al.*, 2013).

4.2 Habitat selection, depth, urchins and growth

Interpreting results on a site specific scale is important because abalone will be seeded according to the criteria developed and evaluated through this series of experiments. All three geographic areas have yielded both good and bad recovery rates, overall however, the results show that with appropriate habitat selection seeding could be successful in any of the areas. These areas reflect the abalone fishery area along the western Dhofar coast, in other words there is abundant similar habitat available throughout the fishery. Those factors measured in these experiments are only part of the process required to evaluate the potential viability of seeding juvenile *H. mariae*, either wild or hatchery bred. The costs of producing different size classes of juveniles and the potential impact on wild fisheries have not been addressed here (Roberts *et al.*, 2007; Hart *et al.*, 2013a,b).

The most important fact that drives short-term survival is the fact that juvenile abalone are photosensitive and they attempt to move into shade as soon as possible (de Waal *et al.*, 2013; Prince and Peeters, 2010; de Waal, 2005; 2002). If that shade is provided by habitat that can protect the abalone from predation it is an added benefit. Approximately 70% of the total area seeded comprised habitat that has the potential to shelter and protect juveniles (boulders <50 cm

Ø). This type of habitat typically comprises layers of small boulders, the more physically complex the site the more habitat there is for juvenile abalone (Hutchette *et al.*, 2005; Dixon *et al.*, 2006; Heasman *et al.*, 2007). In total 93% of the juveniles recovered utilized this habitat. The pattern of specific habitat selection made by recovered juveniles did not vary significantly between areas (Figure 2). The measure of quality of the most favored habitat could include availability of food, specific predator species, and unmeasured small scale (the scale at which an individual abalone lives) microhabitat effects. Those sites with an abundance of smaller boulders appear to be more effective for survival. This could reflect the availability of surface area on which microalgae settles and grows, and therefore grazing can take place.

Within the restricted depth range of this study, no significant effect on survival by depth was evident. In this study, urchins played an insignificant role in the survival of seeded *H. Mariae* juveniles. The relationship between seeded juveniles and urchins is also not that significant with either *Haliotis midae* in South Africa (de Waal, 2005), or with *Haliotis rubra* in Australia (Goodsell *et al.*, 2006). The growth rates measured in the sea are comparable to those for the same species reared in the Mirbat hatchery where juveniles have been shown to grow up to 4.1 mm per month (Al-Rashdi and Iawo, 2008). These growth rates are seasonal and monitoring of tagged wild juveniles in 2012 showed a marked increase beginning in May/June (de Waal *et al.*, 2013). Growth rates are important because of the potential relationship between seed size and survival reported in a number of experiments internationally (Schiel, 1993; Hart *et al.*, 2007; Heasman *et al.*, 2007). In this study Hassila, not the shallowest site yielded the highest average growth. It is the easterly site and factors such as water temperature and available nutrients may have caused this. These factors are not measured in our study.

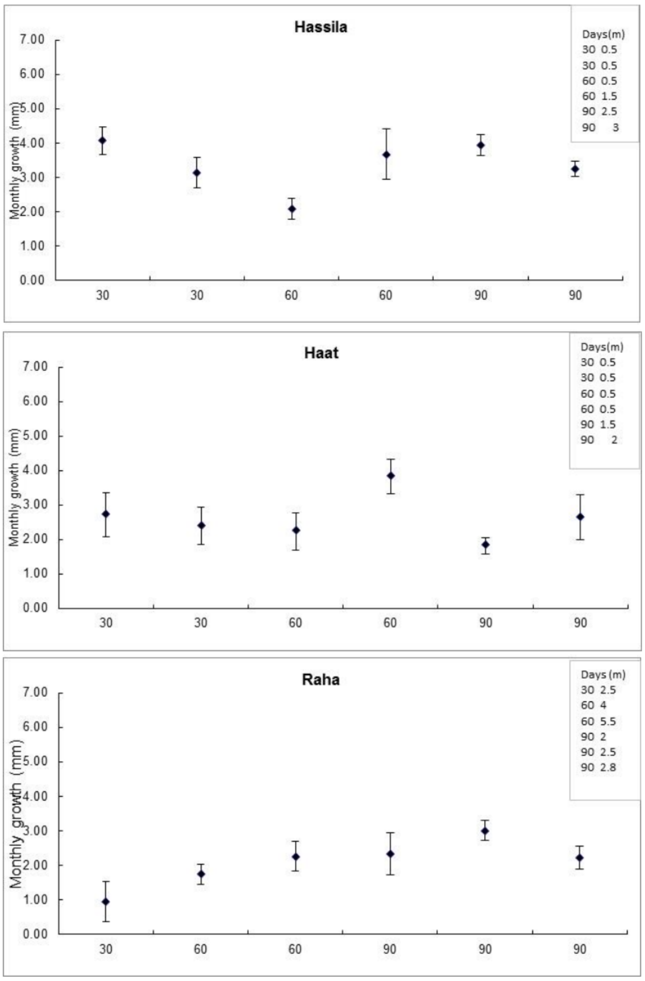

Figure 3. Mean monthly growth rates (± S. E.) for each site over the three sample periods in each of the three geographic areas. Inset in each figure gives the period in days (left hand column), and depth for each site in meters (right hand column).

4.3 Dispersal

Evidence of dispersal could indicate that low recovery rates may not be because of mortality but because of dispersal (de Waal *et al.*, 2003; Prince and Peeters, 2010; de Waal *et al.*, 2013). In the majority of the sites used here, dispersal was limited. As a result, where no dispersal was evident low recovery rates were assumed to indicate low survival. Juvenile abalone need to move as they grow, increased growth and the transition between juvenile and sub-adult phase may require movement to new habitat as they mature (Hart *et al.*, 2013a). If this dispersal occurs during a short-term experiment recovery rates will be low but not a reflection of potential survival. The relationship between increased growth rates and dispersal needs much further investigation.

5. Conclusions

This study has shown that the criteria used for site selection and the seeding methodology used is successful. There may be some benefit gained from seeding when food is more abundant, just prior to and after the SW Monsoon. This, amongst other factors such as decreased seeding size need to be investigated in the next phase of research. In the context of larger scale, long term seeding projects research must take place to investigate the relationship between seeding densities, potential survival and adult stocking densities related to habitat capacity.

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