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ROWLEY SHOALS MARINE RESERVES MONITORING PROGRAM:
ESTABLISHMENT OF LONG-TERM MONITORING SITES IN BENTHIC COMMUNITIES IN ROWLEY SHOALS MARINE PARK AND MERMAID REEF MARINE NATIONAL NATURE RESERVE IN OCTOBER 2001

Field Program Report: MMS/RSH/RSMP – 46/2001

A collaborative project between the Department of Conservation and Land Management, Environment Australia and the Department of Fisheries

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September 2001

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This report may be cited as:

Cary J, Grubba T and Lapwood M (2001). Rowley Shoals Marine Reserves Monitoring Program: Establishment of long term monitoring sites in benthic communities in Rowley Shoals Marine Park and Mermaid Reef Marine National Nature Reserve in October 2001. Field Program Report MMS/RSH/RSMP-46/2001. (Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry St., Fremantle, Western Australia, 6160). Unpublished report.

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State and Federal Government collaboration

Department of Fisheries
Environment Australia

Funding / Resources

This project was funded by the Department of Conservation and Land Management and Environment Australia.

Significant resources including personnel, equipment and logistic support were also provided by CALM MCB, CALM Broome Work Centre and Department of Fisheries. The cost of the hiring the Department of Fisheries vessel the '*PV Walcott*' was at a reduced rate due to the Memorandum of Understanding (MOU) for the Rowley Shoals between three management agencies (CALM, Department of Fisheries and Environment Australia,) (see section 3.7 Budget).

1. INTRODUCTION

1.1 GENERAL

This field program report presents information on the first survey of the *Rowley Shoals Marine Reserves Monitoring Program* (RSMRMP) from 12–23 October 2001. The main aim of the RSMRMP is to establish a network of long-term monitoring sites in the Rowley Shoals Marine Park (RSMP) and Mermaid Reef Marine National Nature Reserve (MRMNNR) to gather quantitative baseline data to assess the status of the benthic communities. Re-locatable monitoring sites will be established in undisturbed locations such as proposed Sanctuary Zones and areas of low human usage (to assess natural variability) and also in areas of high human usage (to assess impacts from human activities). The locality and boundaries of RSMP and MRMNNR and surrounds are shown in Figures 1 and 2.

The RSMRMP is a collaborative program being driven by the Department of Conservation and Land Management (CALM) in collaboration with Environment Australia and the Department of Fisheries, the three management agencies that manage the Rowley Shoals through a memorandum of understanding (MOU) (Commonwealth of Australia 1999a).

The October 2001 field survey of the RSMRMP will establish a network of approximately 54 long-term monitoring sites in sub-tidal and inter-tidal coral communities in RSMP and MRMNNR (Table 1). Approximately 15 permanent monitoring sites will be established at each atoll in representative undisturbed areas to monitor both natural variability and broadscale changes to benthic communities. Approximately three permanent monitoring sites will be established at each atoll in areas of high human usage to access impacts from human activities. Site selection will be assisted by human usage data found in the report '*Human usage in the Rowley Shoals Marine Park and Mermaid Reef Marine National Nature Reserve*' (Lapwood and Grubba, 2001).

The October 2001 field trip will be coordinated by the Marine Conservation Branch (MCB) of CALM (Project Supervisor: Jennie Cary) in collaboration with the Broome Work Centre of CALM (contact Allen Grosse). Field trip preparation will be coordinated by Tim Grubba and Mike Lapwood. The Field Team Leader between 12-19 October will be Jennie Cary and between 20-23 October it will be Tim Grubba. The Dive Supervisor will be Mike Lapwood.

Field staff will include Jennie Cary, Tim Grubba, Judy Davidson and Kylie Ryan from MCB, CALM and Mike Lapwood and Kingsley Miller from Broome Work Centre, CALM. Jill St John from the Department of Fisheries and David Harasti from Environment Australia. The field team will operate from the Department of Fisheries vessel "*PV Walcott*" skippered by Daron Cooper with three crew members.

Reference to 'The Rowley Shoals' in this report includes the Rowley Shoals Marine Park (RSMP) and Mermaid Reef Marine National Nature Reserve (MRMNNR). The long-term benthic community monitoring program will be known as the 'Rowley Shoals Marine Reserves Monitoring Program' (RSMRMP).

1.2 BACKGROUND

The successful management of the marine environment is contingent upon comprehensive long-term monitoring programs that provide information on natural variability and long-term trends in key biological communities. They must determine the status of important natural attributes at regular intervals and identify undesirable trends resulting from human activities in time for remedial management action to be implemented effectively. Monitoring programs generally comprise of one or more of the following components: (i) local scale impact and/or *compliance monitoring* that examines the effects of human activities in a localised area; (ii) temporally-constrained, broadscale *surveillance monitoring* to assess the impact of episodic regional physical and biological processes (eg the effect of cyclones and predators) and (iii) spatially-constrained, long-term monitoring of key biological

parameters to determine the extent and cause of *natural variation* (eg seasonal and inter-annual variability) of key ecosystem attributes.

The RSMRMP will be linked to the strategies of the *Rowley Shoals Marine Park Draft management plan and indicative management plan for extensions to the existing marine park* that include:

- Monitoring of marine flora and fauna will be carried out to gain an understanding of natural factors, which will influence the natural variability of benthic communities in the Park.
- Monitoring and undertaking periodic surveys of recreational and commercial uses in and adjacent to the park will be carried out to determine the effect of human usage on benthic communities in the Park.
- Develop and progressively implement a coordinated monitoring program of the key ecological values of the park, including the evaluation of the ecological impacts of recreational activities in the park.
- Monitoring of coral diversity, cover and 'health' at moorings, anchoring and dive sites.

1.3 AIMS

The main aim of the RSMRMP is to establish a network of long-term monitoring sites to assess and monitor the status of the benthic communities in the RSMP and MRMNNR. The objectives of the October 2001 field survey are:

- To establish permanent monitoring sites in representative undisturbed areas of RSMP and MRMNNR to assess the effects of natural disturbances on intertidal and sub-tidal benthic communities.
- To assess the impacts of human activities at selected sites on the benthic communities of the RSMP and MRMNNR and, if appropriate, establish permanent monitoring sites to assess trends over-time.
- To determine the presence/absence and relative abundance (if appropriate) of key species at each site.
- To take still images and video footage of benthic communities at representative sites on an opportunistic basis to assist with the future education programs and habitat mapping.

2. SITE SELECTION AND METHODS AND EQUIPMENT

2.1 SITE SELECTION

2.1.1 Surveillance and natural variability monitoring sites

Sites will be selected to represent the ecological attributes of reef front, reef flat and lagoonal coral communities found in undisturbed areas at each of the atolls. Fifteen monitoring sites will be established at each atoll in areas of low human usage using the 'transect' monitoring method. These will consist of:

- six intertidal sites on coral communities on the reef flat/back reef;
- six sub-tidal sites (less than 10 m depth) on the seaward reef front. These sites will complement the Australian Institute of Marine Science (AIMS) monitoring sites established on the north-east reef front of each atoll; and
- three sub-tidal sites in the lagoon.

The surveillance monitoring sites will be used to monitor impacts from broad-scale natural events including cyclones, coral predation (eg Crown of thorns starfish and *Drupella* sp) and coral bleaching events. A subset of the surveillance monitoring sites, preferably those in proposed Sanctuary Zones, will be used as natural variability sites.

2.1.2 Human usage monitoring sites

The types, intensity and spatial and temporal scales of human activities in the Rowley Shoals can be found in the report '*Human Usage in the Rowley Shoals Marine Park and Mermaid Reef Marine National Nature Reserve*' (Lapwood and Grubba, 2001). Monitoring sites will be established in coral communities considered most vulnerable to human activities (Table 1). These sites include the designated mooring and anchoring areas, boat channels and dive and/or snorkel sites with easily damaged corals such as gorgonian and branching corals. Sites will include both 'transect' and 'non-transect' monitoring methods. At sites chosen to assess the impacts of broad-scale human influences, the 'transect' method will be used. For sites with localised human usage activities, such as dive and snorkel sites, a 'non-transect' method of recording impacts will be used.

2.1.3 Priority of monitoring sites

Priority will be given to establishing permanent surveillance and natural variability 'transect' sites during this field trip. Further human usage monitoring sites will be established at popular dive sites in collaboration with the local charter boat operators over the next few years.

2.2 METHODS

2.2.1 General procedures

Two tenders will be used throughout the field trip including the '*PV Walcott'* tender (a 6m Zodiac with 90hp o/board) and the CALM Zodiac (3.5m Zodiac with 25hp o/board). The '*PV Walcott*' tender will be referred to as tender 1, and the CALM MCB Zodiac as tender 2.

1. The mother vessel '*PV Walcott'* anchors or maintains position in the vicinity of the monitoring site.
2. Gear is made ready and the two tenders are launched from the '*PV Walcott'*.
3. Both tenders leave the *'PV Walcott'* together and navigate to pre-selected monitoring sites.
4. Monitoring sites are established and surveyed using the methods described below.
5. At the end of the day the tenders return to the *'PV Walcott'* and are unloaded and gear stored.
6. When all the sites have been established and surveyed at one atoll, the *'PV Walcott'* will move on to the next atoll.

Each tender will be used to establish and survey separate monitoring sites, however both tenders should maintain sight and/or radio contact with each other. This is especially important when operating outside the lagoon.

Between October 13-18 eight field crew will go into the field. Tender 1 will be skippered by a '*PV Walcott*' crew member. Tender 2 will be skippered by a member of the field team and if required this person can anchor the boat and work in the water. Between October 19–22 the field team will be reduced to seven (as Jennie Cary leaves the field trip on the evening of October 18). During this time each tender will be skippered by a *'PV Walcott'* crew member. Where possible field team members will be rotated, however this is dependent on diving restrictions, skills, experience and performance (Table 2).

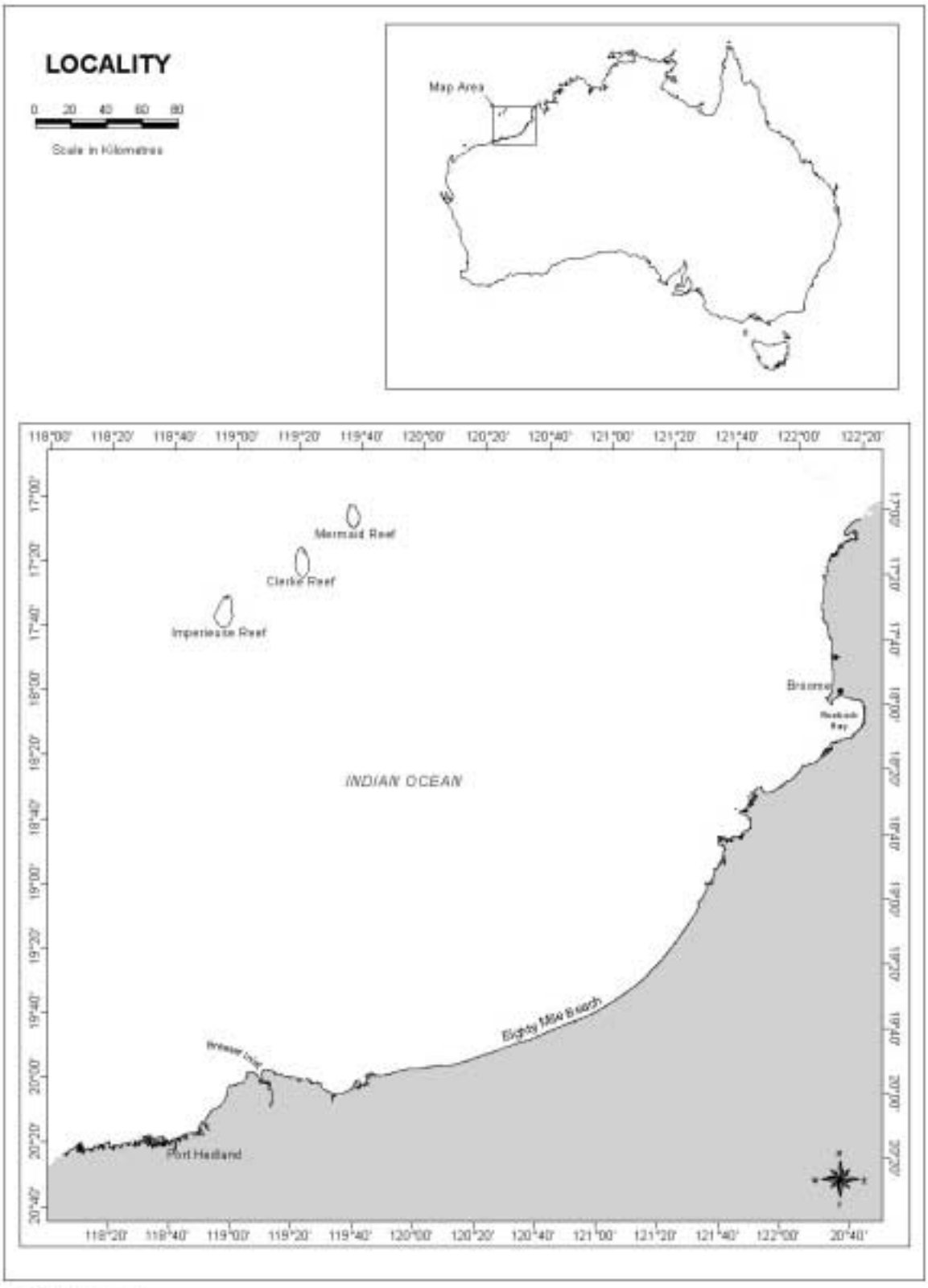


Figure 1. Locality

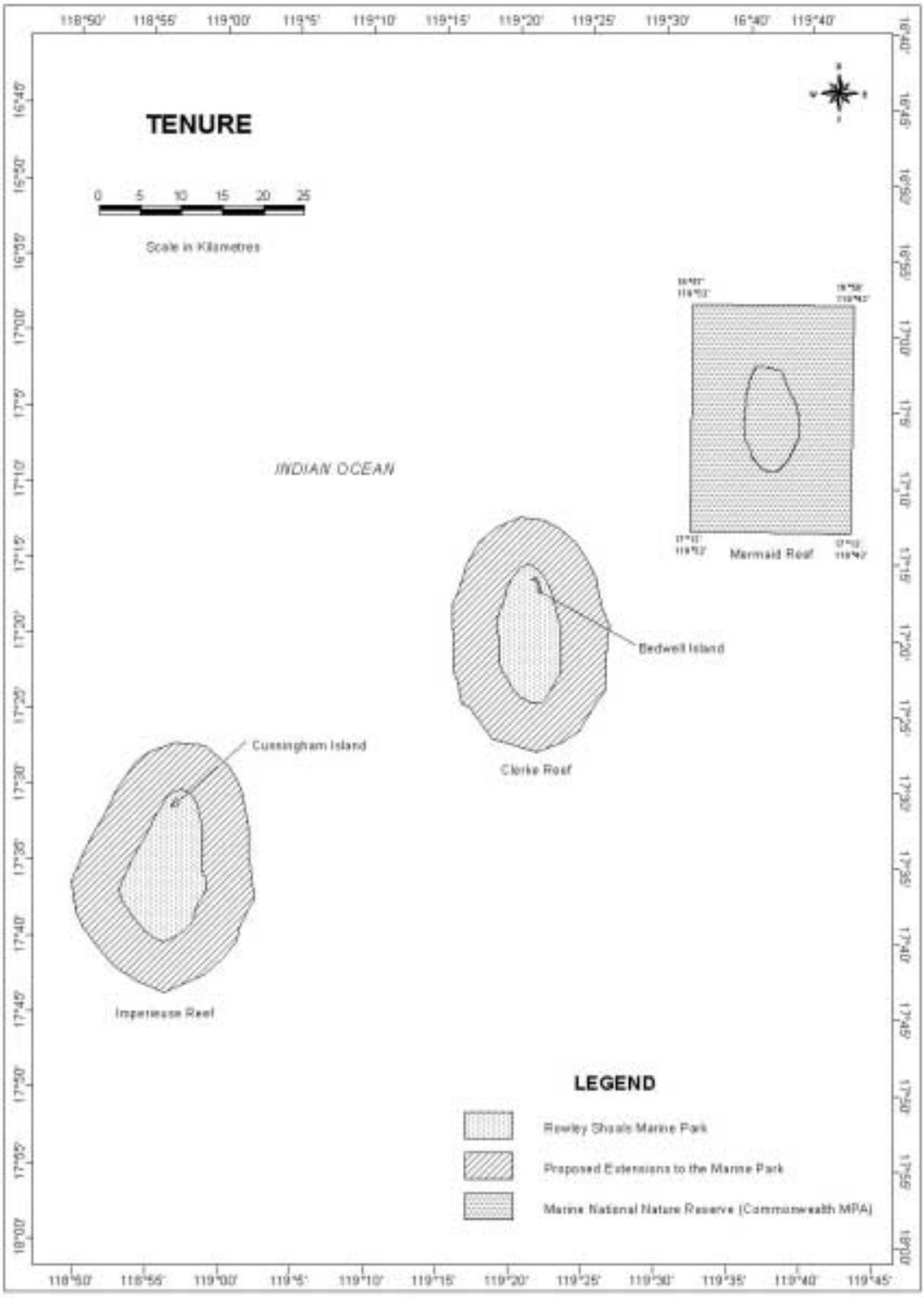


Figure 2. Tenure.

Table 1. Description of sites to be established

Site No	Atoll	Latitude		Longitude		Location on reef	Site
I1	Imperieuse	17º	29.9082	118º	57.1500	Reef front	Surveillance
I2	Imperieuse	17º	30.3156	118º	57.1560	Back reef	Surveillance
I3	Imperieuse	17º	32.2236	118º	55.1934	Reef front	Surveillance
I4	Imperieuse	17º	32.3460	118º	55.5738	Back reef	Surveillance
I5	Imperieuse	17º	35.7198	118º	53.4048	Reef front	Surveillance
I6	Imperieuse	17º	35.7792	118º	53.8488	Back reef	Surveillance
I7	Imperieuse	17º	39.6252	118º	55.6410	Reef front	Surveillance
I8	Imperieuse	17º	38.8686	118º	55.9152	Back reef	Surveillance
I9	Imperieuse	17º	36.6318	118º	58.4418	Reef front	Surveillance
I10	Imperieuse	17º	36.6090	118º	58.2060	Back reef	Surveillance
I11	Imperieuse	17º	37.0440	118º	56.4156	Lagoon	Surveillance
I12	Imperieuse	17º	35.3322	118º	57.8052	Lagoon	Surveillance
I13	Imperieuse	17º	33.6060	118º	56.5158	Lagoon	Surveillance
I14	Imperieuse	17º	33.1836	118º	58.1166	Back reef	Surveillance
I15	Imperieuse	17º	33.1488	118º	58.3362	Reef front	Surveillance
I16	Imperieuse	17º	29.9118	118º	57.3372	Reef front	Human usage
I17	Imperieuse	17º	30.4320	118º	57.9048	Reef front	Human usage
I18	Imperieuse	17º	32.8266	118º	57.7278	Lagoon	Human usage
C1	Clerke	17º	14.8326	119º	20.7168	Reef front	Surveillance
C2	Clerke	17º	14.9454	119º	20.7114	Back reef	Surveillance
C3	Clerke	17º	16.8084	119º	19.2978	Reef front	Surveillance
C4	Clerke	17º	16.9656	119º	19.6638	Back reef	Surveillance
C5	Clerke	17º	21.0270	119º	18.9846	Reef front	Surveillance
C6	Clerke	17º	21.0186	119º	19.3830	Back reef	Surveillance
C7	Clerke	17º	23.7360	119º	21.4116	Reef front	Surveillance
C8	Clerke	17º	23.3100	119º	21.2796	Back reef	Surveillance
C9	Clerke	17º	21.3702	119º	22.9920	Reef front	Surveillance
C10	Clerke	17º	21.3402	119º	22.7004	Back reef	Surveillance
C11	Clerke	17º	20.7564	119º	21.0438	Lagoon	Surveillance
C12	Clerke	17º	18.2358	119º	20.1528	Lagoon	Surveillance
C13	Clerke	17º	17.6574	119º	22.0554	Lagoon	Surveillance
C14	Clerke	17º	17.2752	119º	22.5198	Back reef	Surveillance
C15	Clerke	17º	17.3628	119º	22.5612	Reef front	Surveillance
C16	Clerke	17º	14.7690	119º	21.0594	Reef front	Human usage
C17	Clerke	17º	17.0118	119º	22.3134	Reef front	Human usage
C18	Clerke	17º	16.7184	119º	21.8958	Lagoon	Human usage
M1	Mermaid	17º	1.7052	119º	37.0674	Reef front	Surveillance
M2	Mermaid	17º	2.1216	119º	37.2588	Back reef	Surveillance
M3	Mermaid	17º	4.6602	119º	35.8080	Reef front	Surveillance
M4	Mermaid	17º	4.9938	119º	36.0048	Back reef	Surveillance
M5	Mermaid	17º	7.6926	119º	35.6934	Reef front	Surveillance
M6	Mermaid	17º	7.5966	119º	36.1152	Back reef	Surveillance
M7	Mermaid	17º	9.7890	119º	37.6368	Reef front	Surveillance
M8	Mermaid	17º	9.2874	119º	37.7382	Back reef	Surveillance
M9	Mermaid	17º	7.6806	119º	39.6330	Reef front	Surveillance
M10	Mermaid	17º	7.7580	119º	39.4494	Back reef	Surveillance
M11	Mermaid	17º	8.0280	119º	38.0016	Lagoon	Surveillance
M12	Mermaid	17º	6.9366	119º	38.0964	Lagoon	Surveillance
M13	Mermaid	17º	5.3190	119º	38.1300	Lagoon	Surveillance
M14	Mermaid	17º	4.8228	119º	39.0492	Back reef	Surveillance
M15	Mermaid	17º	4.7322	119º	39.2622	Reef front	Surveillance
M16	Mermaid	17º	2.5872	119º	37.5444	Reef front	Human usage
M17	Mermaid	17º	2.1660	119º	37.8348	Reef front	Human usage
M18	Mermaid	17º	4.5774	119º	38.4102	Lagoon	Human usage

Table 2. Potential roles of field team members

	Data Recorder	Transect	Video Operator	Tender Operator	Data Entry	Tank Fills
Jennie Cary	✔	✔	✔		✔	
Tim Grubba	✔	✔	✔	✔	✔	
Mike Lapwood	✔	✔	✔	✔	✔	
Kingsley Miller	✔	✔		✔	✔	
Judy Davidson	✔	✔	✔	✔	✔	
Kylie Ryan	✔	✔	✔	✔	✔	
David Harasti	✔	✔	✔		✔	
Jill St John	✔	✔			✔	
Walcott crew				✔		✔
Walcott crew				✔		✔
Walcott crew				✔		✔

2.2.2 'Non-transect' sites

Approximately nine 'non-transect' sites will be established as part of the RSMRMP in areas of high human usage such as dive sites and (Table 1). Proposed site positions will be digitised in ArcView (GIS software) to determine site coordinates in degrees (latitude/longitude) using the datum WGS84. Site coordinates will be up-loaded to a Lowrance global positioning system (GPS) unit that will be used in the field to locate proposed sites. Located sites will then be surveyed (generally) to determine the spatial extent of human activities and impacts. A sample of this area is then temporarily marked out using weighted marker buoys on each corner (rectangular area). At 'wall'-type sites it will only be possible to establish two markers on the reef edge, due to excessive depth. Differential GPS (DGPS) coordinates of each marker buoy will be recorded along with a site map on a long-term monitoring site data sheet printed on underwater paper (Appendix 1).

At each site digital video footage will be taken of any damage to benthic communities from assumed human activities (eg anchor or diver damage) and any observed litter. In addition the following observations are recorded onto the habitat sheets and 'non-transect' data sheets printed on underwater paper (Appendix 1):

- habitat description, including dominant species and those vulnerable to impacts by humans eg gorgonian and branching corals;
- type and extent of impacts from human activities on benthic communities;
- type of litter and number of items;
- presence/absence and relative abundance of non-cryptic indicator species. Four categories (absent, rare, uncommon, common) will be used to determine relative abundance and the number of species per category will vary between species.
    - Fish
        - Potato Cod (*Epinephelus tukula*)
        - Humphead wrasse (*Cheilinus undulatus*)
        - Coral trout (*Plectropomus leopardus*)
    - Molluscs
        - Giant clam (*Tridacna gigas*)
        - Trochus (*Trochus maculatus*)
        - Tiger cowrie (*Cypraea tigris*)
    - Other invertebrate
        - Sea cucumbers (all species)
- Presence/absence and relative abundance of coral predators
        - Crown of thorns starfish (see Appendix 4 for method); and
        - *Drupella sp* (see Appendix 5 for method)

The data from the data sheets will be entered electronically onto standard data files. All written data is to be transferred to the computer files during the field survey, and preferably on the day of collection.

2.2.2.1 Methods for the establishment of 'non-transect' sites

The following outlines the field procedures to be used when establishing 'non-transect' monitoring sites. The procedures are based on Tender 1 having a team of five people and Tender 2 having a team of four people. Each team will play the following roles:

- *TENDER OPERATOR (TO)*: operates the tender
- *DECK PERSON (DP)*: draws a site map and records DGPS coordinates;
- *OBSERVER 1 (VO1)*: operates the video camera for benthic community monitoring;
- *OBSERVER 2 (VO2)* operates the video camera for fish monitoring (only on Tender 1); and
- *OBSERVER 3 (DR)*: records habitat data.

It may be possible to rotate the roles of the crew to some degree to increase surface intervals when diving at deeper sites. Rotation however is dependent on the capabilities of each team member (Table 2).

1. Navigate to the site using pre-selected site coordinates up-loaded to a GPS in conjunction with marked aerial photographs.
2. Temporarily mark the boundaries of the site using weighted marker buoys. Refer to human usage data and site maps to determine the spatial scale of the human activities/impacts occurring at the site.
3. VO1 records video footage of the general area (360º pan) from one of the marker buoys before swimming through the entire site recording video footage of visible impacts (eg broken coral, litter, etc.) and anything else of significance. VO2 records video footage for the fish monitoring method (refer to Department of Fisheries for methodology).
4. The DR follows the video operators and records general observations such as dominant species, general health and any visible impacts etc. The DR draws a detailed site map that marks the location of impacts in relation to prominent site features.
5. The TO and DP (or DR) record the coordinates for each corner marker buoy of the site using a DGPS (datum: WGS84, decimal degrees to four decimal places) (Appendix 2) and draw a site map.
6. Once the site has been surveyed all temporary markers are removed prior to moving to the next site.

2.2.3 'Transect' sites

Fifteen 'transect' sites will be established at each atoll as part of the RSMRMP (Table 1). Proposed site positions will be digitised in ArcView to determine site coordinates in degrees (latitude/longitude) using the datum WGS84. Site coordinates will be up-loaded to a Lowrance global positioning system (GPS) unit that will be used in the field to locate proposed sites.

At each 'transect' site three permanent 50 m transect will be established, with each transect being a replicate. The alignment of the transects will be governed by bathimetry and the benthic composition. Where practical 'transects' will be set in a line, one after the other with the transect start and end points separated by a 10 m space. For this configuration the distance between the start of the first transect and the end of the last transect will be 50+10+50+10+50 = 170m. If this configuration is impractical at a particular site then the three 50m transects can be set up parallel to each other or in what ever configuration is appropriate for the area to ensure each transect is a replicate.

The start of the first transect will be positioned so that it is adjacent to a distinctive physical feature (to assist in future site re-location). The position of the start and end of each transect will be recorded using DGPS (datum: WGS84, decimal degrees to three decimal places) which provides an accuracy of 3-4 m. In addition, comprehensive site maps will be drawn that describe the start of each transect in relation to distinctive physical features. This information is recorded on the long-term monitoring site data sheet printed on underwater paper (Appendix 1). If the start of transect one can not be positioned adjacent to a distinctive feature then a star picket with PVC cap will be installed.

A 50 m scaled (every 10cm) and weighted transect line is laid out so that follows the contour of the seabed. Digital video footage is taken (set height and speed) to record the sessile benthic composition along each transect, resulting in a belt transect approximately 50m x 1m being sampled. This survey technique provides a permanent record of benthic habitats that can be latter analysed using the line intercept transect method (LIT).

In addition the following observations are recorded onto the habitat data sheet printed on underwater paper (Appendix 1):

- habitat description, including dominant species and those vulnerable to impacts by humans eg gorgonian and branching corals;
- type and extent of impacts from human activities on benthic communities;
- type of litter and number of items;
- presence/absence and relative abundance of non-cryptic indicator species. Four categories (absent, rare, uncommon, common) will be used to determine relative abundance and the number of species per category will vary between species. Data will be collected along a two metre belt (one metre on either side of the transect line).
    - Fish
        - Potato Cod (*Epinephelus tukula*)
        - Humphead wrasse (*Cheilinus undulatus*)
        - Coral trout (*Plectropomus leopardus*)
    - Molluscs
        - Giant clam (*Tridacna gigas*)
        - Trochus (*Trochus maculatus*)
        - Tiger cowrie (*Cypraea tigris*)
    - Other invertebrate
        - Sea cucumbers (all species)
    - Presence/absence and relative abundance of coral predators
        - Crown of thorns starfish (see Appendix 4 for method); and
        - *Drupella sp* (see Appendix 5 for method)

The data from the data sheets will be entered electronically onto standard data files. All written data is to be transferred to the computer files during the field survey, and preferably on the day of collection.

2.2.3.1 Methods for the establishment of 'transect' sites

The following outlines the field procedures to be used when establishing 'transect' monitoring sites. The procedures are based on Tender 1 having a team of five people and Tender 2 having a team of four people. Each team will play the following roles:

- *TENDER OPERATOR (BO)*: operates the tender;
- *TRANSECT LAYER (TL)*: lays/retrieves transect lines, draws site maps and records DGPS coordinates;
- *OBSERVER 1 (VO1)*: operates the video camera for benthic community monitoring and draws site maps;
- *OBSERVER 2 (VO2)* operates the video camera for fish monitoring (only on Tender 1); and
- *OBSERVER 1 (DR)*: records habitat data (assists TL on tender 2).

It maybe possible to rotate the roles of the crew to some degree to increase surface intervals when diving at deeper sites. Rotation however is dependent on the capabilities of each team member (Table 2).

Site identification

1. Tenders navigate to the site using pre-selected site coordinates up-loaded to a GPS in conjunction with marked aerial photographs.
2. In the case of reef front sites the '*PV Walcott*' can be used to access the site.

3. Tenders reconnoitre the general area referring to pre-marked aerial photographs and GPS coordinates for guidance.
4. The benthic habitat is viewed using a viewfinder or by snorkelling to identify a prominent physical feature (eg coral bommie, patch of sand) from which to start the first transect, ensuring enough room to lay all three transects.
5. A weighted marker buoy is deployed at the start of transect 1.
6. Tender travels 60 m from the first marker following the direction that the transect will run. Mark the start of transect 2 using a weighted marker buoy.
7. Tender travels another 60 m from the second marker following the compass bearing used for transect 1. Mark the start of transect 3 using a weighted marker buoy.
8. Tender travels a final 50 m from the third marker using the same compass bearing used for transects 1 and 2. Mark the end of transect 3 using a weighted marker buoy.
9. Tender returns to the start of transect 1 and stands by.

'Transect' line deployment

1. As soon as the marker buoys have been deployed tenders can deploy TL, DR and VOs.
2. If it is necessary to install a star picket the TL is provided with a 60cm or 90cm (depending on substrate) galvanised star picket , sledge hammer, pvc cap and wire. The TL install the star picket, ensuring the star picket is firmly embedded (ie at least 2/3 embedded) and wire on the pvc cap.
3. TL takes a compass bearing of the next float and clips the transect line to marker buoy and lays out the 50m transect line (and 10m spacer) along the bottom following the compass bearing.
4. The DR follows behind the TL recording ensuring that the transect line follows the bottom contours and records general observations such as dominant species, general health and any visible impacts etc.
5. The VO remains at the start of transect 1 and draws a site map that describes the position of the start of the transect in relation to distinctive physical features.
6. In some circumstances (eg strong currents, flat bottom) the transect line can be deployed from the tender following the compass bearing.
7. Tender returns to the start of transect 1 and hands the VO the video camera to start video taping transect 1.
8. The TL uses the previous compass bearing repeat steps 3 and 4 for transect 2 and 3.
9. When the transects are laid out the tender retrieves the TL while the DR swims back along the transect to join the VO.

'Transect' survey

1. Once the site map for the start of transect 1 has been completed, VO1 records video footage (360º pan) of the general area at the start of transect and the site and transect details written on the pvc cap.
2. The VO records video footage along the length the transect (section 2.2.3.2).
3. VO2 records video footage for fish monitoring method (refer to Department of Fisheries for methodology).
4. At the end of transect 1 the VO1 draws a site map and then draws a site map for the start of the next transect.
5. The VOs repeats steps 1 to 4 for the remaining two transects.
6. After all transects are laid the DR re-locates the VOs and takes over the job of drawing site maps.

'Transect' coordinates and transect line retrieval

1. When the TL has completed laying all transects the TL is retrieved by the tender. The TL then draw site maps and record the coordinates of the start of each transect and the end of transect 3 (using the marker buoys as reference points) using DGPS (datum WGS84, decimal degrees to four decimal places) (Appendix 2).
2. When each transect is surveyed and site coordinates recorded the TL is deployed to retrieve the transect lines. The VOs and DR can also assist in retrieving transect lines if they are finished.

2.2.3.2 Methods for obtaining video footage of permanent transects

The transect sampling technique is adapted from the AIMS Standard Operating Procedure No. 2 (Christie *et al*., 1996). The recording of data for each transect should be carried out according to the following steps:

1. Fill out the details on the in-water data sheet (positioned on the top of the housing) identifying the transect. Record the site number, date, transect number, and recorder's name.
2. Before beginning to film the transect, record a panoramic shot of the area adjacent to the start of the transect (for instructions on the set up and use of the video see Appendix 3). Start at the beginning of the transect, hold the camera in a horizontal position and turn slowly clockwise, videoing the immediate surroundings and ending at the initial view. Move in on top of the star picket to record the site number and transect number written on the pvc cap.
3. Record the start time code on the data sheet. Press REC and video the base of the star picket for a few seconds and then move along the transect line. Keep the housing lens parallel to the substrate at a distance of 50cm.
4. Follow the transect line keeping the housing at the set height of 50cm, ensuring that the screen image is in focus. Adjust your swimming speed so that it is constant and you cover 10m approximately every minute, and not faster. This is important to ensure a high quality of image. Each 50m transect should take between 5 and 6 minutes in total. At the end of the transect, video the weight of the marker buoy for a few seconds and then press STBY.
5. Record the finish time code on the data sheet.
6. If video recording along a transect has to be aborted for any reason, or if there is considerable variation in the height or speed of the recorder, then the entire transect should be re-sampled, beginning again from the start point of the transect. It is important that the new start and finish time codes for any repeated transects are clearly recorded on the data sheets.
7. Proceed to the next transect. Once all three transects at a site have been completed and the tape has been viewed and checked, full details must be recorded on the main video transect data sheet (Appendix 1). Any repeated or incomplete transects, or situations where transects were recorded out of order or with false starts should be noted on the data sheets.
8. A total of two sites should be recorded on each 60min digital video tape. The tape and tape cover should be clearly labelled (using a permanent marker) with the designated tape number (Appendix 3), the site number and date of recording. The copy protect switch on the tape should be switched on to prevent accidental recording over any data, and the tapes should be stored in a waterproof case at all times.

2.2.4 Contingency for adverse conditions

In the event of adverse weather or sea conditions the Field Team Leader in consultation with the tender skippers may choose to re-evaluate the day's field program and change the schedule if necessary. This would primarily involve the abandonment of a site at which conditions are unsuitable and the replacement of the site with a site that is sheltered from the wind and/or offers better sea conditions for underwater work.

3. PROJECT MANAGEMENT

3.1 SURVEY TEAM

3.1.1 CALM personnel

The survey team will be comprised of four CALM (MCB) personnel (Tim Grubba, Jennie Cary, Judy Davidson and Kylie Ryan) assisted by Mike Lapwood and Kingsley Miller (Broome Work Centre)

Jennie Cary	Project leader and Field Team Leader Senior Marine Ecologist	Ph (w) (08) 9432 5105 Fax (08) 9430 5408 Ph (h) (08) 9339 7881
Tim Grubba	Field Team Leader Marine Ecologist	Ph (w): (08) 9432 5118 Fax: (08) 9430 5408 Ph (h) (08) 9271 5560
Mike Lapwood	Dive Supervisor	Ph (w): (08) 9192 1036

	Marine Operations Officer.	Fax:	(08) 9193 5027
		Ph (h)	(08)
Kingsley Miller	Diver	Ph (w):	(08) 9192 1036
	District Wildlife Officer.	Fax:	(08) 9193 5027
		Ph (h)	(08)
Judy Davidson		Ph (w)	(08) 9432 5117
	Marine Conservation Officer	Fax	(08) 9430 5408
		Ph (h)	(08) 9354 3567
Kylie Ryan		Ph (w)	(08) 9432 5115
	Marine Conservation Officer	Fax	(08) 9430 5408
		Ph (h)	(08) 9438 2930

3.1.2 Department of Fisheries personnel

Daron Cooper	PV Walcott Skipper	Ph (mobile)	0438 940 018
		Ph (sat phone):	0011 872 761 876 574
	.	Fax: (sat)	0015 872 761 876 575
		Ph (mobile)	0419 049 379
Jill St John	Research Scientist	Ph (work)	(08) 9246 8488
	.	Fax:	
		Ph (h)	

3.1.3 Environment Australia personnel

David Harasti		Ph (work)	(02) 6274 1806
	.	Fax:	
		Ph (h)	

3.2 FLIGHT ITINERARY

Flight Details are as follows:

Perth to Broome

Departure flight:

Departure date and time:	Wednesday, 10 October at 9:45am (D Harasti) Friday, 12 October at 9:45am (T. Grubba) Friday, 12 October at 6:00pm (J. Cary, J. Davidson, K. Ryan, J St John)
Arrival time:	Wednesday, 10 October at 12:30pm (D. Harasti) Friday, 12 October at 12:30pm (T. Grubba) Friday, 12 October at 8:45pm (J. Cary, J. Davidson, K. Ryan, J St John)

Broome to Perth

Departure flight:

Departure date and time:	Friday, 19 October at 1:00pm (J. Cary) Tuesday, 23 October at 1:00pm (K. Ryan) Wednesday, 24 October at 1:00pm (T. Grubba and J. Davidson)
Arrival time:	Friday, 19 October at 4:00pm (J. Cary) Tuesday, 23 October at 4:00pm (K. Ryan) Wednesday, 24 October at 4:00pm (T. Grubba and J. Davidson)

3.3 FIELD ITNERARY

Table 3. Field itinerary for the period 12-24 October 2001

Date	day	Site number location	Activity
3/10/01	Wed		• Equipment road freighted to Broome • Depart Perth (9:45am and 6:00pm) • Arrive Broome (12:30pm and 8:45pm)
12/10/01	Fri		• Load and secure equipment on PV Walcott • Department Broome (10:00pm) for the Rowley Shoals
13/10/01	Sat		• Arrive Imperieuse Atoll (am) • Survey sites
14/10/01	Sun		• Survey sites
15/10/01	Mon		• Survey sites
16/10/01	Tue		• Depart Imperieuse Atoll (am) • Arrive Clerke Atoll (am) • Survey sites
17/10/01	Wed		• Survey sites
18/10/01	Thu		• Survey sites • Jennie Cary leaves on Charter Vessel 'True North' (pm)
19/10/01	Fri		• Survey sites • Jennie Cary arrives Broome am
20/10/01	Sat		• Depart Clerke Atoll (am) • Arrive Mermaid Atoll (am) • Survey sites • Jennie Cary departs Broome (2:35pm)
21/10/01	Sun		• Survey sites
22/10/01	Mon		• Survey sites • Stow gear late afternoon • Depart Mermaid Atoll (pm) for Broome
23/10/01	Tue		• Arrive Broome (am) and unload boat • Depart Broome 1:00pm (Kylie)
24/10/01	Tue		• Depart Broome (1:00pm) (Tim and Judy)

3.4 SAFETY

3.4.1 General

Field operations shall be carried out in accordance with departmental procedures and protocols. Overall responsibility for field procedures during this field trip and the personal safety of all team members rests with the Field Team Leader – Jennie Cary (12-19 October) and Tim Grubba (20-23 October).

3.4.2 Diving

All diving activities, both SCUBA and snorkelling shall be accordance with 'Safe Diving in CALM: (September 1998)' document. The Dive Supervisor is responsible for diving safety at all times. The Dive Supervisor will be Mike Lapwood. A dive plan has been lodged to the Departmental Dive Officer (DDO) and approved.

3.4.3 Boating

Boating and navigation are the responsibility of the boat skipper and shall be conducted in accordance with CALM Boating Policy (Draft). Safety issues are the responsibility of the vessel skippers in consultation with the Field Team Leader. People qualified to be skippers include the '*PV Walcott*' crew , Mike Lapwood, Kingsley Miller, Tim Grubba, Judy Davidson, Kylie Ryan, and Jill St John.

3.5 COMMUNICATIONS AND EMERGENCY CONTACTS

3.5.1 General

- The survey team will contact CALM Broome Work Centre daily or as required by fax on board '*PV Walcott*' (Fax #: 0015 872 761 876 575).
- Hand-held VHF radios will be carried on board the mother ship and tenders.
- The '*PV Walcott*' will have a satellite phone (# 0438 940 018)

3.5.2 CALM offices

CALM, Broome Work Centre: Ph.(08) 9192 1036, Fax (08) 9193 5027
Marine Conservation Branch, Fremantle: Ph (08) 9432 5100; Fax (08) 9430 5408

3.5.3 Emergency

Broome District Hospital/Ambulance: Ph.(08) 9192 9222, fax (08) 9192 2322
Broome Police: Ph. (08) 9192 1212, fax (08) 9193 5077
Broome Hyperbaric/Diving Service: Paul Cookson (08) 9192 1748, mob: 0418 715 717
Royal Flying Doctor Service: Admin: Ph (08) 9414 1200
Broome Aviation: Ph 9192 1369, a/h 0417 992 618 - In the case of emergency evacuation, Broome Aviation can mobilise a 9 seater Otter floatplane to evacuate in extreme cases

3.5.4 Other

Fisheries Department, Broome: Ph (08) 9192 1996
Workline Dive: Ph (08) 9192 2233 (Back-up compressor hire)

3.5.5 Suppliers

Aerial photos: DOLA, Gary Caporn, Ph. 9273 7209
Transport: Wesfarmers Transport Ph. (08) 9192 1425 fax. (08) 9192 2352
Underwater video system: Sea Optics, David Hill, Ph. (08) 3626161
DGPS: Fugro, Silvi, Ph. (08) 9322 4955
DGPS Hire: Global Positioning, Marina, Ph. (08) 9388 7333

3.6 ACCOMMODATION

Field staff will be accommodated on the Fisheries Western Australia vessel *'PV Walcott'* which accommodates 8 passengers and 3 crew. The crew and field crew will prepare meals.

3.7 BUDGET

Table 4. Budget reconciliation for the Rowley Shoals Marine Reserves Monitoring Program – 2001 Field Trip.

Budget Item		CALM MCB Funds ($) in kind & Operational.	CALM BWC Funds ($) in kind & Operational	EA Funds ($) Operational	Dept Fisheries Funds ($) in kind)	Total costs ($)
Travel						
Vehicles	CALM MCB vehicle - $0.45/km for 1,000 km	450				450
	CALM WKD vehicle - $0.45/km for 500 km		225[3]			225
		450	**225**			**675**
Boat charter*	2 x ½ days at $3,100 (steaming) and 10 days @ $1,500 (anchor, > 4 hours steaming).		1,200[3]	20,000	34,900[2]	56,100
Food and Drink	6 people @ $20/person/day x 12 days		1,440[3]			1,4400
Airfares	4 x return Perth-Broome (based on full fare)	4,000[3.]				4,000
		4,000	**2,640**	**20,000**	**34,900**	**61,440**
Staff						
Jennie Cary		3,288[1]				3,288
Tim Grubba		11,943[1]				11,943
Judy Davidson		2,032[1]				2,032
Kylie Ryan		2,455[1]				2,455
Mike Lapwood			11,465			11,465
Kingsley Miller			2,866			2,866
Mark Sheridan		1,262				1,262
Dive medicals		300[3.]				300
Hard living allowance						
Diving allowances						
		21,280	**14,331**			**35,611**
Equipment						
MCB inflatable & 25 hp o/b	12 days @ $100		*1,200*			1,200
DGPS unit	12 days @ $150	*1,800*				1,800
DGPS unit	12 days @ need to check with Mark Laming	500[3.]				500
DGPS unit	12 days @ $50 stand-by or $280 used	1,000[3.]				1,000
Equipment hire (compressor)	12 days @ $71.50 stand by or $110 used	1,200[3.]				1,200
7x SCUBA sets	12 days @ $400	*3,000*	*1,800*			4,800
1 x SCUBA sets			500[3]			500
11 x SCUBA cylinders	12 days @ $100	*1,200*				1,200
5 x SCUBA cylinders	12 days @ 50		*600*			600
1 x Laptop Computer	12 days @ $100	*1,200*				1,200
3 x Underwater digital videos	12 days @ $150	*1,200*	*600*			1,800
		11,100	**4,700**			**15,800**
Consumables						
Fuel and oil			1,000[3]			1,000
Freight costs		2,000[3.]				2,000
Star pickets and extensions	100 @ $5	*1,000*				1,000
Digital video tapes	15 x DVM – E60 @ $14.75	250[3.]				250
Digital video backup tapes	15 x DVM – E60 @ $14.75		250[3]			250
Slide film	10 x Slide film and Processing	700[3.]				700
Printing		500[3.]				500
Other consumables		1,100[3.]	385[3]			1,485
		5,550	**1,635**			**7,185**
	Total	**42,380**	**23,531**	**20,000**	**34,900**	**121,251**
	Total Operational cost	**11,550**	**5,000**	**20,000**		

[1.] Includes days pre and post field

[2] Difference between CALM's discounted rate and Dept of Fisheries usual rate of 11 days @ $4,675 (total $51,425)

[3.] Operational funds

* Final costs to be determined

3.8 EQUIPMENT

3.8.1 Video systems

CALM Marine Conservation Branch

Primary Unit

- Canon MV1 digital video camera with battery packs (4) and chargers (2).
- Amphibico underwater video housing
- Housing O-ring kit and silicone grease
- Cleaning kit
- Video transect data sheets
- Instruction manuals
- Digital video tapes (30)
- Leads, remote control, and spares

Backup Unit

- Canon MV1 digital video camera.
- Amphibico underwater video housing
- Housing O-ring kit and silicone grease
- Cleaning kit
- Instruction manuals
- Leads, remote control and spares

2nd Backup Unit

- Blaupunkt CC894 Hi 8 video camcorder, with battery pack (2), battery charger (1), battery discharger (1), yellow and orange filters
- StingRay SR-700 underwater video housing with colour monitor back, super wide-angle and zoom-macro lenses, and built-in red filter
- SunRay underwater lighting system with battery pack (3), battery charger (1), and spare lamps (2).
- Instruction manuals
- Sony professional 90min Hi 8 video tapes (15)
- Housing O-ring kit and silicone grease
- Cleaning kit

CALM Broome Work Centre

Secondary Unit

- Canon MV1 digital video camera.
- Amphibico underwater video housing
- Housing O-ring kit and silicone grease
- Cleaning kit
- Instruction manuals
- Leads, remote control and spares

Department of Fisheries

- TV/video unit

3.8.2 Still photography

CALM Marine Conservation Branch

- Land Camera
- 10 rolls of 36 exposure slide film

3.8.3 Safety

CALM Marine Conservation Branch

- Comprehensive diving first aid kit
- Oxy-viva unit (1)

- Spare oxygen D cylinder and regulator
- Sunscreen

CALM Broome Work Centre

- Emergency response flowsheet
- Emergency contact flow chart
- Patient information log
- Accident log sheets

Department of Fisheries

- Comprehensive diving first aid kit
- Emergency response flowsheet
- Oxy-viva unit (1)
- Spare oxygen D cylinder and regulator
- Vinegar and flask hot water per vessel

3.8.4 Information

CALM Marine Conservation Branch

- Maps with historical data
- Reference books for the identification of corals, fish, birds, marine mammals and marine fauna
- Scientific reference file
- Landsat imagery of the Rowley Shoals
- Laminated scanned copies of aerial photographs of the sites for field use
- Maps with historical data
- Habitat data sheets
- Long-term monitoring site data sheets
- Video data sheets
- 1 laptop computers plus 20 floppy disks
- 4 field notebooks
- 1 box of pencils
- 1 stationary box
- equipment log book

CALM Broome Work Centre

- Marine Charts: Satellite photos, coastal maps, sanctuary zone maps with latitudes and longitudes
- Reference books for the identification of corals, fish, birds, marine mammals and marine fauna
- Full set of aerial photographs (water penetration) of the Rowley Shoals

3.8.5 Diving

CALM Marine Conservation Branch

- Personal dive gear (x 4 people)
- 11 scuba tanks
- 5 BCD's
- 5 regulators with alternate airsource and gauges
- 2 spare masks and snorkels
- 2 spare pairs of fins
- 6 dive computers
- 2 spare weight belts, each with 24 lb of weight
- 4 compasses
- 1 dive spare parts and repair kits
- 2 boat dive flags

- 1 personal dive flag
- 6 pocket size underwater slates, grips and pencils
- 4 large underwater slates, grips and pencils
- 2 catch bags
- 100 sheets underwater paper
- box graphite sticks
- box elastic bands
- printed underwater paper for recording video codes
- 1 viewfinder
- Scuba log book
- Compressor (primary) with spares
- Compressor (back-up) with spares
- Dive torch

CALM Broome Work Centre

- Personal dive gear (2 people)
- 5 scuba tanks
- 2 BCD's
- 2 regulators with alternate airsource and gauges
- 2 dive computers
- 1 spare BDC and regulator with alternative airsource and gauges

Department of Fisheries

- Personal dive gear
- 1 BCD
- 1 regulator with alternate airsource and gauges
- 1 dive computers
- 1 compass

Environment Australia

- Personal dive gear
- 1 BCD
- 1 regulator with alternate airsource and gauges
- 1 dive computers
- 1 compass

3.8.6 Vessels and Vehicles

CALM Marine Conservation Branch

- CALM MCB 3.5m zodiac with all safety equipment for survey exempt vessel, fitted with 25hp Yamaha outboard. Two 20-litre containers for fuel.

CALM Broome Work Centre

- District vehicle for transport of field team and equipment in Broome

Department of Fisheries

- '*PV Walcott*' – 24m vessel that accommodates 8 passengers (6 CALM, 1 FWA and 1 EA) and 4 crew
- 6m Zodiac RHIB 90hp outboard
- 4m aluminium dingy

3.8.7 Position fixing and Communications

CALM Marine Conservation Branch

- 2 hand held Lowrance Globalmap 100 GPS units and accessories
- 1 hand held Garmin 12 GPS unit and accessories
- 1 differential GPS unit, antennae accessories

- 1 Omni star differential GPS unit, antennae accessories (hire unit)
- 1 Omni star differential GPS unit, antennae and accessories

Department of Fisheries

- Hand held radios
- On board navigation and communication equipment

3.8.8 Transect establishment

CALM Marine Conservation Branch

- 8 x pre cut marker buoys (6 x 5m, 4 x 10m)
- 6 x 50m weighted transect lines, marked at 10cm increments
- 30 x 600mm galvanised steel pickets
- 20 x 1800mm galvanised steel pickets
- 25 x 600m PVC caps for pickets
- 25 x 250mm stainless steel for fixing caps
- 3 x permanent markers for marking caps
- 2 x 15lb sledge hammers
- 10 x 8lb weights
- 1 x 100 m rope

CALM Broome Work Centre

- 4 pre cut marker buoys (4 x 20m)

3.8.9 Miscellaneous Equipment

CALM Marine Conservation Branch

- 20 AA batteries
- 20 D batteries
- 12 C batteries
- 2 motorbike batteries and chargers

CALM Broome Work Centre

- 1 x esky
- 1 card table

Department of Fisheries

- Comprehensive mechanical tool kit
- Comprehensive electrical repair kit

4. DATA MANAGEMENT

4.1 FIELD PROGRAM REPORT

Hard copies of this Field Program Report will be held at three locations:

1. Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry St., Fremantle, Western Australia, 6160. Ph (08) 9432 5100 Fax (08) 9430 5408.
2. Woodvale Library, Science and Information Division, Ocean Reef Rd., Department of Conservation and Land Management, Woodvale, Western Australia, 6026. Ph (08) 9405 5100 Fax (08) 9306 1641.
3. Archived with CD ROM, Woodvale Library, Science and Information Division, Ocean Reef Rd., Department of Conservation and Land Management, Woodvale, Western Australia, 6026. Ph (08) 9405 5100 Fax (08) 9306 1641.

The Marine Conservation Branch will hold digital copies of the Field Program Report:

1. On CD-ROM [mms_4601] held onsite at the Marine Conservation Branch
2. On the MCB homepage located within the framework of the Department of Conservation and Land Management Intranet (i.e. CALMweb):
3. http://calmweb.calm.wa.gov.au/drb/ncd/mcb/rep_mms.htm#2001

4.2 DATA

Collected raw data will be:

1. Entered into electronic copies of the data sheets (Microsoft Word) database 'Streettalk\userdata@FREM.MCB@CALM' T:\current projects\mms\NMP\NMP_Monitoring_Program\ RSMRMP_Survey1_10_01\ Datasheets_10_01
2. Written into a Marine Management Support Data Report and copies will be held at the same locations as for the Field Programme Report.

4.3 VIDEO RECORDS

Collected mini digital video (MDV) footage will be held at two locations:

1. Video masters (MDV) to be archived at the Information Management Branch (File: 1999F000508, Box: HOLD 08), Department of Conservation and Land Management, 50 Hayman Road, Como, Western Australia.
2. MDV copies to be stored at the Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry Street, Fremantle, Western Australia.

4.4 SLIDE RECORDS

All photographic slides taken by CALM to be stored at the Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry Street, Fremantle, Western Australia.

5. PUBLICITY/EDUCATION

5.1 PUBLIC RELATIONS OPPORTUNITIES

A free-lance journalist and photographer (writer and photographer) will be visiting the Rowley Shoals aboard the 'True North' from 13-19 October to overlap with the CALM field trip. The journalists will talk to the field crew and observe some of their monitoring activities. They will report on a number of stories that will be include the management of the RSMP and MRMNNR, the biological, physical and social aspects of the area. The stories will be submitted to the '*The Saturday West Australian*' and to various national/international publications (eg dive magazines).

5.2 EDUCATION OPPORTUNITIES

Presentations will be given to charter boat passengers on an opportunistic basis. For example if the '*PV Walcott*' is anchored close to a charter vessel overnight.

6. REFERENCES

Christie CA, Bass D K, Neale S J, Osborne K and Oxley W G (1996). Surveys of sessile benthic communities using the video technique. Long-term monitoring of the Great Barrier Reef. Standard Operational Procedure Number 2. Australian Institute of Marine Science, Townsville, Queensland.

Commonwealth of Australia (1999a). Memorandum of Understanding: Mermaid Reef Marine National Nature Reserve Plan of Management. Environment Australia, GPO Box 787, Canberra, ACT, 2501.

Commonwealth of Australia (1999b). Mermaid Reef Marine National Nature Reserve Plan of Management. Environment Australia, GPO Box 787, Canberra, ACT, 2501.

Department of Conservation and Land Management (Draft – Jan 2001). Rowley Shoals Marine Park Draft management plan and indicative management plan for extensions to the existing marine park. (Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry St., Fremantle, Western Australia, 6160).

Lapwood M and Grubba T (2001). Human usage in the Rowley Shoals Marine Park and Mermaid Reef Marine National Nature Reserve. Data Report MMS/RSH/RSMP - 45/2001 (Marine Conservation Branch, Department of Conservation and Land Management, 47 Henry St., Fremantle, Western Australia, 6160). Unpublished report.

7. DISTRIBUTION LIST

Department of Conservation and Land Management
Dr. Chris Simpson, Manager, Marine Conservation Branch, CALM
Allen Grosse, A/Manager, Kimberley Region, CALM
Mike Lapwood, Operations Officer, Broome Work Centre, CALM
Kingsley Miller, Wildlife Officer, Broome Work Centre, CALM
Jennie Cary, Senior Marine Ecologist, MCB, CALM
Tim Grubba, Marine Ecologist, MCB, CALM
Judy Davidson, Marine Conservation Officer, MCB, CALM
Kylie Ryan, Marine Conservation Officer, MCB, CALM

Department of Fisheries
Greg Finlay, Department of Fisheries
Daron Cooper, Skipper PV Walcott, Department of Fisheries
Jill St John, Research Scientists, Department of Fisheries

Environment Australia
Lesley Hodges, Environment Australia
David Harasti, Environment Australia

Others
Rochelle Mutton, Freelance journalist

APPENDIX 1: DATA RECORDING SHEETS

ROWLEY SHOALS MARINE MONITORING PROGRAM
LONG-TERM MONITORING SITE DATA SHEET

SITE NO.		**SITE NAME**			
DATE ESTABLISHED		**TIME**		**RECORDER**	
MPRSWG		**IMCRA BIOREGION**	OSS		
MARINE PARK		**SITE TYPE**			
MPA ZONE		**SITE ZONE**			
WATER DEPTH (MEAN)		**CORRECTED WATER DEPTH (MEAN)**			
METHOD		**GPS/DGPS**		**DATUM**	
NOTES					

COMPLETE FOR TRANSECT SITES

TRANSECT NUMBER	1	**DIRECTION OF TRANSECT (BEARING °)**			
START: LATITUDE (DECIMAL DEGREES)	S	**START: LONGITUDE (DECIMAL DEGREES)**	E		
TRANSECT MARKER (START)		**TRANSECT MARKER (END)**		**WATER DEPTH**	
NOTES					

TRANSECT NUMBER	2	**DIRECTION OF TRANSECT (BEARING °)**			
START: LATITUDE (DECIMAL DEGREES)	S	**START: LONGITUDE (DECIMAL DEGREES)**	E		
TRANSECT MARKER (START)		**TRANSECT MARKER (END)**		**WATER DEPTH**	
NOTES					

TRANSECT NUMBER	3	**DIRECTION OF TRANSECT (BEARING °)**			
START: LATITUDE (DECIMAL DEGREES)	S	**START: LONGITUDE (DECIMAL DEGREES)**	E		
FINISH: LATITUDE (DECIMAL DEGREES)	S	**FINISH: LONGITUDE (DECIMAL DEGREES)**	E		
TRANSECT MARKER (START)		**TRANSECT MARKER (END)**		**WATER DEPTH**	
NOTES					

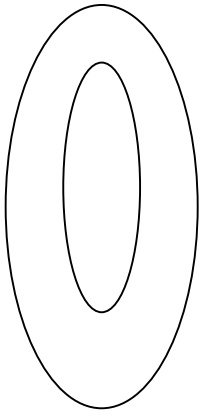
COMPLETE FOR NON-TRANSECT SITES
BOUNDARIES

1. LATITUDE (decimal degrees)	S	**1. LONGITUDE (decimal degrees)**	E
2. LATITUDE (decimal degrees)	S	**2. LONGITUDE (decimal degrees)**	E
3. LATITUDE (decimal degrees)	S	**3. LONGITUDE (decimal degrees)**	E
4. SE LATITUDE (decimal degrees)	S	**4. LONGITUDE (decimal degrees)**	E
WATER DEPTH		**NOTES**	

ROWLEY SHOALS MARINE MONITORING PROGRAM
LONG-TERM MONITORING SITE DATA SHEET

SITE NO.		**SITE NAME**			
DATE ESTABLISHED		**TIME**		**RECORDER**	

SITE MAP TO BE COMPLETED FOR EACH SITE (include north indicator, scale, vessel location, water depth, transect locations and other features of interest)



Transect 1	**Transect 2**	**Transect 3**

ROWLEY SHOALS MARINE MONITORING PROGRAM

HABITAT SHEET

SITE NO		**SITE NAME**					
DATE		**TIME**		**RECORDER**			
WEATHER/SEA CONDITIONS		**WATER DEPTH (MEAN)**		**CORRECTED WATER DEPTH (MEAN)**			
HABITAT TYPE		**SUBSTRATE**					
NOTES							

DOMINANT SPECIES

DOMINANT CORAL (Family/Form)	**DOMINANT VULNERABLE CORALS (Family/Form)**

PERCENTAGE COVER OF LIVE CORAL	**<10%**		**11-30%**		**>30%**	
NOTES						

DOMINANT MACRO-ALGAE	**DOMINANT SEAGRASS**
NOTES	

INDICATOR SPECIES

FISH	**RELATIVE ABUNDANCE**				**FISH**	**RELATIVE ABUNDANCE**			
	0	**1**	**2**	**3**		**0**	**1**	**2**	**3**
Potato Cod (*Epinephelus tukula*)									
Humphead wrasse (*Cheilinus undulatus*)									
Coral trout (*Plectropomus leopardus*)									
NOTES									

MOLLUSCS	**RELATIVE ABUNDANCE**				**OTHER INVERTEBRATES**	**RELATIVE ABUNDANCE**			
	0	**1**	**2**	**3**		**0**	**1**	**2**	**3**
Giant clam (*Tridacna gigas*)					**Sea cucumbers (all species)**				
Trochus (*Trochus maculatus*)									
Tiger cowrie (*Cypraea tigris*)									
NOTES									

ROWLEY SHOALS MARINE MONITORING PROGRAM

HABITAT SHEET

CORAL PREDATORS

CORAL PREDATOR/COTS		CORAL PREDATOR/*DRUPELLA*	
Number of Crown of thorns starfish (COTS)		Number of *Drupella sp* feeding scars	
COTS feeding scars (present/absent)		Number of colonies checked	
Average COTS size (S/M/L)		Number of colonies with *Drupella*	
		Number of colonies without *Drupella*	
NOTES			

HUMAN ACTIVITIES/IMPACTS

HUMAN ACTIVITIES	TYPE OF DAMAGE
NOTES	

LITTER TYPE	NUMBER OF ITEMS	LITTER TYPE	NUMBER OF ITEMS
NOTES			

LEGEND

FISH

FISH	CATEGORIES			
	0 (Absent)	1 (Rare)	2 (Uncommon)	3 (Common)
1.				
2.				
3.				
4.				

MOLLUSCS

MOLLUSCS	CATEGORIES			
	0 (Absent)	1 (Rare)	2 (Uncommon)	3 (Common)
1.				
2.				
3.				
4.				

OTHER INVERTEBRATES

INVERTEBRATES	CATEGORIES			
	0 (Absent)	1 (Rare)	2 (Uncommon)	3 (Common)
1.				
2.				

ROWLEY SHOALS MARINE MONITORING PROGRAM
VIDEO DATA SHEET

SITE NO.		**SITE NAME**			
DATE		**TIME**			
RECORDER		**TAPE ID**			
METHOD		**VIDEO FORMAT**		**DIGITAL COPY**	
TIME CODING FOR SITE (START)		**TIME CODING FOR SITE (FINISH)**			
TAPE DESCRIPTION					

COMPLETE FOR EACH TRANSECT VIDEO

TRANSECT NUMBER	1		
START TIME CODE		**FINISH TIME CODE**	
TOTAL TIME CODE			
NOTES			

TRANSECT NUMBER	2		
START TIME CODE:		**FINISH TIME CODE:**	
TOTAL TIME CODE			
NOTES			

TRANSECT NUMBER	3		
START TIME CODE		**FINISH TIME CODE**	
TOTAL TIME CODE			
NOTES			

COMPLETE FOR ALL OTHER FOOTAGE

DESCRIPTION			
START TIME CODE		**FINISH TIME CODE**	
TOTAL TIME CODE		**NOTES**	

DESCRIPTION			
START TIME CODE		**FINISH TIME CODE**	
TOTAL TIME CODE		**NOTES**	

ROWLEY SHOALS MARINE MONITORING PROGRAM
VIDEO DATA SHEET

DESCRIPTION			
START TIME CODE		**FINISH TIME CODE**	
TOTAL TIME CODE		**NOTES**	

DESCRIPTION			
START TIME CODE		**FINISH TIME CODE**	
TOTAL TIME CODE		**NOTES**	

DESCRIPTION			
START TIME CODE		**FINISH TIME CODE**	
TOTAL TIME CODE		**NOTES**	

DESCRIPTION			
START TIME CODE		**FINISH TIME CODE**	
TOTAL TIME CODE		**NOTES**	

DESCRIPTION			
START TIME CODE		**FINISH TIME CODE**	
TOTAL TIME CODE		**NOTES**	

DESCRIPTION			
START TIME CODE		**FINISH TIME CODE**	
TOTAL TIME CODE		**NOTES**	

APPENDIX 2: NOTES ON GPS USE

It is essential that prior to using the *Lowrance Globalmap 100* that the operator checks the unit's setting to ensure that the correct datum, coordinate format and units have been set. The following are the standard settings used:

- Datum: WGS84 (equivalent to GDA94);
- Coordinate format as decimal degrees (four decimal places); and
- Meters.

It is also good practice to calibrate the unit prior to use by comparing readings taken at known local Department of Land Administration (DOLA) benchmarks. DOLA can provide summary sheets for each DOLA benchmark. DOLA do not have any benchmarks at the Rowley Shoals, so units will be calibrated against the navigation structure on Cunningham Island, Imperieuse Atoll. Any variations between the coordinates displayed on the DGPS unit and those of the navigation structure will be recorded in the field book.

Operators should refer to the Lowrance Globalmap 100 user manual on how to operate the unit. Prior to going into the field all coordinate data for the sites to be re-surveyed should be uploaded to the GPS unit.

In addition operators should always check the datum of any coordinate data entered into the unit, to ensure that it is in datum GDA94/WGS84. In situations where the coordinate data is in a datum not WGS84, then the datum should where possible be converted or noted on the relevant data sheets and field notebooks.

APPENDIX 3: UNDERWATER VIDEO SYSTEM

PREPARATION OF UNDERWATER HOUSING AND VIDEO CAMCORDER

Where possible, store and prepare the equipment at room temperature to prevent condensation on the lenses of the camcorder and housing. Carry out these preparations in a dry, dust and spray-free environment.
The following is to be used as a general guide only. Users should refer to the relevant instruction manual for full details on settings, care and use.

Housing

Check the inside of the housing for any dust or other particulate matter, and clean out using a lens cloth and blower brush if necessary. Check the inside of the lens and clean using blower brush, lens tissues and lens cleaning fluid if necessary.
Remove the O-ring from the housing, clean it with lens tissues and check for any cracks or scratches. If there is any damage to the O-ring, discard and replace with a new one. Apply a small amount of silicone grease (2-3 mm) between thumb and index finger and run the O-ring through several times to spread this evenly. **Ensure that you do not use too much grease as this could cause the seal to leak!** Remember that the grease is there to keep the O-ring supple and not to actually form a seal.
Clean out the O-ring groove with a cotton bud, and carefully replace the clean and greased O-ring back into the groove without twisting it. Ensure that there is no particulate matter sticking to the O-ring. The housing is now ready for the camcorder to be inserted.

CAMERA SETUP

Set the OPERATE switch to CAMERA
Set the STANDBY LEVER (front right) to MOVIE
Press MENU button
Use the small joy stick controller, on the left hand side of the camera, to move around the menu
Set movie mode to PRO SCAN
Set the PROGRAM SELECT switch to AUTO ("A" inside a square)

POST-DIVE PROCEDURE

After every dive immerse the housing in fresh water for about 10-15 minutes. Occasionally operate the external controls to ensure they are well rinsed.
Wipe the housing with a clean, dry towel and leave in a clean, dry, airy and salt-free environment to dry completely.
Wipe carefully around the rear seal of the housing before opening so that no water gets onto the camcorder. Open the housing and remove the camera. **Do not open the housing where salt spray is present.**
Rewind the tape using the either the controls on the back of the camcorder or the remote commander. Connect the camcorder to the TV monitor (refer to camcorder instruction manual) and view the footage. Transcribe the system settings and time code information onto the main Video Transect Data Sheet (Appendix II). Label the tape clearly (using a permanent marker pen) with the designated tape number, the site number and the date of recording as described below.

TAPE NUMBERING

The video tapes should be consecutively numbered according to the following coding system:

Project acronym (NMPMP)/Sampling method (bvt - benthic video transect or nthu - non-transect human use)/Date (03.08.99)/Tape number (#1 onwards).

Thus, the first tape might be labeled as: **RSMRMP/bvt/03.10.01/#1**

If the tape contains footage spanning more than one day the tape number should indicate this (e.g. **RSMRMP/bvt/07-08.10.01/#1).**

A total of two sites should be recorded on each 60 minute digital tape. Before commencing filming at another site, ensure that the tape is wound forward to the end of the footage recorded at the previous site. This will ensure that no data is recorded over accidentally. Once a tape is complete the red copy protect switch on the tape should be switched on to prevent any loss of site data. The tapes should be stored in a waterproof container and duplicated at the end of the field trip.

APPENDIX 4: Marine Community Monitoring Program Method – *Drupella cornus* (coral predator)

Drupella cornus (coral predator)

SKILL RATING: q q EQUIPMENT RATING: q m

TIME RATING: FREQUENCY RATING:

OBJECTIVE

To monitor the presence or absence of the marine snail, *Drupella cornus* on coral reefs in Western Australia.

BACKGROUND

The snail, Drupella cornus, is a small but common natural predator of corals on reefs throughout the world's shallow tropical oceans. Natural population densities are typically ~1 snail/m2 of coral reef. Drupella snails have significantly reduced live coral cover over approximately 100 kilometres of reef in the Ningaloo Marine Park. Drupella outbreaks have also been recorded in southern Japan and the Philippines. Some localised damage has occurred in the Cairns section of the Great Barrier Reef Marine Park.

Drupella are highly cryptic with a camouflaged shell (covered by pink coralline algae) and hide during the day and feed at night. The presence of feeding scars on coral is often the only indication that *Drupella* are present. *Drupella* prefer *Acropora* species, which have staghorn, plate and digitate growth forms. *Drupella* appear to be attracted to damaged corals (eg. by anchors or divers) and aggregations of several hundred *Drupella* are sometimes found on a single coral colony.

Coral reefs are in a constant state of change and the snail outbreaks, like those of the crown-of-thorns, may be natural phenomena. However, it has been suggested that human influences such as overfishing of natural fish predators, such as snappers, sweetlips and wrasses, may be responsible. Further research on the biology and ecology of *Drupella* is necessary to understand these potential links with human activities.

RELEVANCE TO MANAGEMENT

Drupella are a natural part of coral reefs. It is not known whether population outbreaks of this coral-eating snail are caused by human activities. Whatever the cause, *Drupella* have a significant effect on coral reefs, both from ecological and social perspectives. Monitoring of the occurrence of *Drupella* on particular reefs over a long period will help:

- to explain the current condition of corals on reefs; and
- to facilitate a better understanding of the natural influences on coral reefs which is necessary before human impacts can be detected and managed.

LINKS TO OTHER METHOD/S & PROGRAM/S

This method is linked to:

- *Cotswatch* program;
- *Eye on the Reef* ;
- Method 3.5 Reef Check; and
- Method 3.7 Crown of thorns starfish.

SUMMARY OF METHODOLOGY

During a five-minute swim estimate the number of *Drupella* and *Drupella* feeding scars.

EQUIPMENT

NECESSARY

- snorkelling or SCUBA equipment;
- underwater slate (refer to Part II section 3.2);
- *Site Registration Form 3.6*;
- *Data Sheet 3.6*;
- *Information Sheet 3.6*; and
- set of five nautical mile grid sheets for WA (refer to Part I section 13).

OPTIONAL

- GPS unit (Most effective means of determining site position) (refer to Part II section 1.4); and
- video camera or terrestrial camera (refer to Part II section 3.11).

DRUPELLA IDENTIFICATION

The following are excellent sources to assist in identifying *Drupella* and *Drupella* feeding scars.

X **CD-ROM** - *MARINE LIFE IN WESTERN AUSTRALIA: AN IDENTIFICATION GUIDE TO COMMON MARINE PLANTS AND ANIMALS*

X **INFORMATION SHEET 3.6**

X **PART II SECTION 9:** *REFERENCES*

SITE SELECTION

Select sites that have live coral, particularly *Acropora* species.

SITE DESCRIPTION

This method does not require the selection of permanent re-locatable sites. Instead sites are selected and visited on an opportunistic basis. The following details should be recorded on *Data Sheet 3.6*:

- five nautical mile grid reference number;
- name of the reef;
- reef zone; and

FRONT SLOPE	BACK REEF	LAGOON

- site position in latitude and longitude (degrees, minutes and decimals of a minute).

X **PART II SECTION 1**: *SITE DESCRIPTION (ALL SUBSECTIONS)*

HOW TO MONITOR

At each site carry out a five-minute timed swim. The following should be recorded on *Data Sheet 3.6*:

- the number of *Drupella* feeding scars; and
- select up to 30 colonies with feeding scars and determine whether *Drupella* are present (on or near the colony). Record the percentage of colonies with *Drupella* present.

X **INFORMATION SHEET 3.6:** *IDENTIFYING FEEDING SCARS*

OPTIONAL METHODS

If time permits the following information can also be recorded:

- dominant coral life form;

ENCRUSTING	BRANCHING	FOLIOSE	DIGITATE
SUB-MASSIVE	MASSIVE	PLATE	

- an estimate of the percentage cover of live hard corals.

<10%	11-30%	>30%

X **INFORMATION SHEET 3.6:** *DOMINANT CORAL FORMS*

If an underwater camera or video camera is available it is a good idea to photograph and/or video the site. Refer to the information sheet for standard methods. Details should be recorded on the *Data Sheet 3.6.*

X **INFORMATION SHEET 3.6**: *UNDERWATER PHOTOGRAPHY AND VIDEO.*

WHEN TO MONITOR

Monitoring can be carried out throughout the year. However the same reef sites need only be monitored annually.

DATA COLLECTION AND MANAGEMENT

The data collected should be entered on *Data Sheet 3.6*. Data submitted to CALM will be entered in the *Marine Community Monitoring Database* and an average number of *Drupella* feeding scars and estimated *Drupella* abundance for sites in Western Australia will be displayed on the *WA Atlas* internet site, http://www.wallis.wa.gov.au/atlas.

ADDITIONAL NOTES

Please read the following and refer to the relevant sections:

- this method requires participants to use either snorkel or SCUBA diving equipment. Participants should be suitably trained, qualified and take care in this hazardous environment.
- coral reefs are susceptible to human impacts such as diver and anchor damage.

X **PART II SECTION 4**: *SAFETY ISSUES*

X **PART II SECTION 6**: *BE ENVIRONMENTALLY SENITIVE WHEN MONITORING.*

APPENDIX 5: Marine Community Monitoring Program Method – Crown of thorns starfish (coral predator)

Crown of thorns starfish (Coral predator)

SKILL RATING: q q EQUIPMENT RATING: q m

TIME RATING: FREQUENCY RATING:

OBJECTIVE

To monitor the presence or absence of crown of thorns starfish on coral reefs in Western Australia.

BACKGROUND

The crown of thorns starfish (COTS), *Acanthaster planci*, is a common natural predator of corals on reefs throughout the world's shallow tropical oceans. Natural population densities are thought to be less than 10 starfish per kilometre of reef. Population outbreaks, where densities exceed 1000 starfish per kilometre of reef, over the past three decades have caused extensive damage to coral reefs in the Indo-Pacific region, including the Great Barrier Reef. The reasons for these outbreaks are unknown although much debate has centred around human activities, such as the removal of predators through over-fishing and increased larval survival due to increased phytoplankton from nutrient enrichment of reef waters, as possible causes.

Adult COTS feed on the fast-growing and prolific *Acropora* corals while juvenile COTS feed on coralline algae. Spawning of COTS occurs from November to January on the Great Barrier Reef and sexually mature starfish can produce millions of eggs each year. It is not known when these starfish spawn on Western Australian coral reefs but mature gonads have been observed in COTS in late spring/ early summer suggesting a summer spawning season similar to the Great Barrier Reef. COTS hide during the day and feed at night. The presence of feeding scars is often an indication that COTS are present.

RELEVANCE TO MANAGEMENT

COTS are a natural part of coral reefs. It is not known whether population outbreaks of this coral-eating starfish are caused by human activities. Whatever the cause, COTS have a significant effect on coral reefs, both from ecological and social perspectives. Monitoring of the occurrence of COTS on particular reefs over a long period will help:

- to explain the current condition of corals on reefs; and
- to facilitate a better understanding of the natural influences on coral reefs, which is necessary before human impacts can be detected and managed.

LINKS TO OTHER METHOD/S & PROGRAM/S

This method is linked to:

- *Cotswatch*;
- *Eye on the Reef*;
- Method 3.5 Reefcheck; and
- Method 3.6 *Drupella cornus* (coral predator).

SUMMARY OF METHODOLOGY

During a five-minute swim count the number of COTS, estimate the average size and record the presence or absence of COTS feeding scars.

EQUIPMENT

NECESSARY

- snorkelling or SCUBA equipment;
- underwater slate (refer to Part II section 3.2);
- *Site Registration Form 3.7*;
- *Data Sheet 3.7*;
- *Information Sheet 3.7*; and
- set of five nautical mile grid reference sheets for WA (refer to Part I section 13).

OPTIONAL

- GPS unit (Most effective means of determining site position) (refer to Part II section 1.4); and
- underwater video camera or underwater camera (refer to Part II section 3.11).

COTS IDENTIFICATION

The following will assist in identifying COTS and COTS feeding scars.

X **CD-ROM** - *MARINE LIFE IN WESTERN AUSTRALIA: AN IDENTIFICATION GUIDE TO COMMON MARINE PLANTS AND ANIMALS*

X **INFORMATION SHEET 3.7**

X **PART II SECTION 9**: *REFERENCES*

SITE SELECTION

Select sites that have live coral, particularly *Acropora* species.

SITE DESCRIPTION

This method does not require the selection of permanent re-locatable sites. Instead sites are selected and visited on an opportunistic basis. The following details should be recorded on *Data Sheet 3.7*:

- five nautical mile grid reference number;
- name of the reef name;
- reef zone; and

FRONT SLOPE	BACK REEF	LAGOON

- site position in latitude and longitude (degrees, minutes and decimals of a minute).

X **PART II SECTION 1**: *SITE DESCRIPTION (ALL SUBSECTIONS)*

HOW TO MONITOR

At each site carry out a five-minute timed swim. During the timed swim the following should be recorded on *Data Sheet 3.7*:

- the number of COTS observed;
- the presence and absence of COTS feeding scars; and
- an estimation of the average size of COTS observed.

X **INFORMATION SHEET 3.7:** SAFETY, COTS IDENTIFICATION AND *IDENTIFICATION OF FEEDING SCARS*

OPTIONAL METHODS

If time permits the following information can also be recorded:

- the dominant coral life form at the site;

ENCRUSTING	BRANCHING	FOLIOSE	DIGITATE
SUB-MASSIVE	MASSIVE	PLATE	

- an estimate of percentage cover of live corals.

<10%	11 – 30%	>30%

X **INFORMATION SHEET 3.7:** *DOMINANT CORAL FORMS*

If an underwater camera or video camera is available it is a good idea to photograph and/or video the site. Refer to the information sheet for standard methods. If photographs or video footage are taken the details should be recorded on the *Data Sheet 3.7*.

X **INFORMATION SHEET 3.7**: *UNDERWATER PHOTOGRAPHY AND VIDEO.*

WHEN TO MONITOR

Monitoring can be carried out opportunistically throughout the year. However the same reef should only be monitored once annually.

DATA COLLECTION AND MANAGEMENT

The data collected should be entered on *Data Sheet 3.7*. Data submitted to CALM will be entered in the *Marine Community Monitoring Database* and COTS abundance for sites in Western Australia will be displayed on the *WA Atlas* internet site, http://www.wallis.wa.gov.au/atlas.

ADDITIONAL NOTES

Please read the following and refer to the relevant sections:

- this method requires participants to use either snorkel or SCUBA diving equipment. Participants should be suitably trained, qualified and take care in this hazardous environment.
- coral reefs are susceptible to human impacts such as diver and anchor damage.

X **PART II SECTION 4**: *SAFETY ISSUES*

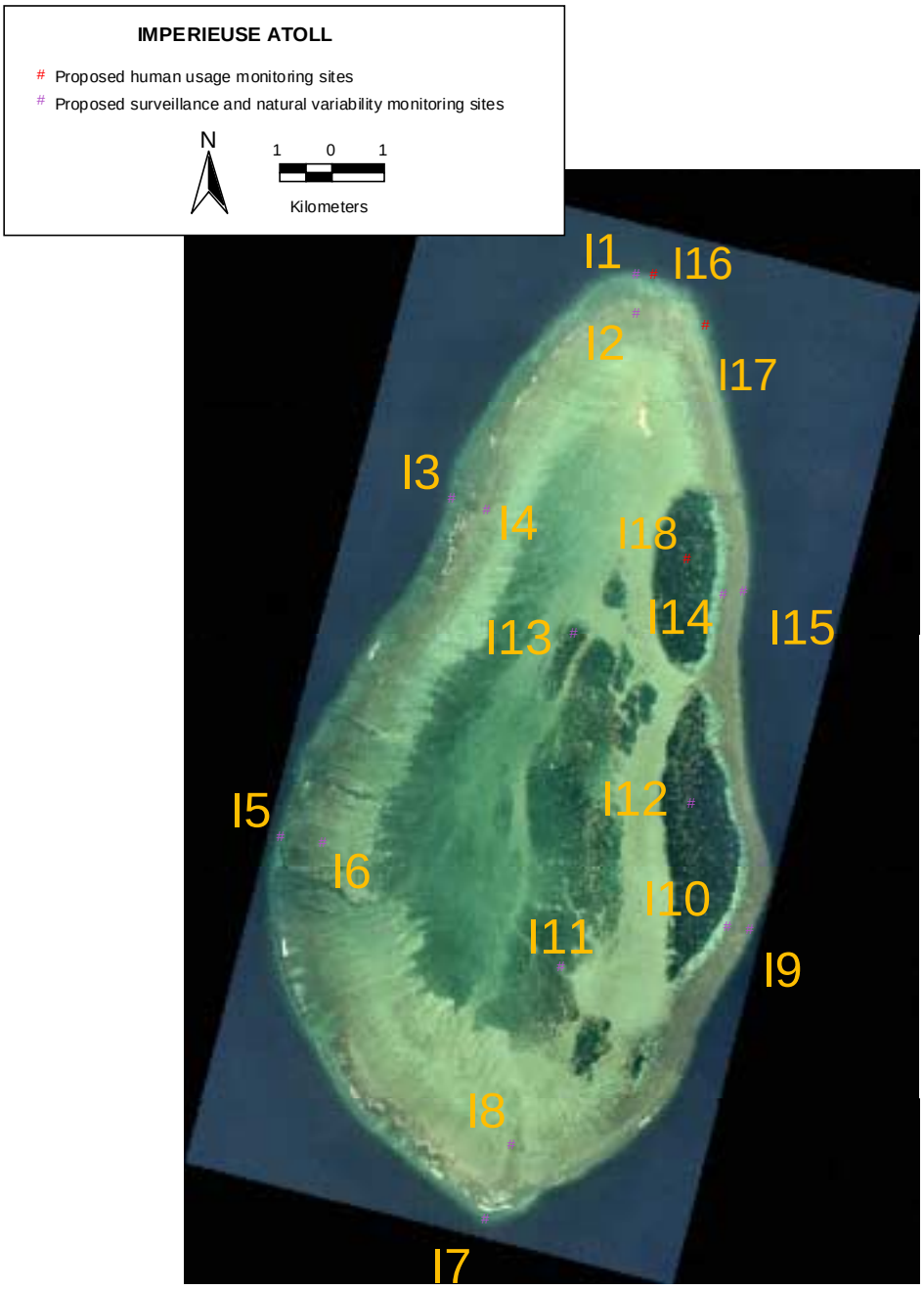
X **PART II SECTION 6**: *BE ENVIRONMENTALLY SENITIVE WHEN MONITORING.*

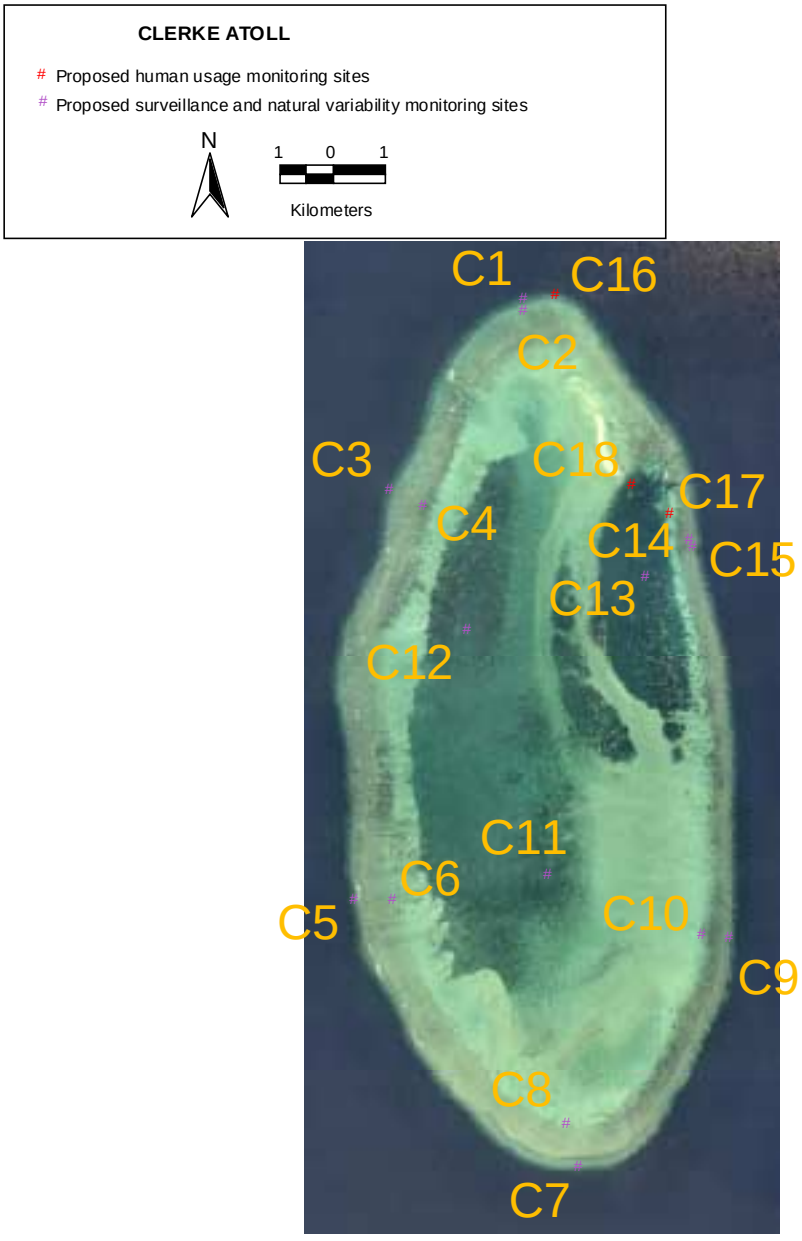
APPENDIX 6: PREDICTED TIDE CHART FOR BROOME (STANDARD PORT) AND ROWLEY SHOALS 10-24 OCTOBER

NOTE: Rowley Shoals projected tide chart derived from information supplied by Peter Trembath, Dive Supervisor for various Charter operators who visit the Rowley Shoals. **This is an estimate only.**

DATE	BROOME HIGH	BROOME LOW	ROWLEYS HIGH	ROWLEYS LOW
WED OCT 10	0201 7.2	0830 2.1	0301 3.6	0930 1.5
	1435 6.1	2034 2.9	1535 3.1	2134 2.0
THUR OCT 11	0238 6.4	0911 3.0	0338 3.2	1011 2.0
	1536 5.3	2126 3.7	1636 2.6	2226 2.0
FRI OCT 12	0353 5.5	1154 3.6	0453 3.2	1254 2.2
	1842 5.1		1942 3.2	
SAT OCT 13		0057 3.9		0157 2.4
	0719 5.5	1416 3.0	0819 3.4	1516 2.0
	2039 6.0		2139 3.6	
SUN OCT 14		0245 3.0		0345 2.0
	0849 6.5	1515 2.0	0949 3.8	1615 1.6
	2121 7.1		2221 4.1	
MON OCT 15		0337 1.8		0437 1.2
	0934 7.5	1559 1.1	1034 4.3	1659 0.8
	2157 8.0		2257 4.5	
TUES OCT 16		0419 0.8		0519 0.8
	1013 8.3	1638 0.4	1113 4.6	1738 0.4
	2230 8.8		2330 4.8	
WED OCT 17		0458 0.0		0558 0.0
(NEW MOON)	1048 8.8	1715 0.0	1148 4.8	1815 0.0
	2303 9.2			
THURS OCT 18		0534 -0.5	0003 4.9	0634 -0.5
	1121 9.0	1748 -0.1	1121 4.7	1848 -0.1
	2334 9.4			
FRI OCT 19		0608 -0.7	0034 4.9	0608 -0.7
	1154 8.9	1820 0.0	1254 4.6	1920 0.0
SAT OCT 20	0005 9.3	0640 -0.5	0105 4.9	0740 -0.5
	1227 8.6	1849 0.4	1327 4.8	1949 0.4
SUN OCT 21	0036 9.0	0710 0.0	0136 4.9	1810 0.0
	1300 8.1	1916 0.9	1400 4.7	2016 0.9
MON OCT 22	0106 8.4	0738 0.7	0206 4.8	0838 0.7
	1332 7.4	1943 1.7	1432 4.0	2043 1.7
TUES OCT 23	0136 7.6	0805 1.6	0236 3.7	0905 1.6
	1406 6.7	2007 2.5	1506 3.2	2107 2.0
WED OCT 24	0206 6.7	0832 2.5	0306 3.2	0932 2.0
	1445 5.9	2030 3.3	1545 2.8	2130 1.6

APPENDIX 7: PROPOSED LOCATIONS OF MONITORING SITES TO BE ESTABLISHED DURING OCTOBER 2001 AT IMPERIEUSE, CLERKE AND MERMAID ATOLLS


IMPERIEUSE ATOLL
Proposed human usage monitoring sites
Proposed surveillance and natural variability monitoring sites
N
1 0 1
Kilometers
I1
I16
I2
I17
I3
I4
I18
I14
I15
I13
I5
I12
I6
I10
I11
I9
I8
I7


CLERKE ATOLL
Proposed human usage monitoring sites
Proposed surveillance and natural variability monitoring sites
N
1 0 1
Kilometers
C1
C16
C2
C3
C18
C17
C4
C14
C15
C13
C12
C11
C6
C5
C10
C9
C8
C7

MERMAID ATOLL

Proposed human usage monitoring sites
Proposed surveillance and natural variability monitoring sites

N

1 0 1

Kilometers