A PRELIMINARY SUMMARY OF *DRUPELLA CORNUS* DISTRIBUTION AND ABUNDANCE PATTERNS FOLLOWING A SURVEY OF NINGALOO REEF IN SPRING 1991

Sue Osborne

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

PO BOX 201 EXMOUTH, WESTERN AUSTRALIA

INTRODUCTION

Surveys of Ningaloo Reef indicate that although common, *Drupella cornus* did not cause massive coral damage before 1980 (Meagher, 1980; Marsh, pers. comm., Western Australian Museum). In addition, visual estimates by scientists from the Western Australian Museum suggest that although variable, live coral cover in back reef areas during 1976 to 1980 was commonly greater than 50 percent.

It is likely that the *Drupella cornus* outbreak at Ningaloo Reef started during the early 1980s. Unusually large numbers of *Drupella* were first observed in the southern section of Ningaloo Reef in 1982 (Forde, pers, comm., University of Western Australia). A subsequent visit in 1985 to sites in the central and northern sections of Ningaloo Reef indicate that the infestation was already widespread during the mid 1980s (Wilson, pers, comm., Department of Conservation and Land Management).

In 1987, a survey of fish numbers and reef habitats facilitated the collection of more data on *Drupella* distribution and abundance patterns. The majority of sample sites during this survey were in the northern section of Ningaloo Reef where the percentages of live coral were low and surviving colonies were heavily infested with snails (Ayling and Ayling, 1987).

An extensive survey of Ningaloo Reef was carried out during 1989. By this time, the activity observed two years earlier in the northern section of the reef had caused extensive coral damage with some areas reduced to rubble. Although the impact of *Drupella* was most evident in the northern section of the reef, measurements of snail densities indicated that they were most abundant towards the southern end of the reef (Stoddart, 1989) and it was suggested that a wave of infestation has slowly moved south (Holborn, 1990).

This preliminary report summarizes the results of a survey that was carried out during September and October of 1991 to determine the status of *Drupella cornus* on Ningaloo Reef.

METHODS

Thirteen sites of predominantly hard substrate were selected from aerial photographs of Ningaloo Reef. The sites were distributed so that there were three back reef sites (located on the sheltered side of the reef crest) and one mid lagoonal site in each of the northern, central and southern thirds of the reef. The thirteenth site was located on Bundegi Reef which is in Exmouth Gulf.

At each of the thirteen sites, there were three replicates. The replicates were distributed within an area of reef that looked similar on the aerial photo for that site. At each replicate, both snail densities and the status of hard corals were determined. Snail densities were estimated by three divers each of whom established a 5metre x 5metre quadrat using pre-marked ropes. The quadrats were placed on predominantly hard substrate in close proximity to the boats, but their boundaries rarely abutted. When the quadrats were marked, the divers searched first their own quadrat for 15 minutes, then they rotated to their neighbours quadrat for 15 minutes and finally they moved to the third quadrat for another 15 minute search. During each 15 minute search, the divers placed all live and dead *Drupella* that they could find in a cloth sample bag which was labelled and then sealed. In this way, each 5metre x 5metre quadrat was searched by three divers for a total of 45 minutes and nine sample bags were used to collect snails from each replicate. Back on dry land, the contents of all sample bags were sorted and the numbers of live and dead *Drupella* were recorded. In addition, up to 130 live snails from each site were measured using vernier callipers. The greatest shell length was used as a record of snail size.

Coral was monitored by three divers at each replicate. The three divers laid 20metre tapes over the substrate and used a line intersect method to estimate the amount of live hard coral. Corals were identified to the level of familly except for members of Acroporidae which were split further to the level of genus. Substrate that was not hard coral was categorized as either hard substrate or soft substrate according to whether it was suitable or not for the settlement of hard corals. Having completed the substrate cover measurements, the divers returned to the beginnings of their tapes to measure coral sizes. The divers measured the greatest radius of each of the the first 35 hard coral colonies which occurred beneath their tapes. Colonies were defined by the boundaries of live tissue and in cases where tissue damage had resulted in many separate colonies on connected skeletal material, a maximum of five such related colonies were measured. In this way, a total transect length of 60metres was sampled and over 100 corals were measured at each replicate.

The same eight divers conducted the entire survey. None of the divers were novices and all but one member of the team had extensive experience on coral reefs. Of the eight divers, three were dedicated to coral monitoring, while the other five worked on *Drupella* densities. Four of the five *Drupella* divers were familiar with Ningaloo Reef and already knew how to look for snails. However, the first field day was dedicated to training in order to refresh their memories and to familiarize the fifth diver.

RESULTS

The total numbers of live and dead snails that were found in each replicate plus average live and dead *Drupella* densities are presented in table one. The average densities of *Drupella* at each site are also represented in figure one. There is some variation among replicates within certain sites. However, the overall live *Drupella* densities at the three southern back reef sites were higher than those recorded at back reef sites in the central and northern sections of the reef. The lowest density of live

		SNAIL DENSITIES				SNAIL SIZES			LIVE CORAL		SOFT SUBSTRATE		HARD SUBSTRATE	
		LIVE		DEAD										
SITE	replicate	total found	no. per sq. m.	total found	no. per sq. m.	sample size	mean (cm)	standard deviation	transect length (m)	% cover	transect length (m)	% cover	transect length (m)	% cover
Bundegi	1	209		2					37.19		3.23		19.58	
	2	50	1.45	4	0.04	105	4.56	0.28	28.05	51.78	0.00	1.87	31.95	46.35
	3	68		2					27.97		0.13		31.90	
Tantabiddi	1	162		20					28.88		3.60		27.52	
	2	59	2.80	10	0.26	105	3.67	0.27	36.09	52.92	0.76	2.56	23.15	44.52
	3	409		29					30.29		0.25		29.46	
Ned's Camp	1	23		67					0.83		9.36		49.81	
	2	1	0.21	10	0.38	47	2.94	0.60	2.73	3.83	12.18	20.73	45.09	75.44
	3	24		9					3.33		15.78		40.89	
Turquoise	1	70		6					6.83		20.45		32.72	
	2	1	0.38	15	0.10	87	3.46	0.46	5.77	11.06	10.86	25.67	43.37	63.27
	3	14		1					7.31		14.89		37.80	
Osprey	1	2		2					8.88		12.20		38.92	
	2	9	0.05	3	0.04	11	3.31	0.37	10.87	16.21	16.52	20.28	32.61	63.51
	3	0		4					9.43		7.78		42.79	
Bunderra	1	8		8					2.91		12.90		44.19	
	2	4	1.78	10	0.18	97	3.55	0.23	3.29	14.79	6.66	13.14	50.05	72.07
	3	389		22					20.42		4.09		35.49	
Winderabandi	1	55		10					10.56		12.74		36.70	
	2	48	0.56	16	0.14	105	3.18	0.34	6.87	14.85	16.07	21.57	37.06	63.58
	3	23		5					9.29		10.02		40.69	
Lefroy Bay	1	55		15					25.26		3.81		30.93	
	2	290	2.96	24	0.32	105	3.80	0.35	36.43	45.02	2.13	3.74	21.44	51.24
	3	163		33					19.35		0.79		39.86	
Cloates	1	2		4					4.32		14.77		40.91	
	2	1	0.02	7	0.06	3	3.43	0.54	16.62	18.53	9.30	22.21	34.08	59.26
	3	2		2					12.42		15.90		31.68	
Bruboodjoo	1	230		6					22.22		16.79		20.99	
	2	166	1.82	10	0.09	104	3.47	0.54	11.48	19.73	13.99	17.32	34.53	62.95
	3	14		5					1.81		0.39		57.80	
Coral Bay Lagoon	1	18		4					29.42		0.89		29.69	
	2	0	0.09	0	0.02	21	4.45	0.49	6.09	43.71	4.87	3.39	49.04	52.90
	3	3		0					43.17		0.34		16.49	
Coral Bay back reef	1	109		13					7.41		7.20		45.39	
	2	504	3.36	23	0.27	130	3.25	0.37	8.14	10.63	5.03	9.37	46.83	80.00
	3	142		24					3.59		4.63		51.78	
Pelican	1	1184		26					41.81		3.88		14.31	
	2	1303	15.95	28	0.36	105	3.46	0.35	51.95	79.82	2.11	5.09	5.94	15.09
	3	1101		26					49.92		3.17		6.91	

TABLE 1. Substrate cover plus *Drupella* sizes and densities at thirteen sites along Ningaloo Reef in Spring 1991. Snail densities are recorded as both the numbers of snails found within three 5metre x 5metre quadrats, which was the area sampled at each replicate, and an average number of snails per square metre from all samples within a site. Substrate cover is presented both as the lengths of substrate type on the 60metres of transect at each replicate and the percentages of each cover type from all samples within a site.

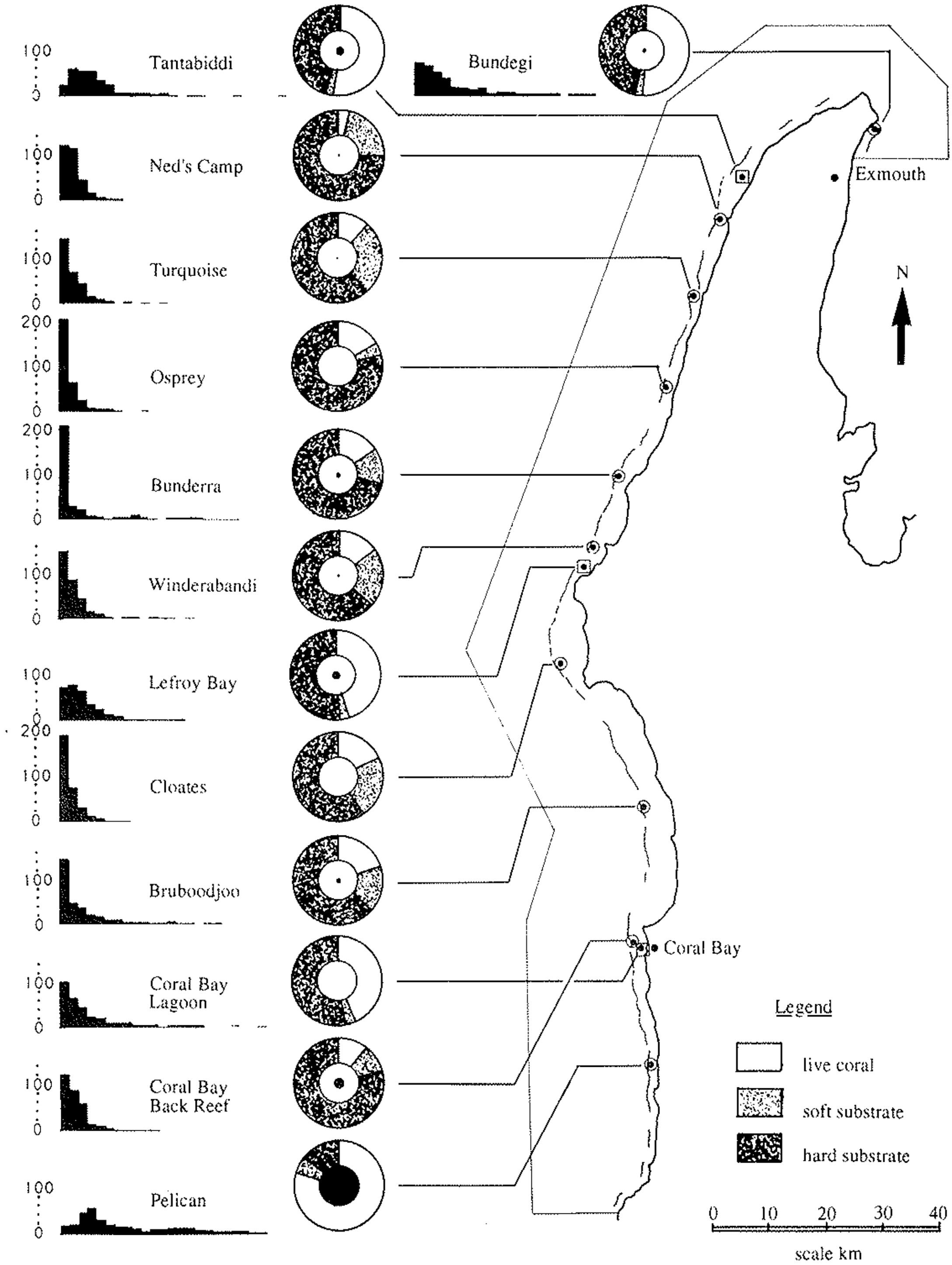

FIGURE 1. Substrate type and *Drupella* densities at thirteen sites along Ningaloo Reef in Spring 1991. The histograms represent the size frequency distributions of hard coral colonies. Each column represents a size class of 5cm in colony radius. The pie diagrams represent the proportions of live hard coral, soft substrate and hard substrate at each site. *Drupella* densities are represented by the radius of the black dot or disc in the centre of each pie diagram. The locations of the thirteen sites are shown on the map of Ningaloo Marine Park. Back reef sites are represented by circles and mid lagoonal sites are represented by squares.

snails was recorded at Cloates while the highest density of live snails was recorded on the back reef at Pelican where a density of 15.95 snails per square metre was recorded. Live snail densities at mid lagoonal sites did not correspond with those at adjacent back reef sites. In the northern and central sections of the reef, mid lagoonal sites harboured higher densities of live snails than back reef sites whereas the mid lagoonal site at Coral Bay in the southern section of the reef had a much lower density of snails than the southern back reef sites.

At all but two sites, the densities of dead *Drupella* were lower that the densities of live *Drupella*. The exceptions to this trend were at Cloates and at Ned's Camp. Ned's Camp harboured the highest density of dead snail with 0.38 snails per square metre.

The means and standard deviations of shell sizes for each site are presented in table one. Shells collected from Bundegi and the lagoonal site at Coral Bay were larger than those collected at other sites. The snails sampled at Ned's Camp were smaller than those from other sites.

The total lengths of live coral, hard substrate and soft substrate are presented for each replicate in table one. The overall percentages of live coral plus hard and soft substrate for each site are also presented in table one and they are represented by pie diagrams in figure one. There is some variation among benthic cover measurements from replicates within certain sites. The summarized percentage cover values for each site indicate that the lowest percent live coral cover was recorded off Ned's Camp which was the most northerly back reef site and the highest percent live coral cover was recorded at Pelican which was the most southerly back reef site. However, data from the other back reef sites did not support a trend of gradual increase in percent live coral from the northern to the southern sections of the reef. With the exception of Pelican, Bundegi Reef and the three mid lagoonal sites were characterized by higher percentages of live coral than the back reef sites.

Colony sizes of all live corals at each site are represented by size frequency histograms in figure one. Sites with high percentages of live coral were characterised by proportionally more large colonies than sites with low percentages of live coral. With the exception of Pelican, very small coral colonies predominated at back reef sites. Although the majority of these small colonies were the remains of large colonies, new coral recruits were evident.

DISCUSSION

Previous work has indicated that divers vary considerably in their abilities to find *Drupella* in the natural environment (Osborne and Williams, these proceedings). To minimize discrepancies resulting from differences in diver abilities the same team of five divers carried out the whole survey. In addition, snail searches in the 5metre x 5metre quadrats were repeated by different divers so that their range of abilities was spread amongst the experimental samples. Future modelling of snail counts from repeat searches will determine an index of ability value for each diver. This will then be used to adjust the data so that the snail counts more closely approximate the number of snails within each sample area.

Although replicates at each site were located in close proximity and within areas that looked identical on aerial photos, variation among *Drupella* densities and live coral cover measurements were recorded at some sites. Considerable variation in the amounts of live coral cover were recorded among replicates within three sites. The high density of live snails in replicate three at Bunderra corresponded with a relatively high value of live coral cover. Just eight and four live snails were found in replicates one and two respectively while the corresponding live coral cover values were 4.85 percent and 5.48 percent. However, replicate three was characterised by 34.03 percent live coral with a corresponding live snail collection of 389. A similar correlation between live coral cover and live snail densities was recorded among the replicates at Bruboodjoo. Here the high variation among live snail counts of 230, 166 and 14, corresponded with percent live coral cover values of 37.03, 19.13 and 3.02 respectively. The other site where live coral cover varied among replicates was in Coral Bay lagoon. Here the comparatively low value of live coral cover at replicate two was the result of a coral kill in 1989. A northerly wind during the coral spawning event of that year empounded the spawn in Coral Bay resulting in the de-oxygenation of water and a mass kill of all marine life.

At Tantabiddi, live snail counts varied considerably among replicates. Here, although similar percentages of live coral were recorded in all replicates, the distribution of preferred coral prey, namely *Acroporas* and *Montiporas* (Ayling and Ayling, 1987), was less even. Percentage cover values for *Acroporas* plus *Montiporas* were 25.83 percent in replicate one, just 17.72 percent in replicate two and 47.75 percent in replicate three. This variation in coral cover type corresponded with the variation in live snail counts of 162, 59 and 409 respectively. Similar variations among live snail densities from replicates at Bundegi and the back reef at Coral Bay could not be related to variations in live coral cover and perhaps represent a level of patchiness in the natural distribution of *Drupella*.

The patchy distributions of *Drupella* and live coral cover were further emphasized by casual observations in reef areas adjacent of those selected for survey. In some cases, quite minor differences on aerial photos represented major changes in reef habitat. For this reason, comparisons with data from previous surveys are restricted to observations from within the same site boundaries.

Six of the thirteen sites that were surveyed during the present survey were also sampled at the beginning of 1989. *Drupella* densities and percentage live coral cover values from the 1989 survey are presented in table two. Comparisons indicate that the majority of *Drupella* densities and percent live coral cover values from 1989 lie within the variation among the 1991 scores from individual 5metre x 5metre quadrats and 20metre transects for the same sites. Exceptions occur at both

	Tantabiddi	Turquoise	Osprey	Winderabandi	Coral Bay Lagoon	Pelican
Drupella densities (snails per sq. m.)	7.3	0.7	0	1.9	0	18.1
Percent live coral	42.0%	9.5%	14.0%	5.5%	66.4%	68.8%

TABLE 2. *Drupella* densities and percent live coral cover values from 1989. Density values for Tantabiddi, Turquoise and Osprey were calculated from samples of 20 square metres while live coral cover was calculated from 40 metre line intersect transects. The sample sizes at Winderabandi, Coral Bay Lagoon and Pelican were 10 square metres and 20 metres of line intersect transect.

Tantabiddi, where there appears to have been a reduction in the density of *Drupella*, and at Winderabandi, where a reduction in *Drupella* densities has been accompanied by an increase in live coral cover since 1989.

During a previous survey in 1987, both *Drupella* density and live coral cover were measured at Osprey. Two mean densities of 9.6 and 16.3 snails per square matre were recorded at this site which indicate that the snails were plaguing in 1987 and their densities have since decreased significantly. The change in *Drupella* densities at this site has been accompanied by an increase in live coral cover from 4.2 percent in 1987 to 16.21 percent in 1991.

Studies on the Great Barrier Reef revealed average *Drupella* densities of 0.61 snails per square metre. At this density minor coral damage was evident, but it was considered unlikely that the *Drupella* population was inflated (Oxley, 1988). Of the 13 sites sampled during the 1991 survey of Ningaloo Reef, as many as six supported *Drupella* populations with densities less than 0.61 snails per square metre. However, only one of these sites, Coral Bay Lagoon, appeared never to have been infested by *Drupella*. At Neds, Turquoise, Osprey, Winderabandi and Cloates, the presence of dead snails, low percentages of live coral, high proportions of very small coral colonies and the obvious skeletal remains of previous corals all provide evidence of prior infestations. The results of this survey therefore indicate that in 1991 most of Ningaloo Reef has either already been infested by *Drupella* or is presently supporting *Drupella* populations which are likely to cause significant reductions to live coral cover in the future.

The reduction in *Drupella* densities and the increase in live coral cover which have been recorded at Winderabandi and Osprey since 1989 and 1987 are encouraging. In addition, the significant numbers of newly recruited coral colonies at several of the back reef sites suggest that recovery might be possible. However, as yet it cannot be assumed that the reef will return to the conditions that were reported during the 1970s.

REFERENCES

Ayling A.M. and Ayling A.L., 1987.
Ningaloo Marine Park: Preliminary fish assessment and habitat survey with information on coral damage due to *Drupella cornus* grazing. A report prepared for the Department of Conservation and Land Management, Western Australia, by Sea Research. 19 pp.

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

Meagher, T.D. and Associates, 1980.
Biology of the Ningaloo Reef around Low Point, North West Cape. A report prepared for Weaver oil and Gas Corporation, Australia. 31pp.

Oxley, W.G., 1988.
A sampling study of a corallivorous gastropod, Drupella on inshore and midshelf reefs of the Great Barrier Reef. Honours Thesis, James Cook University, Townsville. 83pp.

Stoddart, J.A., 1989.
Fatal Attraction. Landscope, 4: 14-20.