SUMMARY OF THE WORKSHOP DISCUSSION

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(incorporating comments from Tony Start and Bob Black)

The Workshop Discussion began with a reminder from the Chairman (Dr Tony Start), that the high numbers of Drupella that are currently being observed at Ningaloo should not necessarily be regarded as an unnatural and/or undesirable phenomenon. Concern was expressed on several occasions during the Workshop, over the use of words such as 'infestations' and 'outbreaks', which imply that Drupella is a pest species and that its high numbers are having a deleterious effect on the reef. Furthermore, it was recognized that a lot of the research that has been undertaken to date, has been predicated by the possibility that the current high numbers of Drupella at Ningaloo Reef is unnatural, and may have arisen because of some (as yet unidentified) human influence. That this should be investigated was accepted, but it was stressed that researchers and managers should not be preoccupied with this notion simply because of a human perception that the large-scale destruction of live corals on a reef is a deleterious and unnatural occurrence. In several years time the community structure at Ningaloo Reef (and, incidentally, other Western Australian reefs) may be very different, but it was suggested that this is not necessarily cause for undue concern. It was, however, agreed that there is a basic need to understand the critical facets of the ecology of Drupella before it can be determined whether the current high numbers recorded at Ningaloo are a natural phenomenon or are human-induced. The task for researchers and managers is, therefore, to gather as much information as possible towards furthering an understanding of the cause(s) and effects of high numbers of Drupella at Ningaloo. It was recognized that management agencies need to understand the phenomena that cause major changes in the communities they are endeavouring to manage.

When asked whether further research on Drupella is warranted, in particular in view of the consideration that the current high numbers at Ningaloo may be part of a natural cycle, the group felt that, regardless of any emotive considerations or value judgments, further research will provide valuable information on coral reef ecology and general population ecology, which are of broad scientific interest. Any contribution towards furthering our understanding of the mechanisms that cause the numbers in a population to fluctuate, was recognized as being of fundamental ecological value.

(a) RESEARCH PRIORITIES:
Although extensive research into the general biology of Drupella has been carried out over the last 2-3 years, the participants agreed that there remain a number of key areas which need to be addressed. One of the aims of the final Workshop Discussion was

to identify important areas where future research efforts should be directed. The following subjects were covered:

REPRODUCTIVE BIOLOGY -
- the age at which sexual maturity is attained and, in conjunction with measurements of the longevity of Drupella, the number of years over which individuals are reproductively active.
- seasonality and/or synchrony in the breeding cycles within and between Drupella populations at different sites and over a number of years. As a result of the work that has already been undertaken, it was suggested that it should be possible to ascertain the gametogenic state of large numbers of individuals by examination of the overall physical appearance of the gonads, without the necessity for detailed histological examination.
- evidence for sperm storage in the females.

LARVAL BIOLOGY -
- larval behaviour in the field, in particular in relation to their dispersal.
- when and where the larvae settle.
- the relationship between the nutritional requirements of the larvae for survival through to settlement and metamorphosis, and the occurrence (temporally and spatially) of natural food resources at these levels.

JUVENILE BIOLOGY -
- measurement of juvenile growth rates.
- distribution and occurrence of juveniles, in particular the missing/cryptic cohort.

ADULT BIOLOGY -
- measurement of annual mortality rates to provide estimates of the longevity of Drupella, which will in turn enable population turnover times to be estimated and the future of the population to be predicted.

FEEDING BEHAVIOUR -
- feeding behaviour (intensive vs. small scale feeding modes) and feeding rates.
- effects of varying densities of Drupella on coral survival. There may be a threshold density of Drupella, over which the coral community is destroyed, but below which some form of equilibrium is maintained. Work on the Great Barrier Reef has suggested that fast-growing coral species can sustain damage to up to 30% of their area/annum and still maintain themselves.

PREDATION -
- predation was recognized as being of potentially critical importance on the larval and juvenile stages in the life-cycle. However, predation, on the planktonic stages in particular, is likely to prove difficult to investigate. Predation on the adults was not considered to be important in controlling the numbers of Drupella at Ningaloo.

GENETICS -

- although interesting results have been obtained from the genetics work already undertaken, and there is considerable scope for further related work, it was felt that genetics could not make any direct contribution towards understanding the processes controlling the success of local recruitment and was unlikely to lead to practical management options.

TEMPORAL PERSPECTIVES -

- paleoabundances of Drupella shells in the fossil record.
- evidence of previous Drupella outbreaks (or the activities of any other agent of coral mortality) may be obtained indirectly from a study of the size (and, consequently, the age) of the corals currently being eaten by Drupella.

CONCLUSIONS:

The early life history of Drupella was recognized as a high priority for further research. As there is no evidence to suggest that the phenomenon observed at Ningaloo is the result of the adult population moving along the reef, it is likely that the outbreaking populations at Ningaloo are recruit-driven. The processes controlling the success of local recruitment were considered to be the central issue if the fluctuations in Drupella numbers are to be understood. However, the factors controlling recruitment were recognized as being very difficult to determine. There is a need for basic information on the temporal and spatial variation in recruitment rates - where, when and how many. One suggested approach to documenting recruitment was to sample, over a long time period, large numbers of the corals where the recruits are characteristically found.

The results from this type of study would provide a measure of the variation in annual recruitment. Whether the current high numbers are within the normal variability of the population fluctuations could then be established. It was further suggested that there is a need to simultaneously study recruitment at other reefs as well as at Ningaloo (e.g. Abrolhos Islands and Dampier Archipelago). In view of the large breeding population that is currently present at Ningaloo, it was considered likely that there will be an increase in recruitment of Drupella onto reefs that are remote from Ningaloo.

The participants also agreed that it is important to establish (possibly through back-modelling), whether the present high numbers of Drupella are the result of a single, transient, chance event, or a series of events during the 1980s, and whether the conditions favouring these high numbers still exist.

The value of laboratory experimental studies was questioned, in particular with respect to the applicability of the results to field situations. Research into the early life history of Drupella was recognized as providing valuable information. However, because it is only possible in the laboratory, it was suggested that the results are unlikely to be a realistic indication of what is actually happening in the natural situation. It was noted that although

considerable work has been done on the early life history of crown-of-thorns there is still no information about the factors that actually enhance/reduce larval survival, where the larvae go in the water column, etc. Furthermore, it was suggested that it is unlikely that this information will ever be obtained given the techniques currently available. The group were urged to concentrate future research on examining questions that will provide useful answers, that can contribute directly towards our understanding of the high density populations which are being observed at Ningaloo. Rather than on issues which are impossible to answer in terms that are relevant to the natural situation.

(b) LONG-TERM MONITORING:
Another issue which was extensively discussed at the Workshop was the desirability of long-term monitoring. The value of long-term surveys that provide basic information on the distribution and abundance of Drupella over extended time periods was emphasized. It was suggested that a few years data may provide a valuable indication of what is happening within the Drupella populations under study. It was noted that long-term monitoring programs have only recently been established to document crown-of-thorns on the Great Barrier Reef.

A number of key points to be considered in any proposed long-term monitoring program for Drupella were identified:
- the results from different sites and different time periods must be statistically comparable (viz. transects of equal length/quadrats of equal size, equal numbers of replicates etc.).
- the methods adopted should be straight-forward and simple, requiring minimum sampling effort, so that they can readily be employed at a large number of sites. Line-transects (20m x 0.5m) were considered to be most suitable for long-term monitoring programs - transects have an advantage over quadrats in that they can rapidly be laid out and searched, thus maximizing the information that can be obtained.
- sampling should be undertaken regularly and consistently.
- to increase consistency in the data collection, wherever possible the same personnel should be employed throughout the monitoring program.

The participants agreed that the following four parameters should be recorded in any long-term monitoring of Drupella :
- % coral cover.
- coral colony size.
- densities of both juvenile and adult Drupella.
- size frequencies of the snails.

It was emphasized that the size frequencies of the snails have to be representative of the whole population (i.e. every Drupella in the transect/quadrat being monitored must be sampled). This issue was raised because the intermediate sized snails (2-2.5cm shell length) have not been adequately represented in previous surveys, because of their occurrence in a habitat distinct from that occupied by the recruits and adults. Furthermore, the sample sizes must be large enough to detect different cohorts in

the population. The value of a simple, complete size frequency distribution was emphasized. Information regarding the history and prognosis for the future of the population can be extracted from size frequency distributions. It was recognized, however, that to achieve this prerequisite of a complete population sample will necessitate destructive sampling. Furthermore, because of the marked clumping of the juveniles by size (and presumably, therefore, by age), recorded in the genetics study, there will be very real sampling problems in obtaining random samples. Thus, relatively large areas will have to be destructively sampled to achieve sample independence.

The real value of long-term monitoring studies, in terms of the solutions provided for effective management action, was questioned. The group were asked to consider what questions long-term monitoring would answer, in particular in the context of the research priorities examined at the beginning of the Discussion, and how the information could be applied to increase our understanding of the cause(s) of the fluctuating numbers of Drupella. Even though there are several examples of long-term monitoring studies, it was argued that none have led to the development of an effective management strategy. Long-term monitoring studies may reveal the patterns of population fluctuations, but they will provide no indication of the cause(s). It was considered that experimental studies addressing carefully posed questions, and designed to eliminate alternative explanations, are the only means by which causality can be effectively examined.

(c) FINANCIAL RESOURCES:

There was considerable concern over the lack of finances available for further research and long-term monitoring programs. The participants recognized Drupella on Ningaloo Reef as a problem of equal importance to the crown-of-thorns on the Great Barrier Reef. It was acknowledged, however, that there is a marked imbalance in the research being undertaken on these species. It was recommended that the Federal Government should be made aware of the implications of not treating Drupella as seriously as the crown-of-thorns, and of not balancing expenditure on marine research between the Indian and Pacific Ocean coasts. Special funds are urgently needed to enable the establishment of a long-term Drupella Research Program (cf. the crown-of-thorns, water quality and the effects of fishing special projects which are currently attracting substantial funds for research on the Great Barrier Reef). Aside from the tourism value (both realized and potential) of Ningaloo Reef to Western Australia (a figure of $15million/annum was given), the study of the dynamics of a major ecological community, such as Ningaloo Reef, was identified as a key factor in justifying any application for funds to support further research.