A PRELIMINARY SUMMARY OF THE EFFECTS OF HAND REMOVAL OF *DRUPELLA CORNUS* ON NINGALOO REEF

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INTRODUCTION

Drupella cornus infestations, result in coral mortality on a massive scale. As a consequence, the causes and management of these population explosions have been the subjects of debate. With millions of tourist dollars in jeopardy, natural resource managers are placed under public pressure to control the infestations. However, the absence of scientific understanding precludes the implementation of well informed management decisions. From a managers viewpoint, there are two basic questions which must be answered; 1) is the plague a natural phenomenon? and, 2) how can the plague be controlled? As a consequence of any delay in the availability of a scientifically verified answer to question 1), natural resource managers must decide whether to manage all of the affected area as though it were a natural phenomenon, manage all of the affected area as though it were a human induced phenomenon, or divide the affected area and implement appropriate management regimes under both scenarios. Even if subsequent research indicates the plague to be part of a natural cycle, there may still be small sections of reef where some form of control of the plague species might be justified. In addition, awaiting a conclusive answer to question 1) could considerably delay the development of control measures. It is therefore appropriate to investigate control techniques before question 1) is fully answered.

Holborn (1990), recommended that management of *Drupella* is likely to be most effective at the larval and recruitment stages. However, efforts so far have concentrated on adult populations. Japanese workers have been removing aggregated snails by using air-lift pumps and trials are in progress to test the effectiveness of baited traps (Yamaguchi, pers. comm. University of the Ryukyus).

The control techniques which have so far been investigated are labour intensive and therefore expensive to implement. One method of minimizing cost is to enlist volunteer assistance. With increasingly restricted budgets, management agencies are under pressure to reduce expenditure and a trend towards increased volunteer involvement is emerging.

This report summarizes the results of an experiment to investigate the effectiveness of hand removal as a technique for controlling *Drupella cornus* in a small area of Ningaloo Reef. The effectiveness of volunteer involvement is also considered.

METHODS

An experimental area was selected offshore from the township of Coral Bay on the back reef section of Ningaloo Reef where a *Drupella cornus* infestation was in full progress. The area was characterized by mostly hard substrate on which branching and plate *Acroporas* predominated but large numbers of snails were active causing obvious coral scaring and mortality.

The corners of two plots, each 25 metres by 25 metres were marked permanently with star irons. Both plots were orientated approximately parallel to the reef crest. One was treated as the experimental area while the other was used as a control. Care was taken to select experimental and control plots with minimal large scale substrate variation.

When each survey was carried out, marker buoys were attached to the corners and ropes were stretched between corner marks to define the plot boundaries underwater. The centre point of each boundary rope was marked to facilitate the placement of line transects, and a tape measure was then run between the rope marks across the centres of each plot. This was done twice, once in a north/south orientation and then in an east/west direction. The tape was used to estimate substrate type and live coral cover using a line intercept technique. In this way, a total transect length of 50 metres (2 x 25m) was sampled in both the experimental and control plots.

Within the experimental plot, ropes were used to delimit a grid of 25 squares each five metres square. Tension was maintained on the ropes which were also secured at each pre-marked cross over point to ensure the formation of geometrically regular grid squares. Numbered strands of surveyors tape were secured near the centre of each square to facilitate square identification.

Within the control area, between three and five grid squares were selected and defined using ropes. Grid squares through which the transects passed were avoided and of the remaining 16 squares, an effort was made to minimize the selection of squares which had been sampled during previous surveys. Marked strands of surveyors tape were secured within each selected grid square to facilitate square identification.

Divers using SCUBA apparatus spent 20 minutes removing all the *Drupella* that they could find within an allocated square. Snails were placed in labelled calico specimen bags until processing. Grid squares were searched repeatedly by at least two and usually by three or sometimes more divers during each survey. Collections were conducted over two or three day periods. Following the first survey, work on the experimental area was divided to ensure that all repeat searches within individual grid squares were completed during a single day.

A effort was made to minimize coral damage during searches. Divers were instructed to secure all gauges and other equipment appendages to prevent damage to the substrate. They were also requested not to enter the control grid unless involved in control collections and to approach their allocated squares along the shortest route from the edge of the plots. In addition, divers were instructed to avoid supporting themselves on live coral and they were told not to break coral in order to collect snails which were beyond their reach.

Surveys were conducted on the following dates: 1) 30th June and 1st July 1990; 2) 21st and 22nd August 1990; 3) 16th and 17th February 1991; and 4) 9th March1991. The intervals between surveys were seven weeks, seven months and three weeks respectively. During the first three surveys, line transects were carried out and all experimental grid squares and selected squares in the control area were searched for *Drupella*. In March, survey work was limited to searches within the control grid plus an incomplete search of the experimental plot.

A total of 32 divers were involved during all four surveys. Most were volunteers with a wide range of abilities and experience. Each diver was assigned to one of four categories of experience namely: novice, recreation diver, scientific diver, or *Drupella* diver, according to their previous diving history. However, care was taken to ensure that approximately half of the divers involved in each survey had either worked with *Drupella* before or were experienced scientific divers.

Collected snails were processed as follows; the date, diver's name, grid number and search number were recorded together with the numbers of live and dead snails from each sample bag. Maximum shell length was measured using vernier callipers. Random samples of 100 shells were measured from each grid square during the first two surveys, but during the February 1991 and March 1991 surveys, most shells were measured with samples of each individuals collection being kept separate to enable comparisons of diver abilities.

Control samples were usually processed on board a boat and returned immediately to the grid square from which they were collected. In March 1991 however, logistic constraints necessitated their processing on shore. Animals were kept overnight immersed in the waters of Coral Bay and they did not appear to suffer any ill effects before being returned to the control area the following morning. Snails collected from the experimental area were not returned.

The numbers of recovered snails were used to determine both the abilities of divers and estimates of snail density using the model:

$$F_i = (T - \sum_{j=1}^{i=1} F_j) \times D_i \qquad - (1)$$

where

F_i is the number of snails found on the ith dive;

T is the total number of snails in the search area; and

D_i is the ability of the diver to find snails.

Equation (1) was log-transformed and solved using linear least-squares estimation. This procedure achieved two aims. First, bias introduced by varying abilities of divers to find snails was determined, thus enabling and estimate to be made of the number of *Drupella* snails initially present.

RESULTS AND DISCUSSION

Substrate cover

The amount of sea bed covered by any substrate type was calculated as the sum of the distances between the boundaries of that substrate type along the line transect. Distances were converted to percentage cover by dividing by the total transect length (25 metres).

	CONTROL		EXPERIMENTAL	
DATE	N-S	E-W	N-S	E-W
June	27.0 (25.1)	13.3 (10.2)	39.2 (35.5)	36.3 (33.2)
August	28.7 (20.8)	31.5 (26.0)	45.3 (41.6)	45.9 (43.6)
February	24.8 (20.5)	13.5 (10.9)	39.4 (37.7)	41.8 (40.2)

TABLE 1. Percentages of live coral cover along four 25 metre transects during June 1990, August 1990 and February 1991. Figures in brackets are the percentages of live *Acroporas* while figures outside brackets are the percentages of all live coral.

Acropora was the dominant genus within both experimental and control plots (Table 1). Throughout the sampling period, the experimental area contained a higher percentage of living coral than the control area.

There is no evidence of any trend toward changes of live coral cover as a result of the experiment. However, as corals grow slowly, the detection of any consistent trend after just seven and a half months would be unlikely.

Transect data from August indicated that there was more live coral at this time. This could not have represented a real change in coral cover since July because of slow coral growth. There was a strong surge while these data were being gathered and it is likely that the tape was bent onto nearby substrate. Such variation within the data will necessitate the continuation of this experiment for some time if real changes in coral cover are to be detected. To minimize variation with subsequent surveys, effort should be made to work only in ideal underwater conditions and to increase the replication of transects.

Diver abilities

The index used to describe the ability of each diver is equivalent to the proportion of snails within a sample area which that diver would be likely to find. Diver ability index values ranged from 15.3354% to 89.6484% with an overall mean value of 47.2% (Table 2). More experienced divers were better at finding *Drupella* snails than novice and recreational divers. Novice and recreational divers generally found less than half of the snails within a plot.

EXPERIENCE CATEGORY	NUMBER OF DIVERS	MEAN INDEX ABILITY VALUE	STANDARD DEVIATION	NO. DIVES REQUIRED TO REMOVE 75% SNAILS
Novice	7	27.71	7.94	5
Recreation	11	42.39	16.12	3
Scientific	6	57.10	17.17	2
Drupella	8	63.32	16.24	2

TABLE 2. Diver experience categories and search abilities. The ability index values are equivalent to the percentages of snails which a diver would remove from an experimental area. The right hand column represents the amount of effort required by each diver category to undertake the same task.

Based on the mean abilities of each group, the minimum number of dives required for divers within each experience category to remove 75 percent of the snails within the experimental area was calculated. On average, it takes novice divers more than twice the effort of either scientific or *Drupella* divers to complete the same task. In addition, novice divers are relatively clumsy underwater and cause more coral damage than experienced divers. As a result, scientists need to be selective when recruiting divers to undertake even simple tasks such as the removal of snails, and the enlisting of inexperienced volunteer divers is a false economy.

The ability of each diver to find juvenile snails was investigated by correlating the proportion of small snails (less than 2.95cm) found by each diver with their search ability indices. A small correlation ($R^2 = 0.16$) was detected. This implies that divers who were good at finding snails were more likely to be good at finding juvenile snails than divers with low ability index values.

Variations in snail numbers

Model-corrected estimates of snail numbers were compared between dates, and between control and experimental grids using contrasts following analysis of variance. As this experiment is as yet incomplete, we do not present the ANOVA results here. The following summarizes our interim results: Variation among the numbers of snails within control and experimental plots on different survey dates are summarized in figure one. No significant differences were detected between control samples from the first and second surveys, nor between the combined control data from the first and second survey and the experimental data from the first survey. No significant difference was found between control samples from the third and fourth surveys. However, the number of snails within the experimental plot on the third survey was significantly different from the combined control samples from surveys three and four. The repeated hand removal of snails had therefore resulted in a reduction in snail numbers within the experimental plot.

Although the intervals between surveys ranged from three weeks to seven months, by careful examination of the data we found no evidence to suggest that there were more snails towards the edges of the experimental grid than in the centre. It can

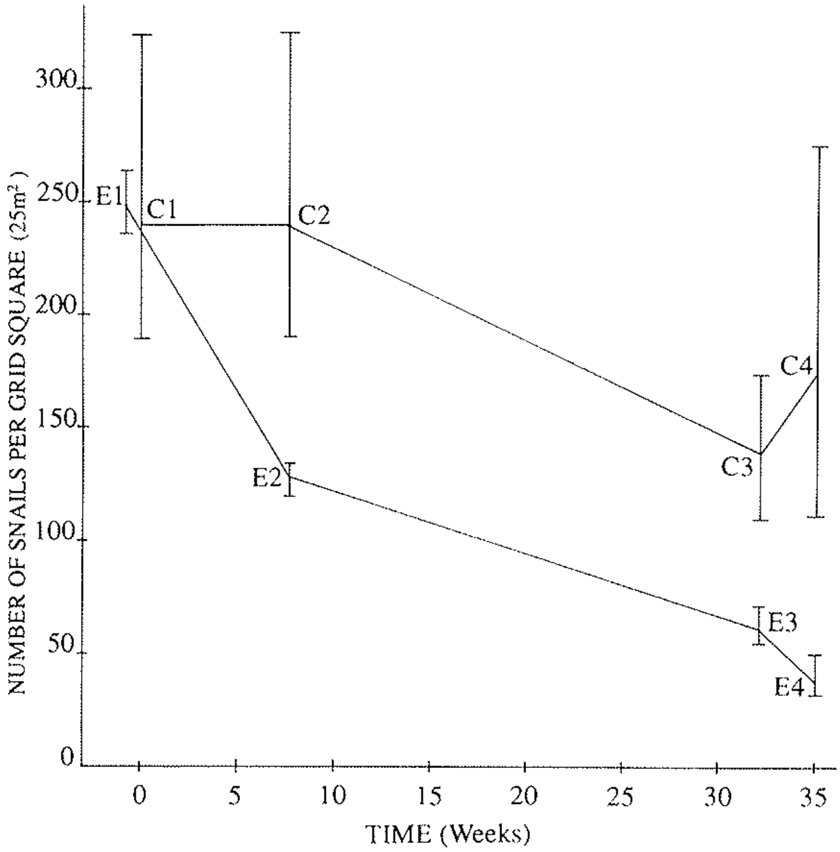

FIGURE 1. Mean number (± s.e.) of *Drupella* snails estimated to be present in experimental (E) and control (C) grids between date (week 0) and date (week 35).

therefore be concluded that there was no significant external recolonization as a result of migration by adjacent adult *Drupella.* This is in contrast to previous experiments which indicated that *Drupella* can move up to three metres in 24 hours, and may be attracted towards damaged coral (Forde pers. comm. University of Western Australia). The snails used in these movement studies had been removed from the water to facilitate marking and this disturbance may have influenced their behaviour.

There was a tendancy for the numbers of snails within an individual grid square to remain either high or low in subsequent surveys. All three paired comparisons between consecutive dates showed a significant trend. This probably signifies the patchy distribution of prefered *Drupella* habitat, and a concomitant clustered distribution for *Drupella* snails.

Variations in snail sizes

Variations in *Drupella* snail sizes were analyzed using contrasts following ANOVA. As this experiment is as yet incomplete, we do not present the ANOVA results here. Interim results are summarized in figure two where variations among snail sizes within control and experimental plots during different surveys are presented. No significant differences were detected between control samples during

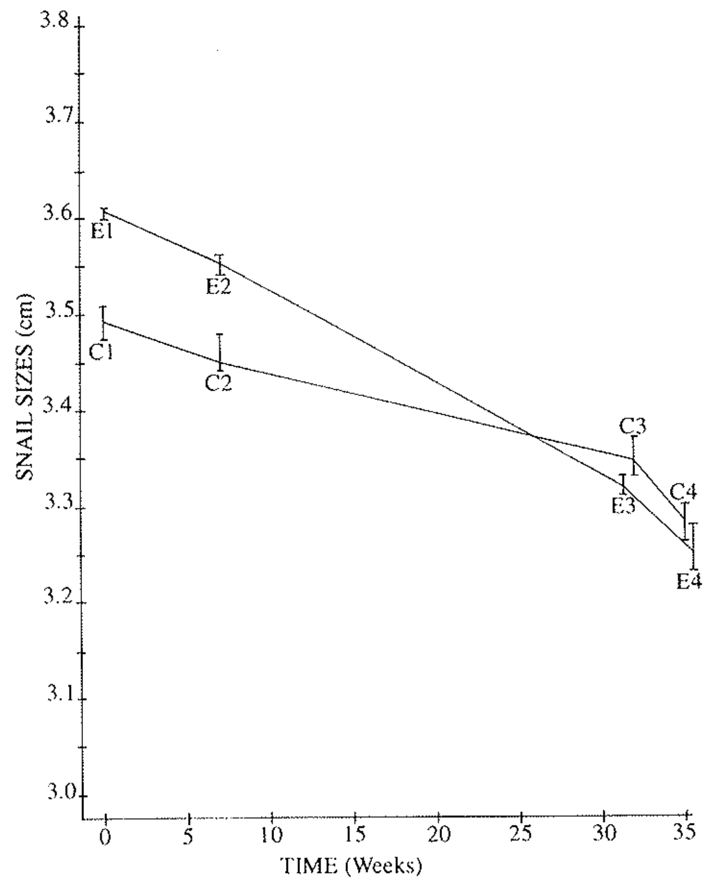

FIGURE 2. Mean maximum shell length (± s.e.) of *Drupella* snails collected on experimental (E) and control (C) grids between date (week 0) and date (week 35).

surveys one and two. However, snails in the experimental plot during the first survey were significantly larger than those within the control plot. A significant difference was detected between the sizes of snails in the control plot during surveys three and four, but this may be explained by the exceptional ability of one diver to find juvenile snails. Snail sizes within the experimental plot on the third survey were not significantly different from the snail sizes from the control plot at the same time.

During the course of the experiment, snail sizes fell in both the experimental and control plots. However, the decrease in sizes within the experimental plot was greater than within the control plot. This could indicate that recruitment into the experimental area was primarily from larval settlement and growth rather than from adults immigrating from surrounding substrate. However, this hypothesis is clouded by the reduction in size of animals outside the experimental plot.

CONCLUSION

- Early results of experimental hand removal of *Drupella* snails indicate that a significant reduction in snail numbers can be achieved within a limited area. This decline appears to persist over a 35 week period.
- Hand removal appears to selectively reduce the numbers of large snails and

there is no evidence of significant recolonization by adult snails.
- Novice divers are of limited use in snail removal exercises.

REFERENCE

Holborn, K., 1990.
Population genetics of *Drupella cornus* at Ningaloo Marine Park, Western Australia. Honours Thesis, University of Western Australia. 65pp.