INCIDENCE OF *DRUPELLA* ON CORAL MONITORING TRANSECTS BETWEEN SERRURIER ISLAND AND MERMAID SOUND

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INTRODUCTION

This paper describes the incidence of *Drupella* gastropods on coral monitoring transects off the Pilbara coastline of Western Australia. The transects were established for various projects and developments which required implementation of a Marine Biological Monitoring Programme (MBMP) following environmental impact assessment by the Western Australian Environmental Protection Authority (EPA).

BACKGROUND

Between October 1985 and May 1988, over 45 fixed transects were established by LeProvost Environmental Consultants (LEC; formerly LeProvost, Semeniuk & Chalmer) on coral reefs between Serrurier Island and Gidley Island (Mermaid Sound) on the inner North West Shelf (Table 1; Fig. 1). These transects have been monitored on a semi-annual or annual basis on behalf of the following companies managing petroleum exploration and production activities off the Pilbara coast:

- Hadson Energy Limited (Hadson; the Harriet oil and gas field, formerly operated by Bond Petroleum Pty Ltd [1985-present]);
- West Australian Petroleum Pty Ltd (WAPET; the Saladin oil field [1988-present]);
- Western Mining Corportation Pty Ltd (WMC; the South Pepper/North Herald/Chervil oil fields [1987-1990]); and
- Woodside Offshore Petroleum Pty Ltd (Woodside; delegated operator for the North West Shelf Gas Project on behalf of the Joint Venture Participants [1986-present]).

TABLE 1

Coral Transect and Monitoring Details

REGION	DATES OF SURVEYS	NUMBER OF TRANSECTS	TRANSECT TYPE
MERMAID SOUND (including Dampier Archipelago; Fig. 2)	January/October 1986;	14	20-30 m x 0.3 m
	January/August 1987; February 1988	14	20-30 m x 0.3 m
	March/July/October 1989;	14	20-30 m x 0.3 m
	July 1990;	10 of 14	20-30 m x 0.3 m
	June 1991/November 1991.	9 of 14	20-30 m x 0.3 m (belt transects, perpendicular to shoreline)
VARANUS ISLAND (Lowendal Islands to Ah Chong Island; Fig. 3)	October 1985;June/December 1986	10	5 m x 1 m
	January/July 1987; July 1988	11	5 m x 1 m
	April 1989; June 1990; April 1991	11	5 m x 1 m
AIRLIE ISLAND (Rosily Island to Barrow Shoals; Fig. 4)	December 1987 (baseline survey);	10	5 m x 1 m
	January/December 1988;	11	5 m x 1 m
	July/December 1989; July 1990.	11	5 m x 1 m
THEVENARD ISLAND (Serrurier Island to Direction Island; Fig. 5)	May 1988 (baseline survey);	12	5 m x 1 m
	November 1988; May/November 1989;	13	5 m x 1 m
	May/November 1990; October 1991.	13	5 m x 1 m
EAGLEHAWK ISLAND	August 1989; November 1989; November 1990.	2	25 m x 0.3 m and 5 m x 1 m (shallow reef)
DUGONG REEF (on Barrow Shoals)	December 1989 (inspection);	0	
	July 1990 (baseline survey);	7	50 m x 0.1 m
	March 1991; October 1991.	6	50 m x 0.1 m (line intercept transects of shallow reef)
PASSAGE ISLAND (including Meda Reef)	October 1991 (baseline survey)	6	50 m x 1 m (video transects of shallow reef)

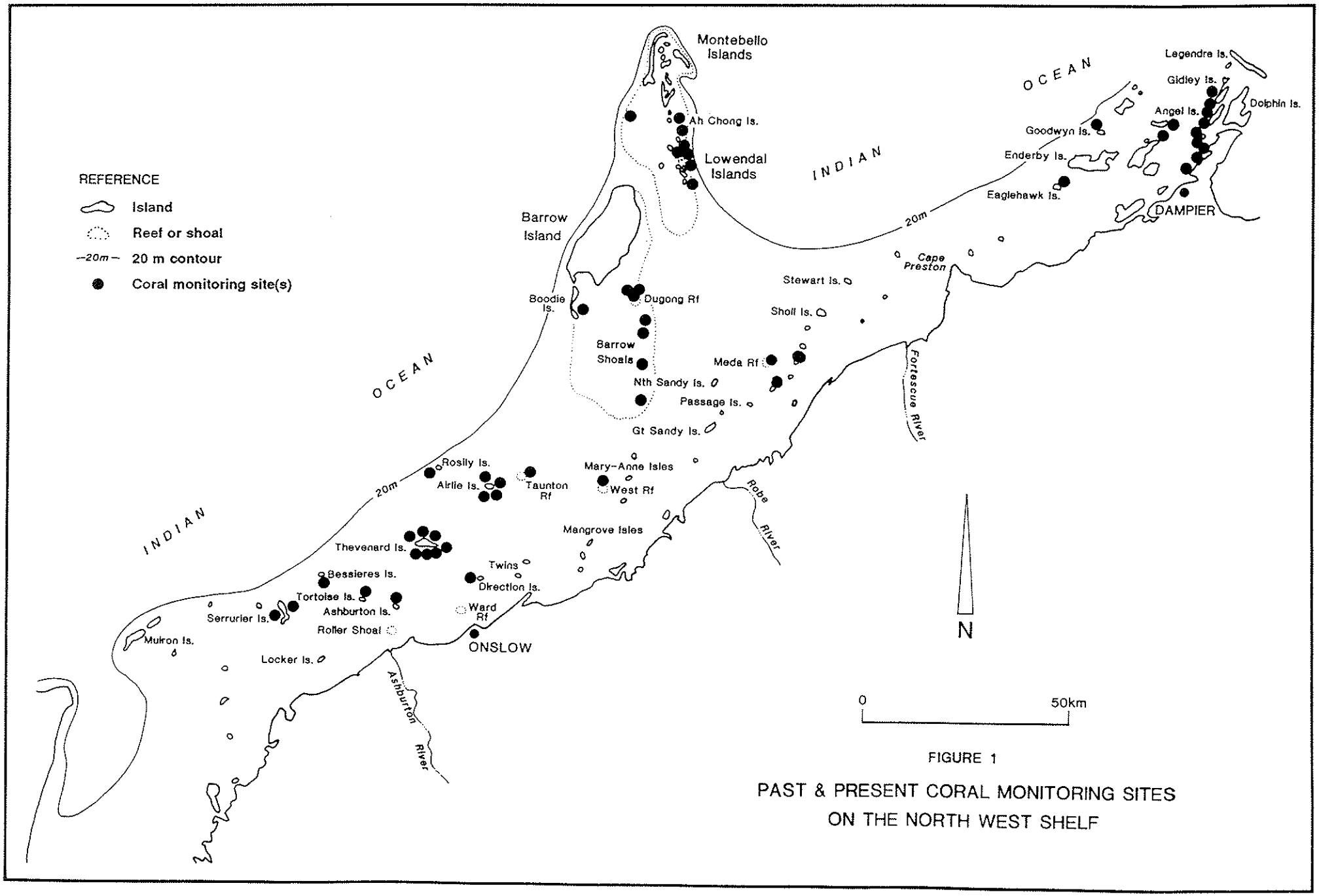


FIGURE 1

PAST & PRESENT CORAL MONITORING SITES ON THE NORTH WEST SHELF

These companies are responsible for operating MBMPs in accordance with conditions set by the EPA following project assessment or, in the case of Woodside, on its own initiative.

The number of transects was increased between 1989 and 1990, when two were established at Eaglehawk Island on behalf of United Salvage Pty Ltd following the wrecking of the McDermott Derrick barge DB20, and when seven were installed over tabular and staghorn *Acropora* 'gardens' at Dugong Reef (Barrow Shoals) on behalf of WAPET, so that corals within 1 km of an exploratory well drilled in 1991 could be monitored. More recently, six transects have been installed at the Passage Island chain on behalf of Hadson as part of its monitoring programme for the installation of a gas transmission line between Varanus Island and the mainland.

No transect has been established specifically to obtain information on corallivores such as *Drupella*, and all have been installed for one or more of the following reasons:

- to enable predictions in the impact assessment documentation to be tested (e.g. oil spill effects or other specified potential impacts on nearby corals);
- to provide and/or maintain an up-to-date a baseline data set (in the event of a petroleum spill or serious accident); and/or
- for general surveillance purposes (including information on the extent and frequency of changes to monitored corals arising from natural causes such as cyclones, regional bleaching events, etc).

CORAL MONITORING METHODS

Approach

Owing to logistical constraints and the cost of monitoring corals in remote areas off the Pilbara coastline, fixed but non-replicated transects were established for each project following inspection of colour aerial photographs and ground-truthing during initial 'baseline' field surveys. The use of fixed transects enabled coral colonies representative of each site to be inspected, photographed and re-mapped onto water-proof sheets at approximately six or twelve month intervals (this approach helped offset the lack of replicate transects and inability to determine variation within and between sites).

Type and Location of Transects

The type of transect, its establishment date, and the frequency of monitoring has varied according to the start-up date and nature of each development and the contract period. Inspection dates for all transects are shown in Table 1.

Belt transects (0.3 m wide) were established as part of Woodside's monitoring programme for the development of the shipping channel and LNG terminal facilities on the Burrup Peninsula between 1986 and 1990 (Table 1; Fig. 2). These were installed to monitor fringing reef corals in Mermaid Sound and the Dampier Archipelago. These transects are perpendicular to the shoreline (from the low intertidal zone to the point where hard substrate gives way to soft sediments below 6 m) and typically 20-30 m in length.

For those developments involving the production and load-out of crude oil at Varanus Island (Hadson), Airlie Island (WMC) and Thevenard Island (WAPET), a series of 5 m x 1 m transects were established in the region of each oil field (Table 1; Figs 3-5). Most of these were located imediately beneath the low intertidal zone and mainly on patch reefs (including 'bommies') which, according to the results of oil spill trajectory modelling, had a high likelihood of intercepting an oil spill. In the case of the transects established near Varanus Island, the majority of these cover a significant proportion (~10% to ~55%) of the shallow subtidal area of the bommies which had been selected for monitoring.

Details of the other transects installed at Eaglehawk Island (west of Dampier), Dugong Reef (north-east Barrow Shoals) and the Passage Island chain are given in Table 1. In addition, inshore coral reefs near Onslow (at Roller Shoals and Ward Reef) were inspected and photographed in October 1991, in preparation for a baseline survey and establishment of new transects for WAPET's Roller development.

All transects were positioned so that the type and cover of monitored corals were representative of the surrounding area and, in the case of the small 5 m x 1 m transects, where colony abundance was high. Thus emplacement of these transects over large colonies (>2 m diameter) was avoided, since this would have considerably reduced the number and diversity of individual colonies within the transect.

Collection of Data

During each survey, the locations and outlines of coral colonies within, or intercepting, transects have been mapped two-dimensionally onto plastic sheets. Freehand mapping of colonies in the 5 m x 1 m transects is facilitated by using a 25 x 25 cm grid supported by a 1 x 1 m aluminium frame, with a similar grid represented on the mapping sheet (Fig. 6). Each 1 m by 1 m quadrat is also photographed with the grid

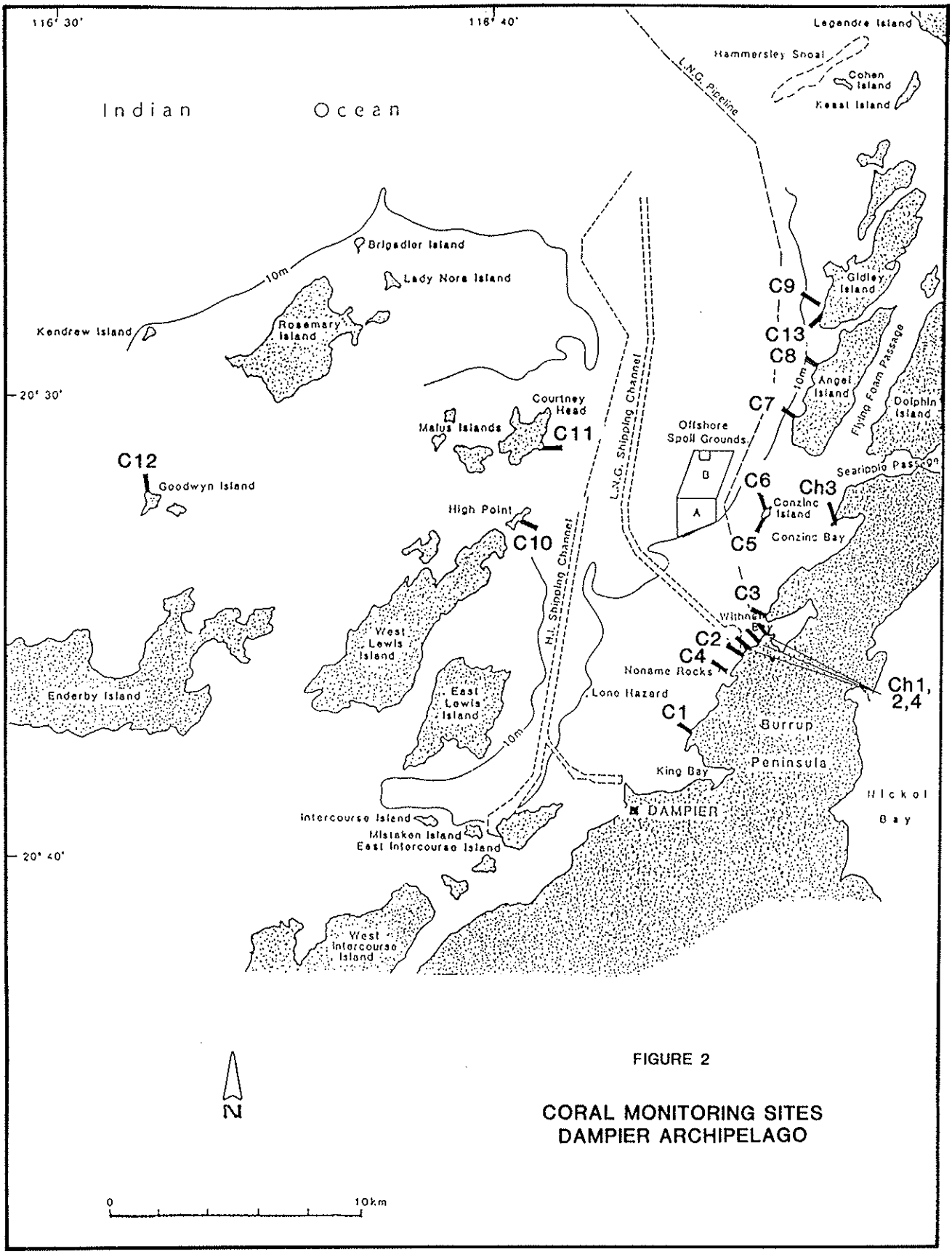


FIGURE 2

CORAL MONITORING SITES
DAMPIER ARCHIPELAGO

in place to maintain a visual archive. The maps were subsequently used to monitor changes to colony numbers in each transect, as well as the percentage of the substrate (in the vertical projection) covered by living hard coral at the time of each survey.

Mapping also involved recording the location of any bleached, partially dead or recently-dead colonies, and the incidence of Crown of Thorns starfish and (since November 1989) *Drupella* (Fig. 6). Brief inspections are also made of the condition of nearby corals up to 6 m from the transect boundaries. The time spent inspecting, mapping and photographing each transect typically ranges from 45 to 100 minutes, depending on the degree of coral cover and topographical complexity.

Assessing *Drupella* numbers

After *Drupella* aggregations were first encountered in November 1989, the number of these muricid snails which could be seen within transects without disturbing the corals were counted. Whether or not *Drupella* were found in a particular transect, an estimate of the density of visible snails was made by visual assessment during the inspection of corals beyond the transect. Because only visual assessments could be made, the density of visible snails was estimated using three broad levels based on the counts obtained in the 5 m x 1 m transects. These levels of density were 'low' (1-5 per 5 m^2), 'moderate' (6-30 per 5 m^2) and 'high' (>30 per 5 m^2). A null score was recorded if no snails were found either on or near the transect.

Drupella observed within or near transects were either counted *in situ*, or temporarily displaced by the diver to enable more accurate counting and to check for empty shells. Snails were not sized owing to constraints imposed by air supply and survey schedules. Separation of individuals at the species level (e.g. *Drupella cornus* versus *Drupella rugosa*) was not attempted. However, the vast majority that have been counted were large (~25-45 mm) and had the robust appearance characteristic of *Drupella cornus*. Feeding aggregations of *D. rugosa* have not been observed at Ningaloo Reef or Exmouth Gulf (Dr S. Turner, pers comm.).

Three LEC divers (all with substantial experience before 1985) have undertaken the transect inspections for the various programmes (mostly PNC to July 1990, then RWH until present). Moreover, almost all inspections have been undertaken with two of these divers in the water, and all three had commenced counting *Drupella* before the end of 1989. Thus the density class information since 1989 provides a temporal data set on *Drupella* aggregations that is based on comparable search efforts over a range of fixed sites.

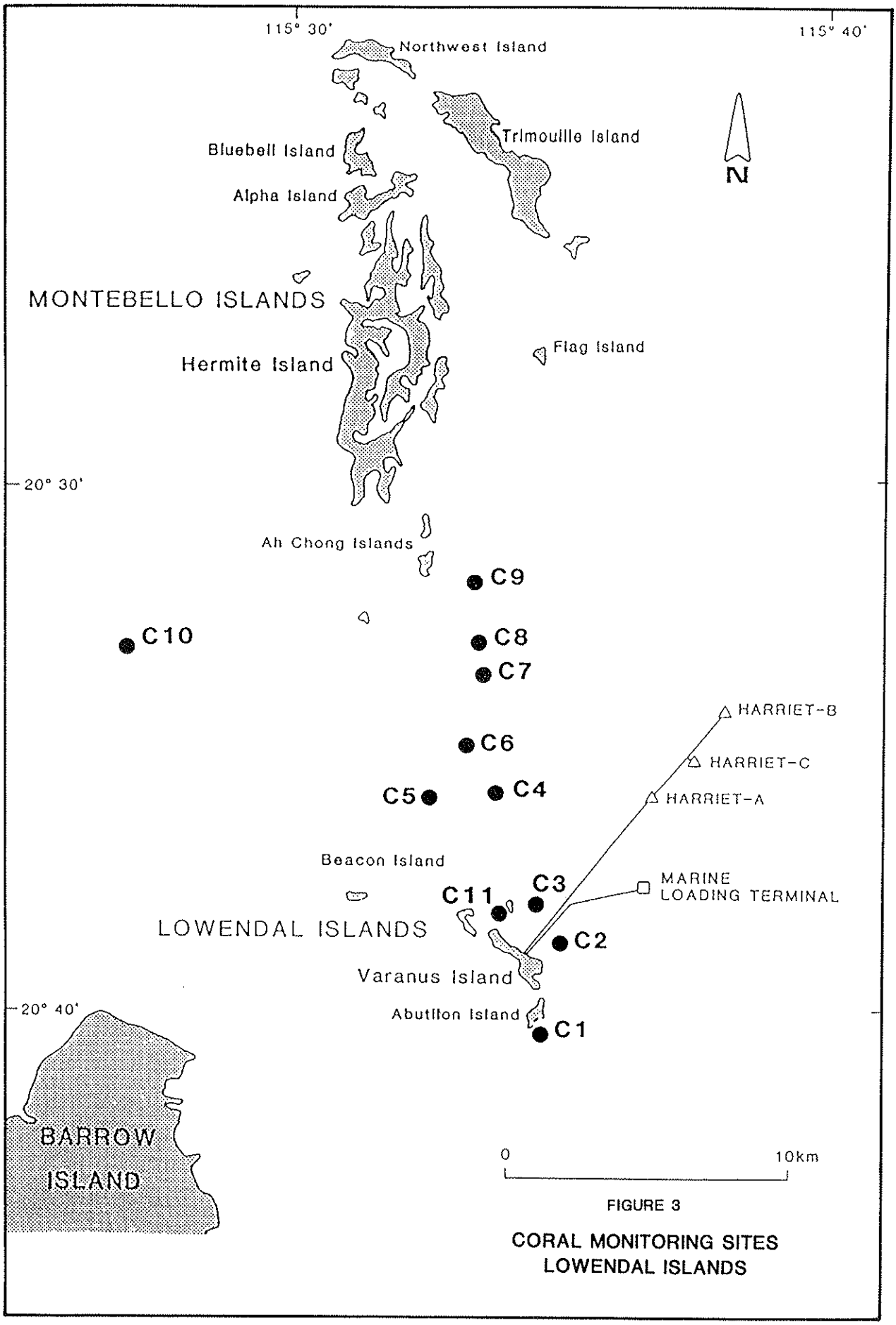
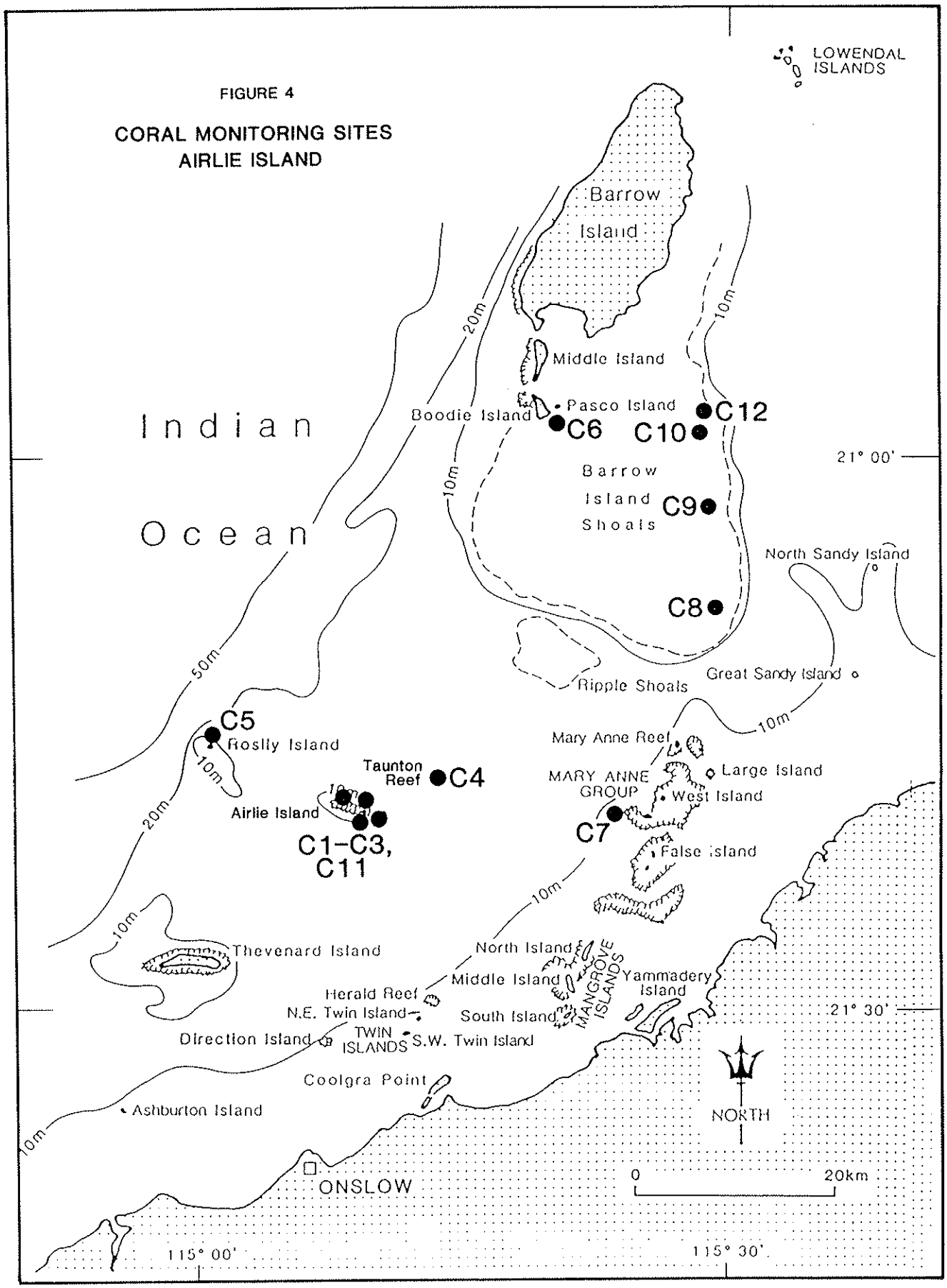


FIGURE 3

CORAL MONITORING SITES
LOWENDAL ISLANDS

FIGURE 4

CORAL MONITORING SITES
AIRLIE ISLAND



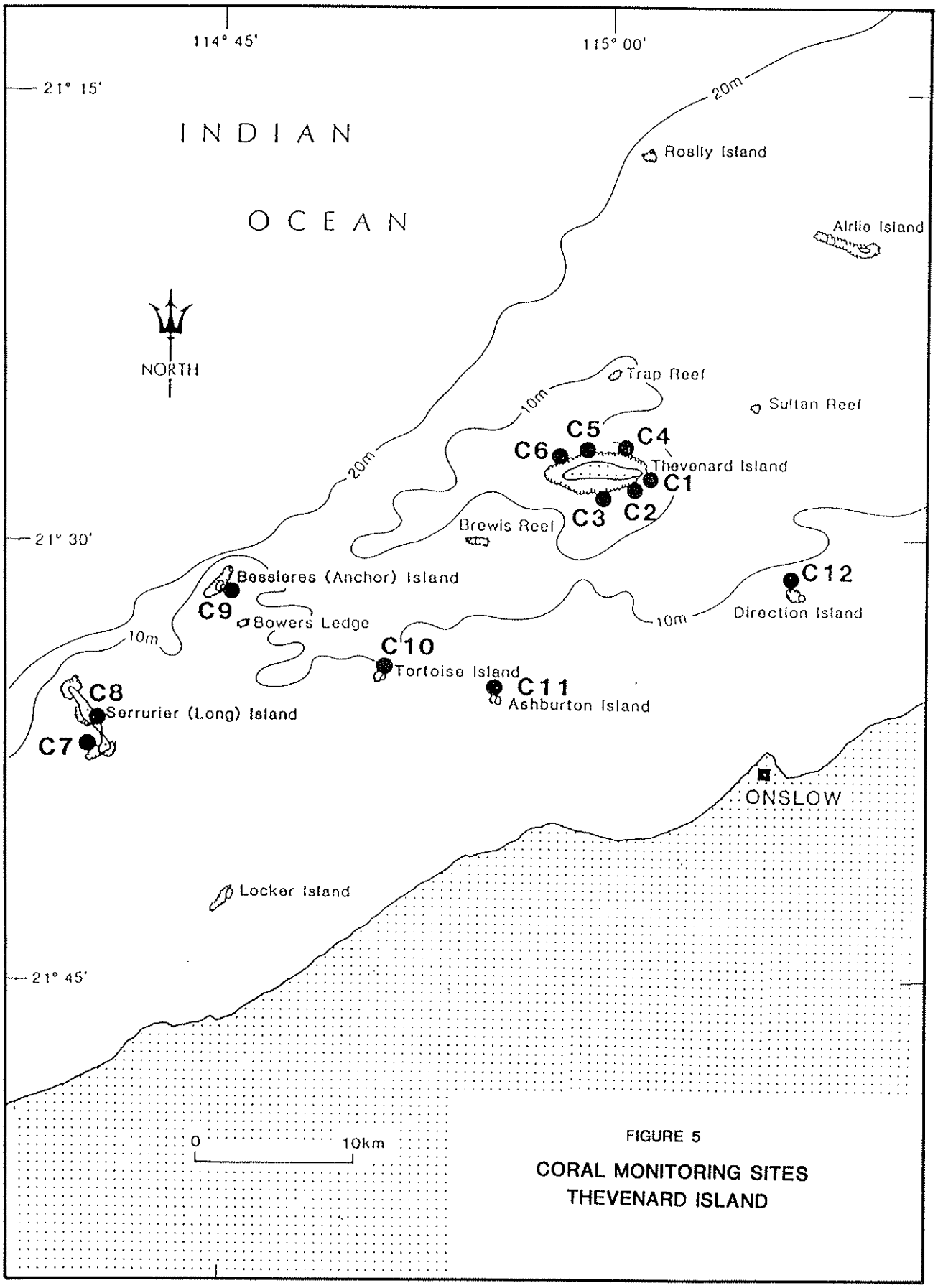


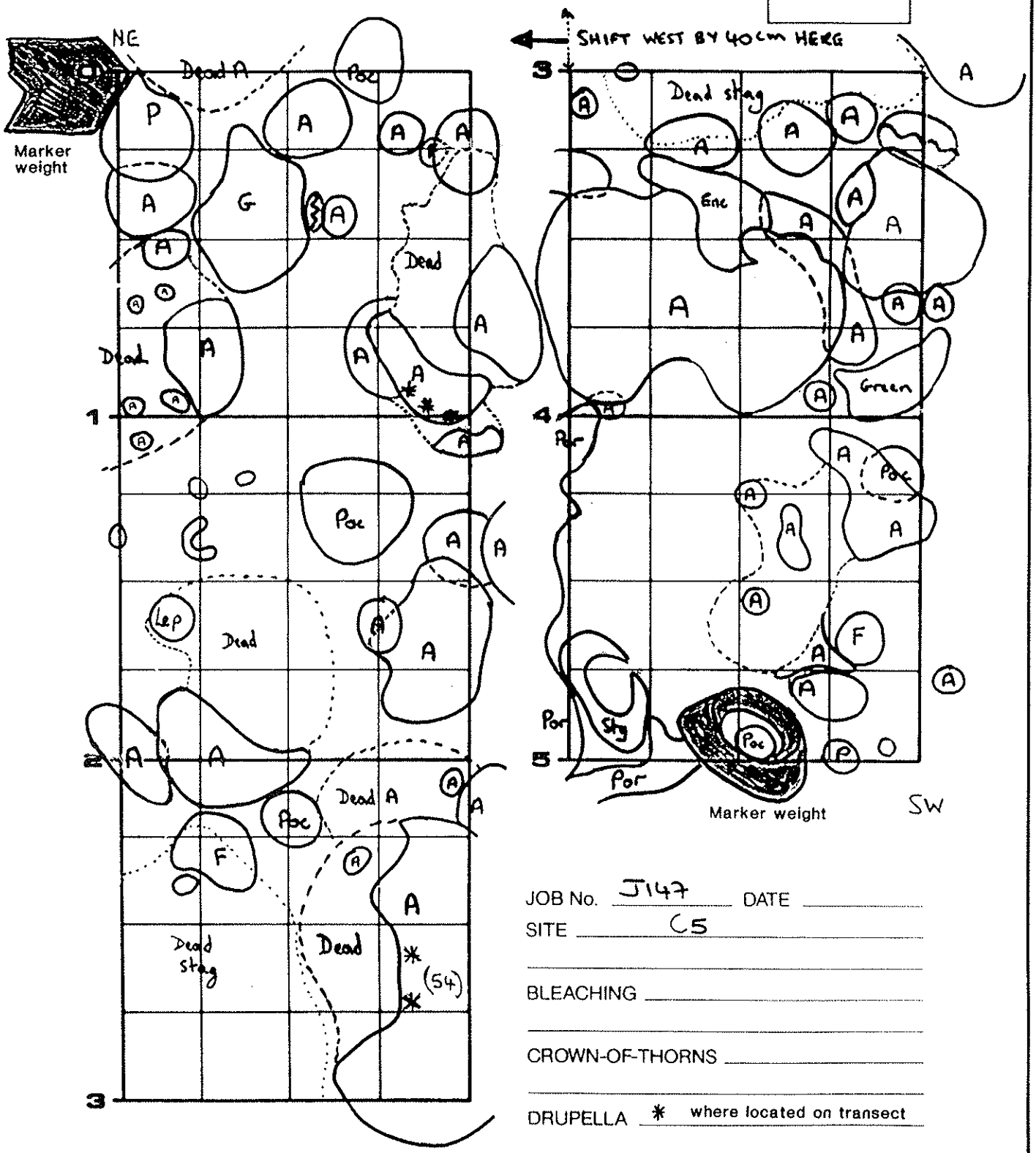
FIGURE 5

CORAL MONITORING SITES
THEVENARD ISLAND

LeProvost Environmental Consultants

SITE LOCATION: LOWENDAL ISLANDS
C5: 20° 36.280'S 115° 32.790'E

NORTH
NE



JOB No. J147 DATE

SITE C5

BLEACHING

CROWN-OF-THORNS

DRUPELLA * where located on transect

NOTES

FIGURE 6

INCIDENCE OF *DRUPELLA*

The incidence of *Drupella* is presented on an annual basis in Figures 7 (for end of 1989), 8 (for 1990) and 9 (for 1991). These figures provide values for monitoring sites which had been visited at least once by the end of 1989, 1990 and 1991 respectively, and each value represents the highest density found on or near the transect during a particular year. Note that a high density signifies the presence of one or more aggregations (and is equivalent to >6 m^{-2}), while a moderate density (equivalent to 1-5 m^{-2}) indicates that only clusters or small aggregations were found on or near a transect. A low density (1-5 snails visible in the transect, and equivalent to <1 m^{-2}) signifies that only a few individuals or a single small cluster had been recorded either on or off the transect. Null values (no snails seen) are not shown in Figs 7-9, but can be determined by comparing these figures with Figure 1.

Clusters and small aggregations of *Drupella* adults producing moderate densities were first observed in November 1989 close to transects established at Thevenard, Tortoise and Ashburton Islands (Fig. 7). These transects had been established in May 1988 (Table 1), and no clusters or aggregations had been encountered at this time or during the subsequent semi-annual surveys in November 1988 and May 1989. At these sites, the density of visible snails in November 1989 ranged from moderate to low (Fig. 7).

Aggregations of *Drupella* producing a high density of visible snails within transects (i.e. >30 animals) were first encountered in the December 1989 survey of sites near Airlie Island and the Mary-Anne Passage (Fig. 7). During this survey, 60 individuals were counted on four colonies within the transect at West Reef, while a moderate density was recorded for a site on Barrow Shoals (C9; Figs 4,7), where 23 of 29 snails counted within the transect 27 were found on one table *Acropora* colony. The Airlie Island MBMP had been established on behalf of WMC in December 1987 and these sites were also being monitored semi-annually (Table 1).

The clusters and aggregations have been found principally on *Acropora* spp., although 18 of the individuals counted on the West Reef transect in December 1989 were on *Porites* colonies. *Drupella* have subsequently been observed on other genera including *Montipora*, *Pocillopora*, *Stylophora*, as well as occasionally on favid species. However, the largest aggregations and the largest feeding scars have been found on corymbose and tabular *Acropora* spp., and banded feeding scars characteristic of *Drupella* aggregations cannot be seen in transect photographs taken before late 1989.

Since 1989, the number of sites between Serrurier Island and Varanus Island where high and moderate densities of visible *Drupella* were found has increased (c.f. Figs 7-9). Thus by the end of 1990, the number of sites where high and moderate densities were encountered increased from one to eight and from four to nine respectively (Fig. 8). One of these sites (at transect C5 some 4 km north-west of Varanus Island; Figs 3, 8), represents the first record of a *Drupella* aggregation detected in the

Lowendal Island group since the start of coral monitoring in October 1985 (Table 1). By the end of 1990, densities exceeding 5 m^{-2} had also been encountered at Serrurier Island, Bessieres Island, Thevenard Island and Direction Island (Fig. 8).

The highest number of *Drupella* obtained from a single colony (a table *Acropora* spp.) has been 123 (in May 1990 at Bessieres Island; site C9 in Fig. 5). At this time, the total number counted within the C9 transect was 193, and the area of this 5 m x 1 m transect covered by living coral was mapped at 2.7 m^2 (i.e. 54% cover). By November 1990, mapping showed that coral cover had declined to 2.35 m^2, which represented a 13% fall over 6 months. The decline at C9 (almost all to *Acropora* spp. where the *Drupella* were located) continued into 1991, and by October 1991 only 1.1 m^2 of the transect (22%) remained covered (mainly by massive species including *Porites* and *Platygyra* spp., with remnant *Acropora* and *Montipora* colonies). This fall represented a loss of over half of the coral cover which had been mapped in November 1990.

The largest reduction in coral cover among the *Drupella*-affected sites near Varanus Island has been at transect C5 (Figs 3,6), where living coral cover in this 5 m x 1 m transect has fallen by 31% between 1990 and 1991 (i.e. from 2.6 m^2 in June 1990 to 1.8 m^2 in April 1991). The incidence of elevated numbers of *Drupella* at monitoring sites in the Lowendal Islands further increased between the 1990 and 1991 annual surveys. Thus the number of sites where the density of visible adults exceeded 1 m^{-2} and 5 m^{-2} rose from nil to four and from one to two respectively (c.f. Figs 8, 9). The highest counts so far recorded near Varanus Island were in April 1991, and where the three largest aggregations on single *Acropora* heads comprised 74, 56 and 54 adult snails. The last of these was inside transect C5 (Figs 3,6). Here, the total number was 93 (counted inside the transect) and 79 (on corals outside the transect).

In contrast to the detected increase in *Drupella* numbers at sites between Serrurier Island and the Lowendal Islands, clusters or aggregations of this predator have not yet been found on or near the transects in Mermaid Sound or the Dampier Archipelago (including Eaglehawk Island), and which have been monitored on the dates listed in Table 1. However, it is recognised that the belt transects in the Dampier Archipelago and Mermaid Sound differ by extending from the low intertidal zone into the deep subtidal zone (6-12 m).

On the other hand, no study has suggested that *Drupella* aggregations are restricted only to the shallowest part of the subtidal zone (1-2 m), and there has been an equal opportunity for clusters or aggregations of snails to be encountered on corals located on and beside these transects. Moreover, to date there have been no reports of serious or unusual damage to coral cover and/or large aggregations in this area (Dr S. Turner, CALM; pers comm.). Given the publicity surrounding the effects of *Drupella* and the Ningaloo Reef and the fact that many reefs in the Dampier region are visited by recreational divers, it is therefore considered unlikely that a widespread and marked elevation in *Drupella* numbers could have occured since 1989 without detection.

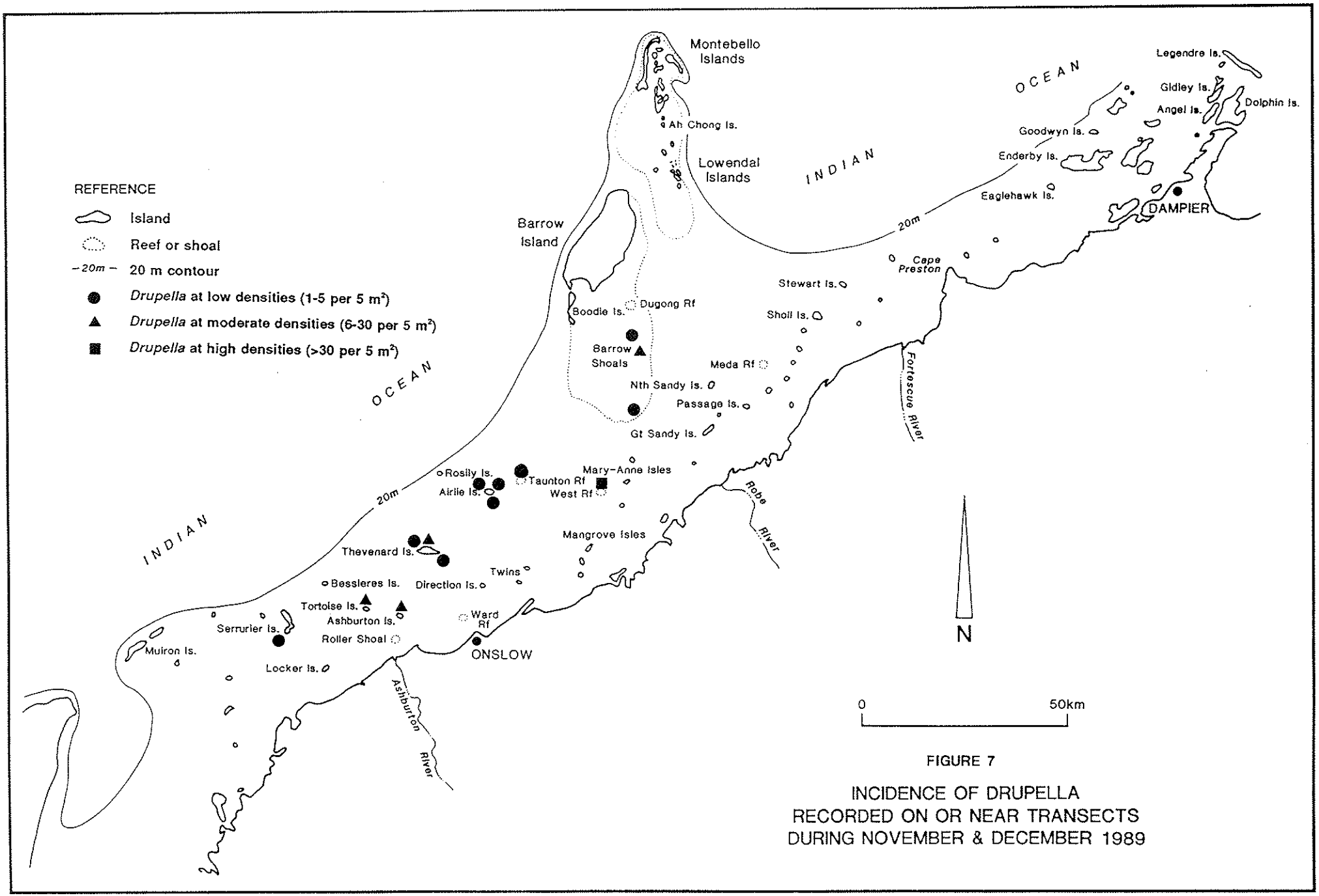


FIGURE 7

INCIDENCE OF DRUPELLA
RECORDED ON OR NEAR TRANSECTS
DURING NOVEMBER & DECEMBER 1989

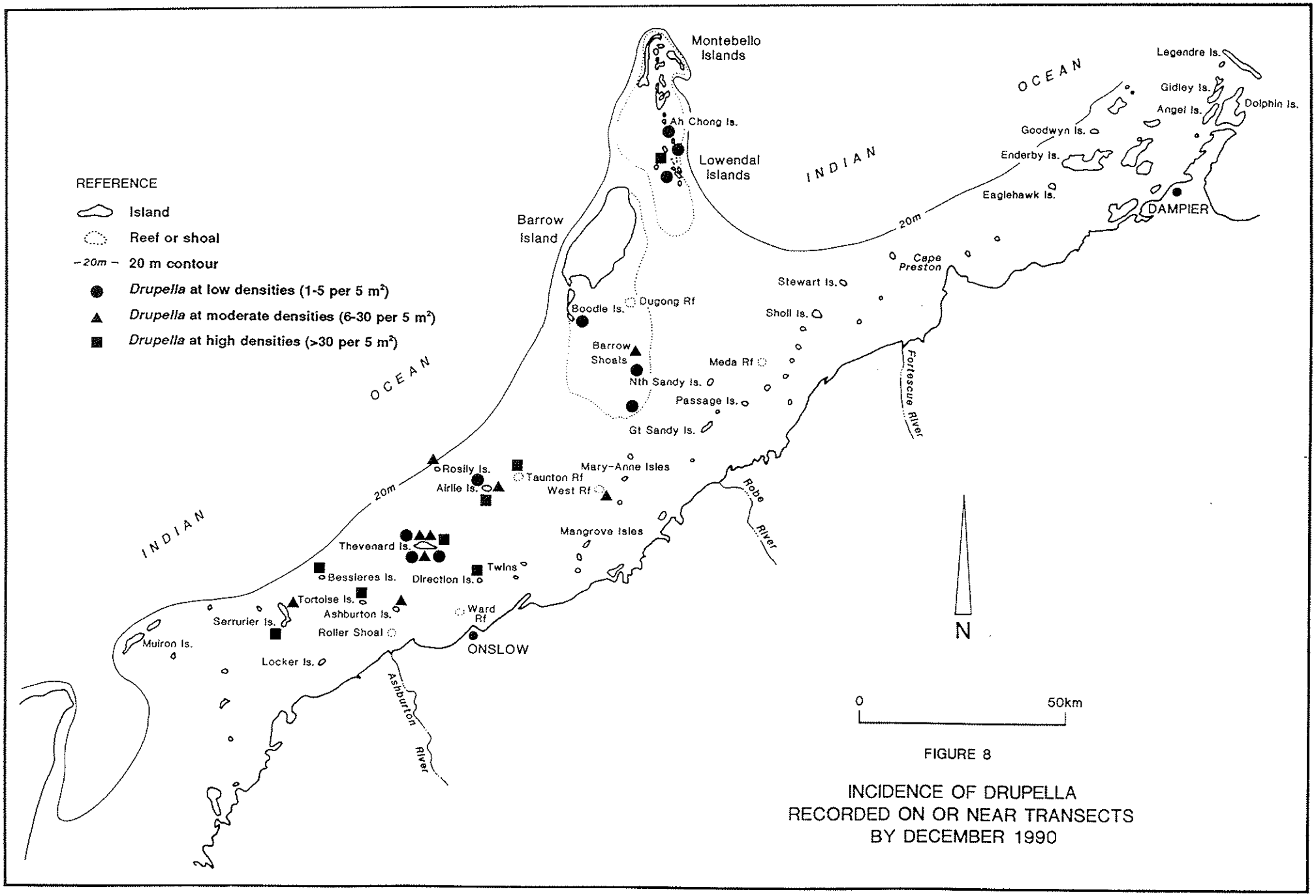


FIGURE 8

INCIDENCE OF DRUPELLA
RECORDED ON OR NEAR TRANSECTS
BY DECEMBER 1990

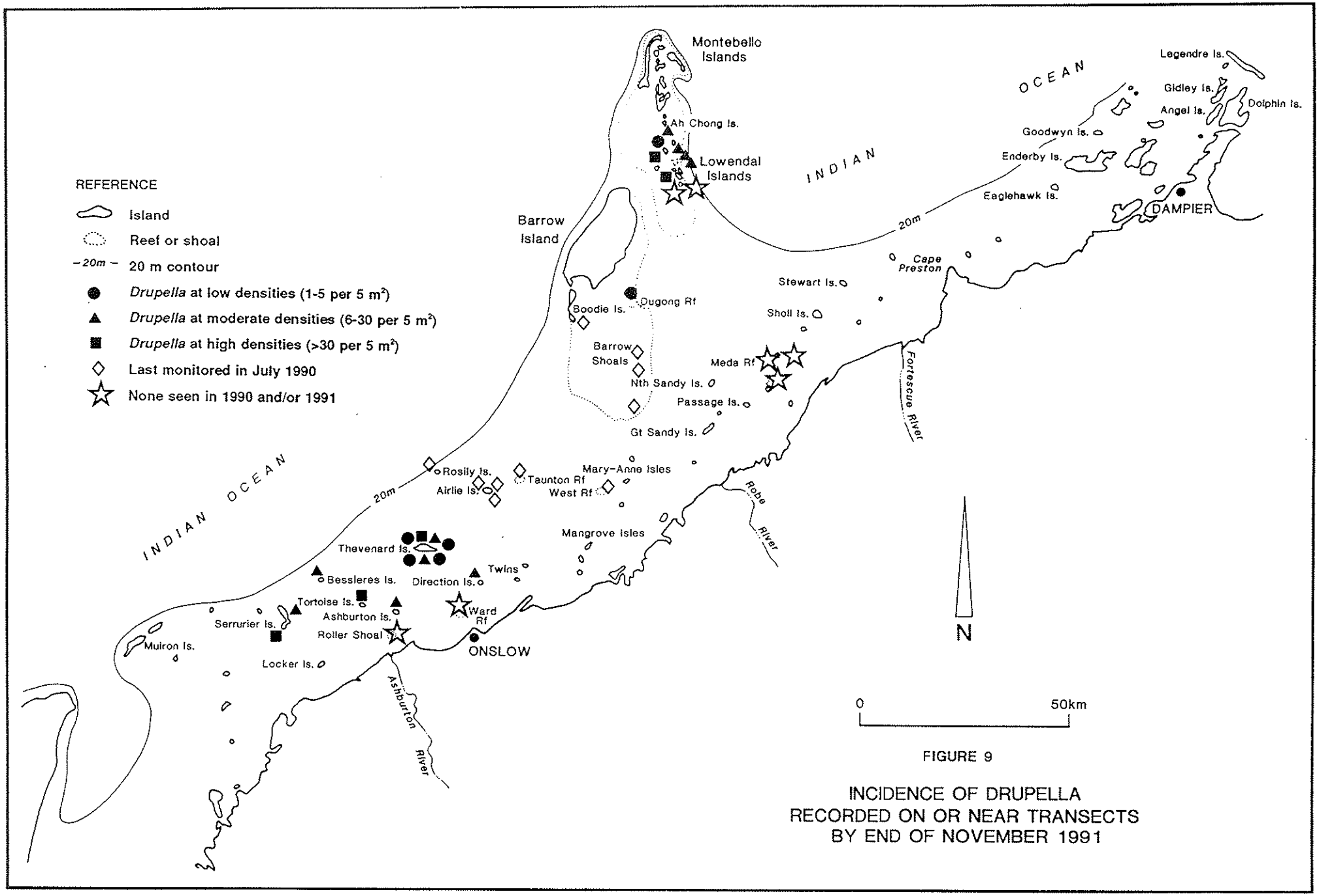


FIGURE 9

INCIDENCE OF DRUPELLA
RECORDED ON OR NEAR TRANSECTS
BY END OF NOVEMBER 1991

Finally, while elevated *Drupella* numbers have caused reductions to coral cover on reefs from the Lowendal Islands westwards, including reefs at the Muiron Islands which lie to the west of Serrurier Island (Mr M. Forde; pers comm.), aggregations and/or feeding scars have not been found at a number of reefs in the area between Onslow and the Lowendal Islands (e.g. monitoring sites on the south-east and north-west sides of Thevenard Island and near Varanus Island, as well as Ward Reef, Roller Shoals, Meda Reef and Passage Island; Table 1, Figs 7-9).

SYNTHESIS

At many of the monitoring sites, an apparent increase in the incidence of feeding aggregations and feeding scars has coincided with marked falls in the amount of hard coral which, in cases such as those near Varanus Island, have not displayed such fluctuations to coral cover since their establishment in 1985. The following preliminary conclusions are therefore drawn from the records of the various monitoring programmes:

(i) there appears to be have been an increase in the number of feeding aggregations of *Drupella* over the past two years at sites on the inner north West Shelf where they were formerly not present;

(ii) feeding aggregations of *Drupella* (signifying elevated densities of adults) presently appear to be more prominent in the western half of the inner North West Shelf; and

(iii) in localities where *Drupella* aggregations have been encountered, their occurrence can be very patchy.

The information collected to date and summarised in Figures 7-9, including the sites where *Drupella* aggregations and feeding damage have not been found, provides background data against which future changes to *Drupella* populations on the inner North West Shelf can be assessed.

Monitoring future changes on reefs along the inner North West Shelf would show whether the apparent increase represents part of a normal cycle in this region (in which fluctuations to *Drupella* numbers are short-term and produce only temporary [and essentially inconsequential] falls in coral cover), or whether the increase represents the start of a major phenomenon similar to that which has occurred on Ningaloo Reef. In addition, future monitoring would also indicate whether or not *Drupella* aggregations will become common in the more eastern sectors of the inner North West Shelf.

Further monitoring of selected sites would also help clarify current questions on *Drupella* population dynamics. Of particular interest is the question as to whether the apparent recent increases in the incidence of adult aggregations at sites between Serrurier Island and the Lowendal Island chain represent localised phenomena (presumably brought about by the same or similar factors which have operated on the Ningaloo Reef), or whether they represent a more direct effect following the marked rise of *Drupella* numbers on Ningaloo Reef in the 1980s (e.g. the result of increased larval dispersal from areas to the south-west of North West Cape and/or the Muiron Islands).

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